LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
- LIGO -
CALIFORNIA INSTITUTE OF TECHNOLOGY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

| Specification | LIGO-E950091-00 -E | | 4/5/96 |
|---|---|---|---|
| *Document Type* | *Doc Number* | *Group-Id* | *Date* |

# Interface Control Document (ICD): LIGO System & Detector (Det) - Vacuum Equipment (VE)

*Title*

D. Coyne

*Authors(s)*

*This is an internal working note of the LIGO Project*

**California Institute of Technology**
**LIGO Project - MS 51-33**
**Pasadena CA 91125**
Phone (818) 395-2129
Fax (818) 304-9834
E-mail: info@ligo.caltech.edu

**Massachusetts Institute of Technology**
**LIGO Project - MS 20B-145**
**Cambridge, MA 01239**
Phone (617) 253-4824
Fax (617) 253-7014
E-mail: info@ligo.mit.edu

www:http://www.ligo.caltech.edu/

**Table 1: TBDs to be resolved by Systems & Detector**

| Section | Subject | Due Date |
|---|---|---|
| 3.2.2.1.2 | Mid-Station Stile definition drawing | 5/22 |
| 3.2.2.1.2 | ACS Optics Tables/Fixtures Definition Drawing | 5/1 |
| 3.2.2.1.2 | Cable tray/conduit (under & around the vacuum manifold & chambers) | 5/22 |
| 3.2.3.1.2 | Detector stay-clear drawing sheets for the LA site | 5/1 |

**Table 2: TBDs to be resolved by VE**

| Section | Subject | Due Date |
|---|---|---|
| 3.2.1.1.2.1 | HAM chamber internal bracket drawing | 5/22 |
| 3.2.1.1.2.2 | Table 3-1: Internal bracket load capacity | 5/22 |
| 3.2.1.1.4.1<br>3.2.1.1.4.2 | HAM chamber drawing | 5/1 |
| 3.2.1.1.4.2 | CF flange vendor specified | 5/22 |
| 3.2.1.1.5.1 | Vacuum tube adapter part drawing | 5/1 |
| 3.2.2.1.1 | Revise mid- and end-station VE configuration drawings to show annulus ion pumps on the +Y side of the vacuum manifold (per recent TDM) | 5/6 |
| 3.2.3.1.1 | VE arrangement drawings for the LA site | 5/13 |
| 3.2.3.2.1 | CDS/VCMS-VE electrical interface drawings for the LA site | 5/22 |

| ICD CHANGE RECORD | | | | |
|---|---|---|---|---|
| REVISION | DATE | AUTHORITY | PAGES AFFECTED | ITEM(S) AFFECTED |
| 00 | 4/3/95 | Draft | All | All |

| *Organization/Group* | *Name* | *Signature* |
|---|---|---|
| Program Manager | Gary Sanders | |
| Integration and Systems Engineering | Albert Lazzarini | |
| Detector | Stan Whitcomb | |
| Interferometer | David Shoemaker | |
| CDS | Rolf Bork | |
| Facilities | Mark Coles | |
| Vacuum Engineering | John Worden | |

# 1 SCOPE

This document defines the interfaces between the LIGO System & Detector (Det) and the Vacuum Equipment (VE). This ICD takes precedence over previous interface definitions between these sub-systems.

## 1.1 Purpose

The purpose of this document is to define the interfaces required to insure compatibility between the LIGO System & Detector (Det) and the Vacuum Equipment (VE) and compliance with the LIGO System Specification.

## 1.2 Content

This document contains interface descriptions, definitions, drawings and requirements. The content is intended to be as concise as possible so as to convey requirements and not duplicate design information.

The intent is that this document be self-contained with little or no requirements included by reference to other documents or drawings. If it is necessary to include information by reference to another document or drawing, then that source must be:

- an approved document
- under configuration control
- cited by document number, date, and revision number

## 1.3 Interface Overview

There are four major subsystems involved in the design and construction of the LIGO project; the detector system, the Civil Construction (CC) package, the Vacuum Equipment (VE) and the Beam Tube (BT). Since a quadripartite ICD is impractical, the interfaces have been approached in a pairwise fashion. This ICD addresses the interfaces between the LIGO System & Detector and the VE. As a consequence, the complete interface definition for any system is the ensemble of (at most) three ICDs.

The interfaces between the LIGO System & Detector and the Vacuum Equipment (VE) involve mechanical and electrical interfaces. For each of these areas, the detailed requirements are delineated in text supported with drawings as required; these drawings (each marked with a note indicating that they are part of an ICD) are an integral part of the ICD and subject to the same control procedures as the overall interface control document.

When an interface is site-specific, the definition is provided separately for the Hanford, WA and the Livingston, LA sites; otherwise, the information applies to both sites.

# 2 APPLICABLE DOCUMENTS

The documents cited in Table 2-1 specifically relate to the interface defined and controlled in this

ICD. In the event of discrepancies, this ICD takes precedence; any conflicts should be reported to LIGO Systems Engineering.

**Table 2-1: Relevant Documents**

| DOCUMENT TITLE | ID NUMBER |
|---|---|
| LIGO System Specification | LIGO-E950084<br>***TBD-CIT-MIT*** |
| *Design Configuration Control Document (DCCD)* | *PAR-FDCM010AB1B03* |
| Vacuum Equipment Technical Specification, Exhibit I of the RFP | LIGO-E940002-02-V |
| *Detector System Specification* | ***TBD-CIT-MIT*** |
| LIGO Master Schedule | Latest Revision |
| Interface Control Document (ICD): Detector - Vacuum Equipment | LIGO-E950093 |
| Interface Control Document (ICD): Vacuum Equipment - Beam Tube | LIGO-E950092 |
| Interface Control Document (ICD): Detector - Civil Construction | LIGO-E950090 |
| Interface Control Document (ICD): Beam Tube - Civil Construction | LIGO-E950089 |

# 3 REQUIREMENTS FOR INTERFACE

## 3.1 General Requirements

### 3.1.1 Responsibilities

The LIGO Integration and Systems Engineering group is responsible for maintaining this ICD and for resolving interface conflicts which may arise between the involved subsystems. The forum for interface conflict resolution is the Interface Control Working Group (ICWG). Members of the ICWG consist of Caltech and MIT personnel; representation of LIGO contractor interests is through the subsystem task managers. It is the responsibility of the subsystem task leaders to insure that they and their contractors design and implement in accordance with this interface specification.

### 3.1.2 Schedules

The LIGO program office is responsible for maintaining the master project schedule. Schedules often have significant interface impacts. Recognizing the often volatile and certainly evolving nature of project schedules, they are included only by reference.

### 3.1.3 Dimensioning

All interface drawings in this document shall be dimensioned in english units with metric units in parentheses.

### 3.1.4 Coordinate System

The common coordinate system to be used in global dimensioning for interfaces is a Cartesian system with its origin located at the corner station vertex (intersection of the projected beam tube centerlines) and with its:

- x-axis aligned along the northwest beam tube centerline in Hanford, WA and along the southwest beam tube centerline in Livingston, LA. These arms are also denoted “Right Arm” or “X-Arm”.
- y-axis aligned along the southwest beam tube centerline in Hanford, WA and along the southeast beam tube centerline in Livingston, LA. These arms are also denoted “Left Arm” or “Y-Arm”.
- z-axis aligned upwards along the normal to the x-y plane.

## 3.2 Specific Requirements

### 3.2.1 Site Independent

#### 3.2.1.1 Mechanical

*3.2.1.1.1 CDS-VE Interface Racks*

3.2.1.1.1.1 Interconnection

VE sensors and actuators which require interfacing to the VCMS are to be routed to, and terminated at, the Vacuum Cross-Connection Area of the appropriate CDS-VE Interface Rack. The Vacuum Cross-Connection Area is on the side of the rack (as indicated in Figure 3-1) and consists of panduit and DIN rails for routing and termination. All wire routing and termination on the other side of the DIN rail connection (i.e. within the CDS-VE Interface Rack and between the CDS-VE Interface Racks) is the responsibility of the Detector/CDS group.

3.2.1.1.1.2 Rack Space Allocation for VE 24V Power Supply

In each CDS-VE Interface Rack, a 4U height (7" [178 mm]) by 28" [711 mm] maximum depth is reserved for a standard 19 in. rack mounted power supply to be furnished by the VE solely for its use; The CDS group will cable and terminate the supply outputs at the DIN rails in the Vacuum Cross-Connection Area at appropriate locations (see sections 3.2.2.2.1 and 3.2.3.2.1 for interconnect wiring).

*3.2.1.1.2 Chamber Internal Attachment Brackets*

3.2.1.1.2.1 Dimensions and Locations

The locations and details of the brackets available for use in attaching Detector components to the interior surface of the main cylindrical vacuum chamber are as indicated in drawing LIGO-D960376 for the BSC chamber and D96xxxx (***TBD-VE***; use VE specification drawing D1101051 in the interim) for the HAM chamber.

3.2.1.1.2.2 Load Capacity

The brackets are not intended to take significant moments at each bolt connection; moments are to be reacted by distributing the load via multiple bolt hole connections. The maximum static loads which can be applied to any bolt hole on any of the brackets (independent of loads to other holes and brackets) are as indicated in Table 3-1.

*3.2.1.1.3 BSC Chamber Floor*

The floor in the BSC chamber is:

- designed for a 500 kg point load
- flat and level to +/1 5 mm, but with a segmented surface (for removal)
- extends to within 25 mm of the interior wall of the chamber
- are tangent to the bottom of the large access port nozzle diameters

**Figure 3-1: CDS-VE Interface Rack**

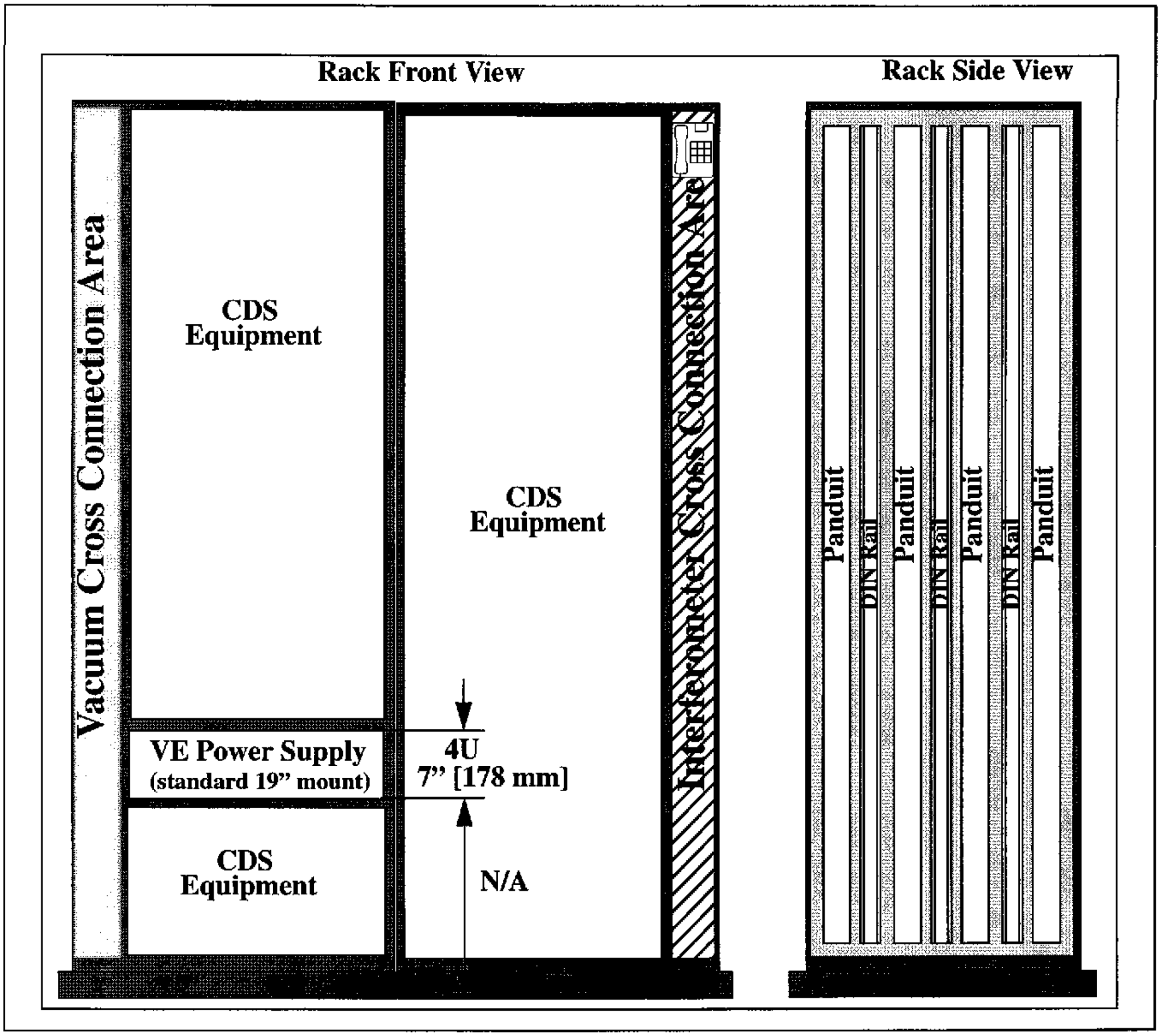



**Table 3-1: Chamber Bracket Attachment Load Capacity**

| *Load Direction* | *Maximum Load per Bolt lbf [N]* |
|---|---|
| vertical | ***TBD-VE*** |
| radial | ***TBD-VE*** |
| tangential | ***TBD-VE*** |

### *3.2.1.1.4 Chamber Interface Ports*

#### 3.2.1.1.4.1 Dimensions and Locations

There are three types of flanged nozzles on each chamber used to interface with Detector components, as indicated in drawings LIGO-D960376 and LIGO-D960377 for the BSC chambers and LIGO-D96xxxx (***TBD-VE***) for the HAM chamber:

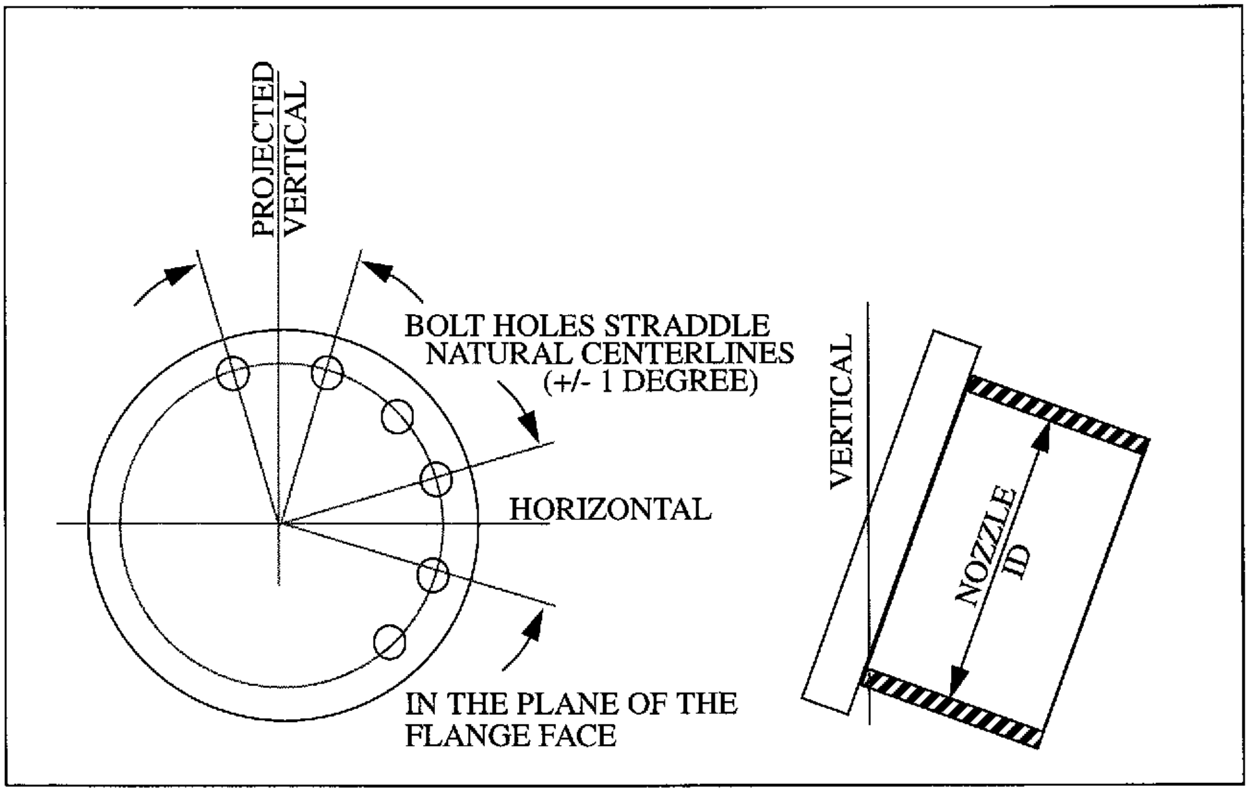
- SIS support beams
- Electrical feedthroughs
- Optical ports

The number and position of these ports are indicated in the referenced drawings.

#### 3.2.1.1.4.2 Flange Details

The interface ports are provided with blank-offs installed. The flanges are all non-rotatable, conflat[1] type, or compatible alternatives. For interchangeability, all flanges of the same diameter are to be of the same design and from the same vendor (vendor ***TBD-VE***). The flange sizes are as indicated in drawings LIGO-D960376 and LIGO-D960377 for the BSC chambers and LIGO-D96xxxx (***TBD-VE*** use VE specification drawing D1101010 in the interim) for the HAM chambers. In all cases, the flange bolt holes straddle natural centerlines of the nozzle (i.e. the intersections of the vertical and horizontal planes with the flange face as shown in the Figure 3-2).

**Figure 3-2: Chamber Flange Angular Alignment** (non-rotatable, conflat[a] type)




a. Registered trademark, Varian Vacuum Products

1. Registered trademark, Varian Vacuum Products

*3.2.1.1.5 Vacuum Tube Ports*

3.2.1.1.5.1 Dimensions and Locations

There are six ports on each of the vacuum tube adapters. The dimensions and locations of these ports are as indicated in drawing LIGO-D96xxxx (***TBD-VE*** use VE specification drawing D1101100 in the interim).

3.2.1.1.5.2 Flange Details

See section 3.2.1.1.7.2

## 3.2.2 Washington Site

Note that the Mid-Station and End-Station Buildings have identical floor plans. Furthermore, the Mid- and End-Stations on the Y-Arm are mirror images of the Mid- and End-Stations on the X-Arm.

### 3.2.2.1 Mechanical Interfaces

*3.2.2.1.1 General Configuration and VE Stay-Clear Envelopes*

The overall configuration and layout of the VE and the critical location dimensions are as given in drawings LIGO-D960373, LIGO-D960374 and LIGO-D960375; These drawings are in compliance with the VE System Specification and are cited herein as reference only -- there are no additional interface requirements regarding the layout.

Stay-clear envelopes, or exclusion zones, reserved for VE are listed in Table 3-1 with reference to appropriate drawings for definition.

**Table 3-2: VE Stay-Clear Envelope Definition**

| *VE Component* | *LIGO drawing number* | | |
|---|---|---|---|
| | *corner station* | *mid-station* | *end-station* |
| Piping (LN2, GN2, exhaust, instrument air) and pipe bridge | D960373 | D960374[a] | D960375[b] |
| Pumps: Rough Pump (RP) and Turbo-Pump (TP) Carts and annulus ion pumps | | | |
| Vacuum envelope: manifolds & chambers & support structures | | | |
| Electrical conduit stub-up locations | D960042 | D960043 | D960044 |

a. ***TBD-VE***: Mid-station drawing to be revised to indicate the annulus ion pumps on the +Y side of the vacuum manifold.

b. ***TBD-VE***: End-station drawing to be revised to indicate the annulus ion pumps on the +Y side of the vacuum manifold.

The RP and TP exclusion zones include a stay-clear region around the pumps for access during use. The access region of the RP and TP exclusion zones can be used for transitory purposes.

#### *3.2.2.1.2 Detector Stay-clear Envelopes*

Stay-clear envelopes, or exclusion zones, reserved for Detector elements are listed in Table 3-3 with reference to appropriate drawings for detailed definition. (Note: Although the stile is provided by the VE group, it is included here in the detector stay-clear envelope definitions to distinguish it from contractor provided equipment.)

**Table 3-3: Detector Stay-Clear Envelope Definition**

| *VE Component* | *LIGO drawing number* | | |
|---|---|---|---|
| | *corner station* | *mid-station* | *end-station* |
| CDS electronics racks | D960378, sheet 1 | D960378, sheet 2 | D960378, sheet 2 |
| Stile (for access to the vertex region) | D960378, sheet 1 | ***TBD-CIT-MIT***[a] | N/A |
| PSL | D960378, sheet 1 | N/A | N/A |
| ACS optical tables/fixtures | ***TBD-CIT-MIT*** | ***TBD-CIT-MIT*** | ***TBD-CIT-MIT*** |
| SIS support structure and columns[b] | BSC chamber: D950132<br>HAM chamber: D950134 | | |
| Cable tray/conduit (under/around vacuum manifold and chamber) | ***TBD-CIT-MIT*** | ***TBD-CIT-MIT*** | ***TBD-CIT-MIT*** |

a. A movable cross-over stile will be used to provide access to the region behind the VE vacuum manifold after acceptance testing of the VE. This stile will be designed around the

b. The orientation of the chambers are to be defined (chamber rotation ***TBD-VE***) in the configuration/layout drawings, LIGO-D960373, D960374 and D960375.

The exclusion zones for the CDS electronics racks include a stay-clear region around the racks for door swing and access to equipment/connections inside the racks. The access region of the rack exclusion zones can be used for transitory purposes.

#### *3.2.2.1.3 CDS/VCMS-VE Interface Rack Locations*

The number and location of CDS-VE Interface Racks are indicated in drawing D960378.

### 3.2.2.2 Electrical Interfaces

#### *3.2.2.2.1 CDS/VCMS*

The signal interconnection (wiring) diagram for the CDS/VCMS interface with the VE is given in the drawings cited in Table 3-4.

**Table 3-4: CDS/VCMS-VE Electrical Interconnection**

| *drawing title* | *drawing number* |
|---|---|
| CDS Interface Diagram: LIGO VE WA Site: Corner Station | D960101 |
| CDS Interface Diagram: LIGO VE WA Site: Left Mid-Station | D960102 |
| CDS Interface Diagram: LIGO VE WA Site: Right Mid-Station | D960103 |
| CDS Interface Diagram: LIGO VE WA Site: Left End-Station | D960104 |
| CDS Interface Diagram: LIGO VE WA Site: Right End-Station | D960105 |

#### 3.2.2.3 Thermal Interfaces

Not applicable.

### 3.2.3 Louisiana Site

Mid station buildings exist only at the Hanford, Washington site. At Livingston, a pump station building with a VE gate valve and space for portable pump carts will exist at the 2km point.

#### 3.2.3.1 Mechanical

##### *3.2.3.1.1 General Configuration and VE Stay-Clear Envelopes*

Refer to section 3.2.1.1.1 where the corresponding drawings are ***TBD-VE*** (a subset of the Washington site drawings). There are no Detector-VE interfaces at the Louisiana mid-station.

##### *3.2.3.1.2 Detector Stay-clear Envelopes*

Refer to section 3.2.1.1.2 where the corresponding drawings are ***TBD-CIT-MIT*** (a subset of the Washington site drawings).

##### *3.2.3.1.3 CDS/VCMS-VE Interface Rack Locations*

The number and location of CDS-VE Interface Racks are indicated in drawing D960378.

#### 3.2.3.2 Electrical Interfaces

##### *3.2.3.2.1 CDS/VCMS*

The signal interconnection (wiring) diagram for the CDS/VCMS interface with the VE is given in the drawings cited in Table 3-1.

**Table 3-5: CDS/VCMS-VE Electrical Interconnection**

| *drawing title* | *drawing number* |
|---|---|
| CDS Interface Diagram: LIGO VE WA Site: Corner Station | ***TBD-VE*** |
| CDS Interface Diagram: LIGO VE WA Site: Left Mid-Station | ***TBD-VE*** |
| CDS Interface Diagram: LIGO VE WA Site: Right Mid-Station | ***TBD-VE*** |
| CDS Interface Diagram: LIGO VE WA Site: Left End-Station | ***TBD-VE*** |
| CDS Interface Diagram: LIGO VE WA Site: Right End-Station | ***TBD-VE*** |

#### 3.2.3.3 Thermal Interfaces

Not applicable.

# 4 INTERFACE VERIFICATION

Verification of the interface is to be performed by one of the following methods:

- Test/Measurement
  A test (wherein the specific test is to be specified) is conducted to insure compliance with the ICD requirements. In some cases this test may be part of a planned component or subsystem test program and not required specifically for verification of the interface.
- Inspection
  In some cases verification may be accomplished by an inspection of the physical article (e.g. measurement of critical dimensions).
- Analysis
  Verification by analysis (wherein the specific analysis is to be specified) may be appropriate in instances where verification by test is expensive or impractical.
- Demonstration
  Demonstration may be used for qualitative determination of properties and performance of an item. Demonstration is accomplished by observation of the item in the performance of its function.
- Similarity
  Arguments of similarity of design may be invoked to verify compliance with interface requirements (e.g. lifetime of a component based upon demonstrated lifetime of similar component designs).

The specific verification method is called out for each of the requirements in the following table.

**Table 4-1: Verification Matrix**

| *Para.* | *Requirement Title* | *Test/ Measurement* | *Inspection* | *Analysis* | *Demonstration* | *Similarity* |
|---|---|---|---|---|---|---|
| 3.2.1.1.1.1 | CDS-VE Interface Rack Interconnection | ✓ | ✓ | | | |
| 3.2.1.1.1.2 | Rack space allocation for VE 24V power supply | | ✓ | | | |
| 3.2.1.1.2.1 | Chamber internal attachment bracket dimensions and locations | | ✓ | | | |
| 3.2.1.1.2.2 | Chamber internal attachment bracket load capacity | | | ✓ | | |
| 3.2.1.1.3 | BSC chamber floor | | ✓ | ✓ | | |
| 3.2.1.1.4.1 | Chamber interface port dimensions and locations | | ✓ | | | |
| 3.2.1.1.4.2<br>3.2.1.1.5.2 | Chamber interface port flange details | | ✓ | | | |
| 3.2.1.1.5.1 | Vacuum tube port dimensions & locations | | ✓ | | | |

**Table 4-1: Verification Matrix**

| *Para.* | *Requirement Title* | *Test/ Measurement* | *Inspection* | *Analysis* | *Demonstration* | *Similarity* |
|---|---|---|---|---|---|---|
| 3.2.2.1.1<br>3.2.3.1.1 | General configuration and VE stay-clear envelopes | | ✓<br>dwgs | | | |
| 3.2.2.1.2<br>3.2.2.1.3<br>3.2.3.1.2<br>3.2.3.1.3 | Detector stay-clear envelopes | | ✓<br>dwgs | | | |
| 3.2.2.2.1<br>3.2.3.2.1 | CDS/VCMS-VE electrical interfaces | ✓ | ✓ | | | |

# 5 NOMENCLATURE AND ACRONYMS

| *Acronym* | *Meaning* |
|---|---|
| Arm | One of the two perpendicular beam lines which constitute the LIGO interferometer vacuum envelope between stations |
| BT | Beam Tube |
| BTE | Beam Tube Enclosure |
| Caltech | California Institute of Technology |
| CB | Circuit Breaker |
| CC | Civil Construction |
| Corner Station | The vertex or point of intersection of the LIGO arms. Also may refer to the facilities erected around this point. It is also called the vertex or vertex station. |
| DCCD | Design Configuration Control Document -- the requirements document for the Civil Construction design |
| End-Station | The 4 km termini of the LIGO arms. There are buildings situated at these points at both sites. |
| ICD | Interface Control Document |
| ICWG | Interface Control Working Group |
| LIGO | Laser Interferometer Gravitational Wave Observatory |
| iff | if and only if |
| KVA | Killo-volt-amperes; apparent power (total current times rms voltage) |
| $LN_2$ | *Liquefied nitrogen (cryogenic fluid)* |
| LVEA | Laser and Vacuum Equipment Area |
| Mid-Station | The 2 km mid-points along the LIGO arms. At the Hanford site, there are buildings located at the mid-station. At the Livingston site, there is no mid-station building, just a minor expansion of the Beam Tube Enclosure (BTE) |
| MIT | Massachusetts Institute of Technology |
| N/A | Not Applicable |
| N.B. | Nota bene; note well |
| NEMA | National Electrical Manufacturer's Association |
| SIS | Seismic Isolation System; a Detector Sub-system |
| TBD | To be determined (for as yet unspecified quantities). |
| TBR | To be resolved/reviewed; used when a provisional data value is possibly uncertain |
| VCMS | Vacuum Control and Monitoring System |
| VE | Vacuum Equipment |

| | |
|---|---|
| VEA | Vacuum Equipment Area |
| Vertex | The point of intersection of the LIGO arms. Also may refer to the facilities erected around this point. It is also called the corner or corner station. |
| $\varphi$ | electrical power phase |

# 6 DRAWINGS:

| *LIGO Dwg (PSI Dwg)* | *Title Subtitle* | *No. of Sheets* | *Completed* |
|---|---|---|---|
| D960101-00-V (V049-3-123-P1) | CDS Interface Diagram: LIGO VE WA Site: Corner Station | 4 | ✓ |
| D960102-00-V (V049-3-208-P1) | CDS Interface Diagram: LIGO VE WA Site: Left Mid-Station | 2 | ✓ |
| D960103-00-V (V049-3-308-P1) | CDS Interface Diagram: LIGO VE WA Site: Right Mid-Station | 2 | ✓ |
| D960104-00-V (V049-3-408-P1) | CDS Interface Diagram: LIGO VE WA Site: Left End-Station | 1 | ✓ |
| D960105-00-V (V049-3-508-P1) | CDS Interface Diagram: LIGO VE WA Site: Right End-Station | 1 | ✓ |
| D960373-00-V (V049-5-001-P4) | Equipment Arrangement: LIGO VE WA Site: Corner Station | 1 | ✓ |
| D960374-00-V (V049-5-004-P4) | Equipment Arrangement: LIGO VE WA Site: Right Mid-Station | 1 | ✓ |
| D960375-00-V (V049-5-005-P4) | Equipment Arrangement: LIGO VE WA Site: Right End-Station | 1 | ✓ |
| D950132-01-V | Detector/SIS Stay-Clear Envelope Around HAM Chamber | 2 | ✓ |
| D950134-01-V | Detector/SIS Stay-Clear Envelope Around BSC Chamber | 2 | ✓ |
| D960376-00-V (V049-4-001-P5) | BSC Chamber | 5 | ✓ |
| D960377-00-V (V049-4-014-P1) | Type 1 Cover, BSC Chamber | 1 | ✓ |
| ***TBD-VE*** | HAM Chamber | | |
| D960378-00-E | Detector Stay Clear Envelopes (racks, stile, ACS, PSL) | 2 | ✓ |
| D960042-01-V (V049-3-124-P2) | Electrical Stub-Up Plan, LIGO VE, Corner Station | 2 | ✓ |
| D960042-01-V (V049-3-124-P2) | Electrical Stub-Up Plan, LIGO VE, Right Mid Station | 1 | ✓ |
| D960042-01-V (V049-3-124-P2) | Electrical Stub-Up Plan, LIGO VE, Right End Station | 1 | ✓ |

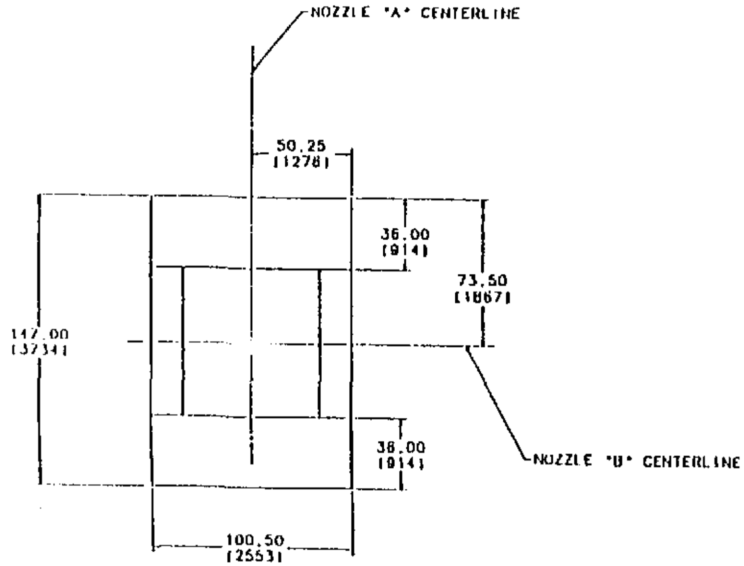
| REV | DATE | DRWN | APPD | DCN/DESCRIPTION |
| --- | --- | --- | --- | --- |
| | | | | |

LIGO-D950132-~~Sk~~01-V

~~Oct 19/95~~ Sheet 1

~~John Worden~~

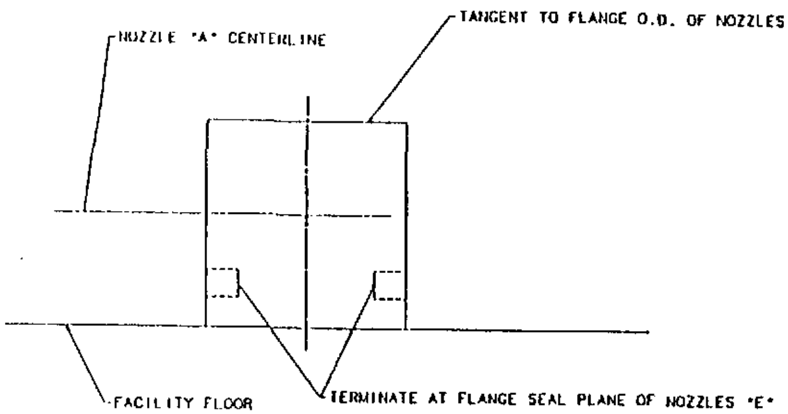
PRELIMINARY

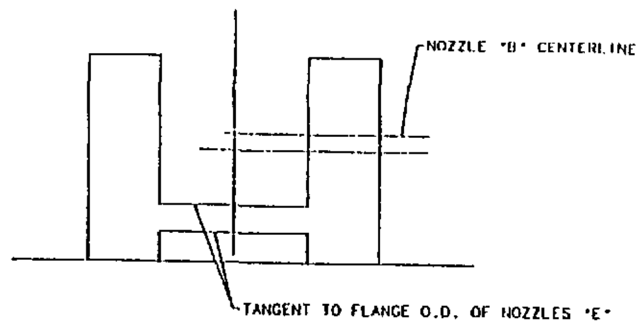



LIGO HAM CHAMBER
DETECTOR EQUIPMENT
RESERVED SPACE

(PRELIMINARY)

MEZ 10/13/95




CALIFORNIA INSTITUTE OF TECHNOLOGY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

LIGO PROJECT

HAM CHAMBER
DETECTOR EQUIPMENT
RESERVED SPACE

SCALE: N/A | DRAWING NUMBER: N/A

| REV | DATE | DRWN | APPD | DCN/DESCRIPTION |
|---|---|---|---|---|
| | | | | |

~~LIGO-D950137-SK-V~~ 2-01

~~Oct 19/95~~ Sheet 2

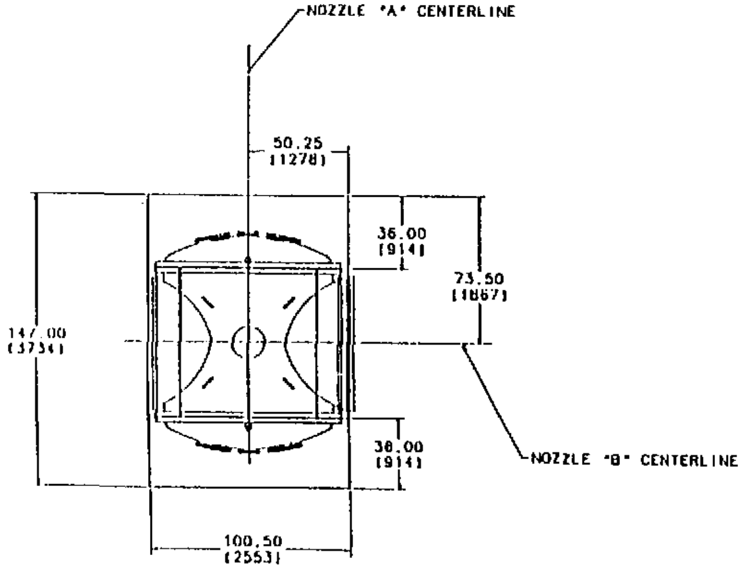
~~John Worden~~

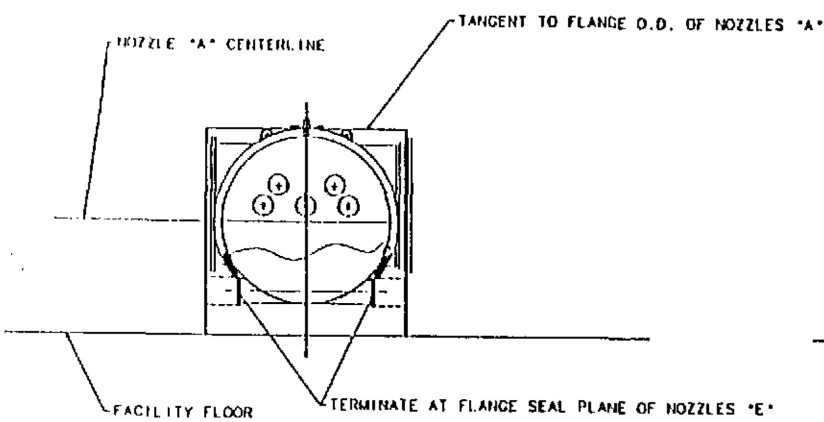
PRELIMINARY

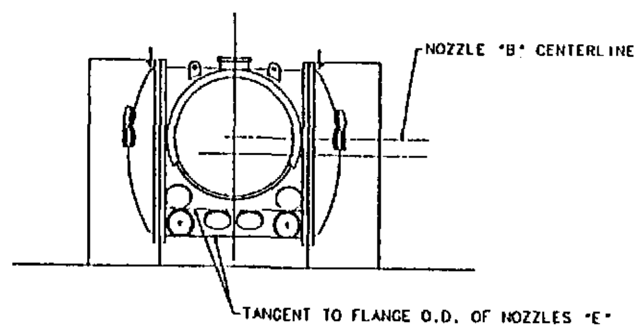
LIGO HAM CHAMBER
DETECTOR EQUIPMENT
RESERVED SPACE

(PRELIMINARY)

MEZ 10/13/95



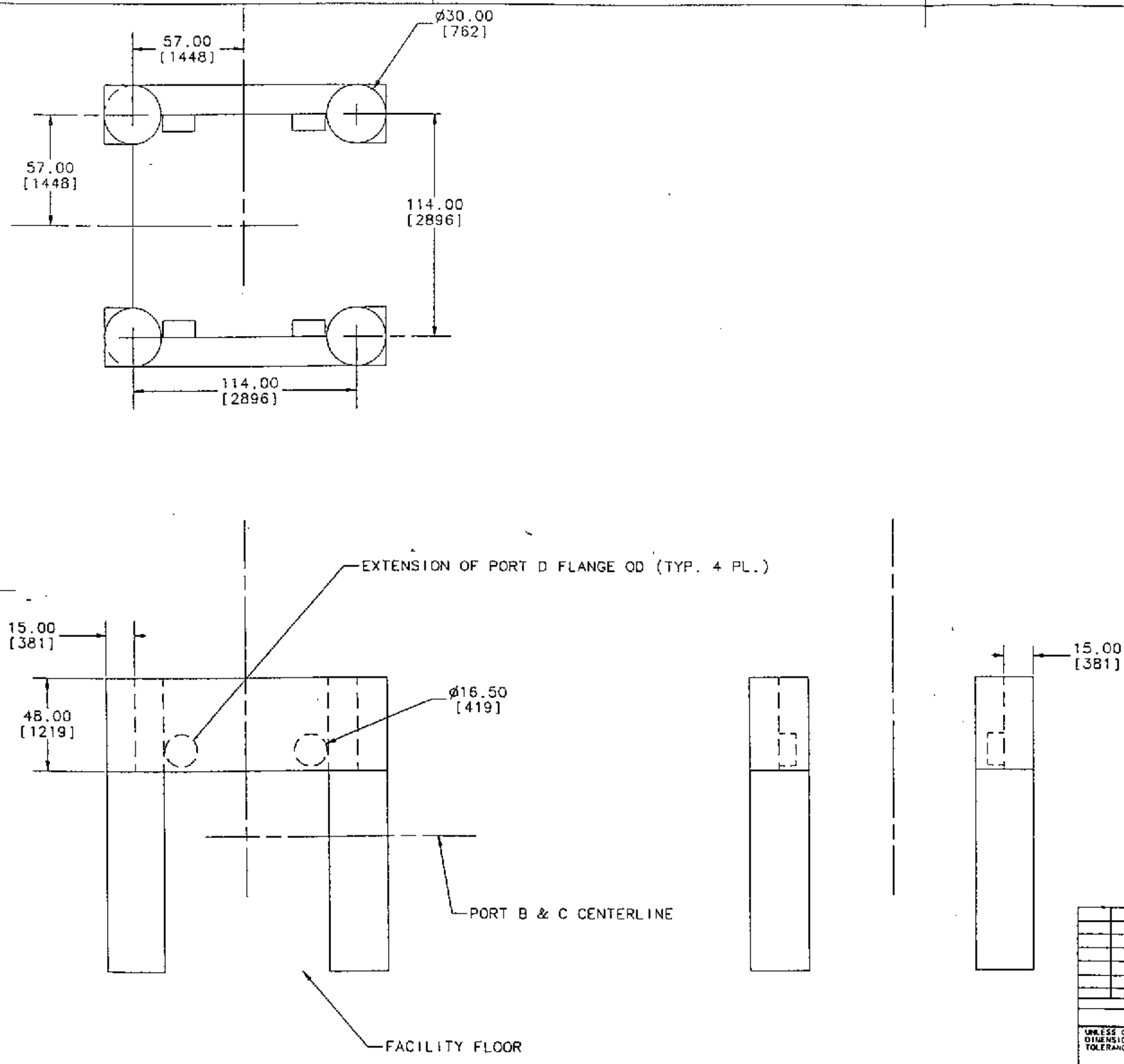




LIGO PROJECT

HAM CHAMBER
DETECTOR EQUIPMENT
RESERVED SPACE

SCALE: N/A — SHEET 1 of 1




| REV | DESCRIPTION OF CHANGE | APPROVAL | DATE |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN in [mm] TOLERANCES ARE:

MATERIAL

| | | | |
|---|---|---|---|
| D. Coyne | Systems | | 4/8/96 |
| A. Lazzarini | Systems | | |
| S. Whitcomb | Detector | | |
| D. Shoemaker | Detector | | |
| M. Coles | Facilities | | |
| J. Worden | Vacuum Eqp. | | |

LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

DETECTOR/SIS STAY-CLEAR REGION

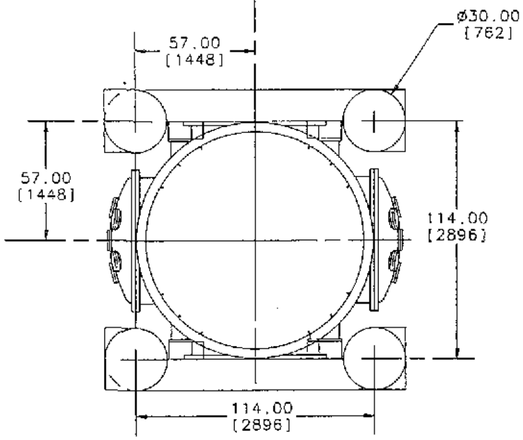
D960134 REV 01

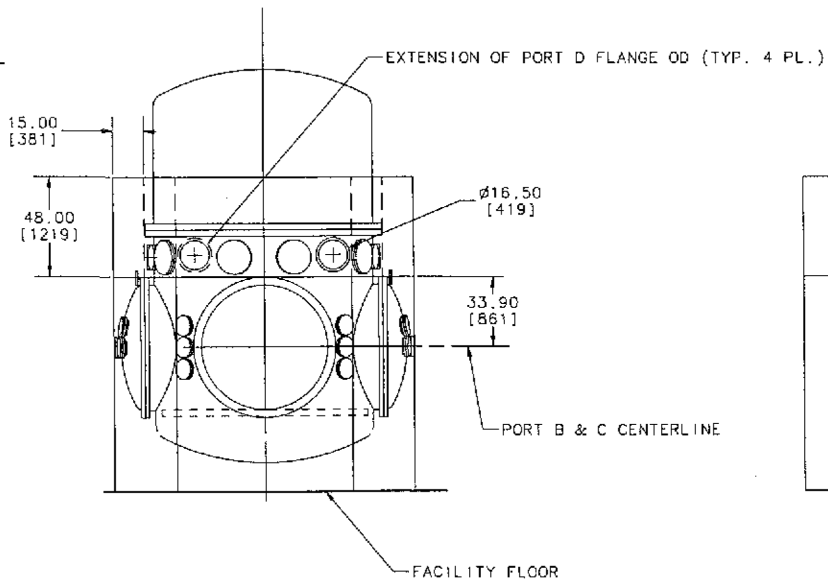
D960134_1_BSCclear.asc

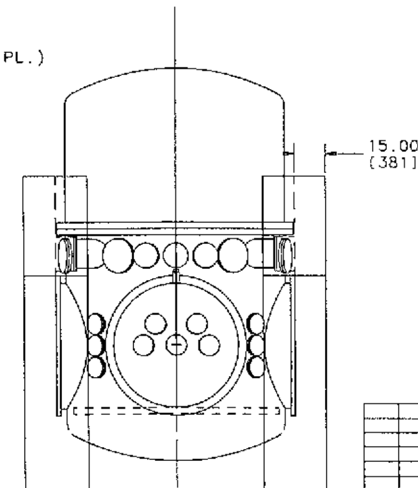
1 OF 2

| REV | DESCRIPTION OF CHANGE | APPROVAL | DATE |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

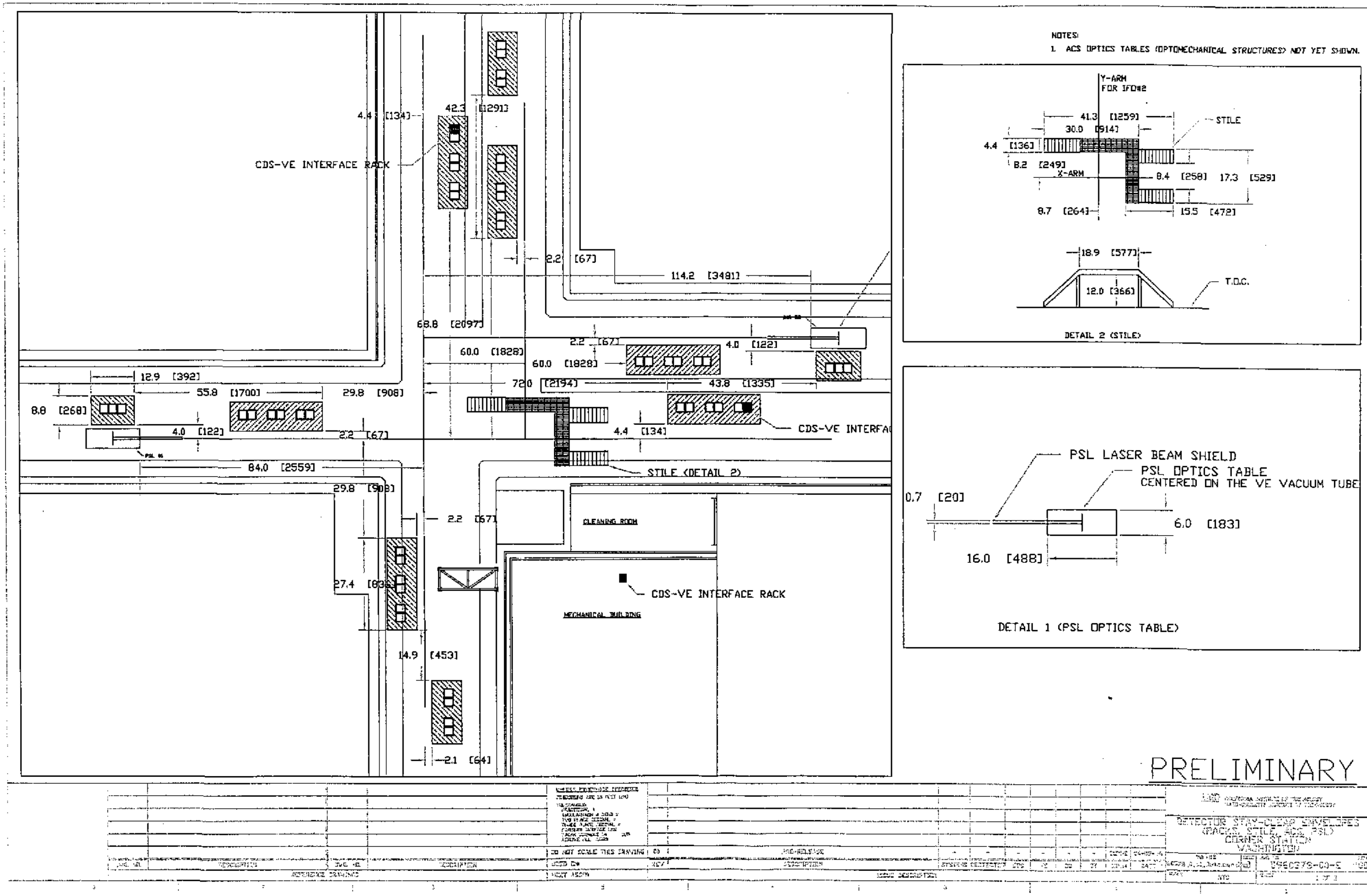
1) CHAMBER OUTLINE SHOWN FOR REFERENCE ONLY;
DIMENSIONS & PORT CONFIGURATION ARE NOT ACCURATE.

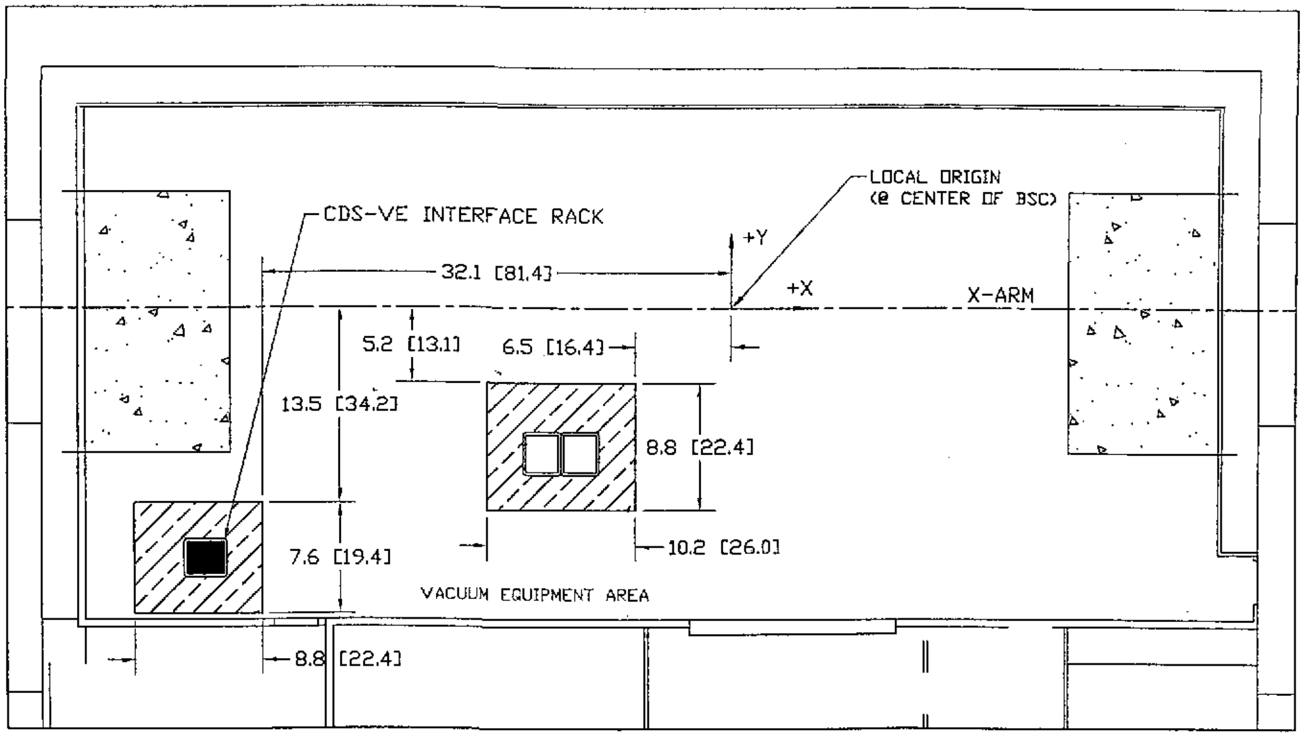



| | | | | |
|---|---|---|---|---|
| UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN in (mm) TOLERANCES ARE: | D. Coyne | Systems | 4/8/98 | LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY |
| | A. Lazzarini | Systems | | DETECTOR/SIS STAY-CLEAR REGION |
| | S. Whitcomb | Detector | | WITH BSC CHAMBER SHOWN |
| MATERIAL | D. Shoemaker | Detector | | |
| | M. Coles | Facilities | | D960134 REV 01 |
| | J. Worden | Vacuum Eqp. | | |
| | D960134_1_BSCclear.osc | | | 2 OF 2 |


NOTES:
1. ACS OPTICS TABLES (OPTOMECHANICAL STRUCTURES) NOT YET SHOWN.
CDS-VE INTERFACE RACK
CDS-VE INTERFACE RACK
CDS-VE INTERFA
STILE (DETAIL 2)
CLEANING ROOM
MECHANICAL BUILDING
4.4 [134]
42.3 [1291]
2.2 [67]
114.2 [3481]
68.8 [2097]
60.0 [1828]
60.0 [1828]
2.2 [67]
4.0 [122]
72.0 [2194]
43.8 [1335]
12.9 [392]
55.8 [1700]
29.8 [908]
8.8 [268]
4.0 [122]
2.2 [67]
4.4 [134]
84.0 [2559]
29.8 [908]
2.2 [67]
27.4 [835]
14.9 [453]
2.1 [64]
Y-ARM
FOR IFO#2
41.3 [1259]
30.0 [914]
STILE
4.4 [136]
8.2 [249]
X-ARM
8.4 [258]
17.3 [529]
8.7 [264]
15.5 [472]
18.9 [577]
12.0 [366]
T.O.C.
DETAIL 2 (STILE)
PSL LASER BEAM SHIELD
PSL OPTICS TABLE
CENTERED ON THE VE VACUUM TUBE
0.7 [20]
6.0 [183]
16.0 [488]
DETAIL 1 (PSL OPTICS TABLE)
PRELIMINARY
DO NOT SCALE THIS DRAWING
DETECTOR STAY-CLEAR ENVELOPES
(RACKS, STILE, ACS, PSL)
CORNER STATION
WASHINGTON




NOTES:

1. ACS OPTICS TABLES (OPTOMECHANICAL STRUCTURES) NOT YET SHOWN.
2. STATIONS ALONG Y-ARM ARE MIRROR REFLECTIONS OF STATIONS ALONG X-ARM.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| DO NOT SCALE THIS DRAWING | 00 | PRE-RELEASE | - | - | - | - | - | - | CONLEY | 4-9-96 |
| USED ON | REV | DESCRIPTION | SYSTEMS | DETECTOR | CDS | VE | CC | ST | DRWN | DATE |
| NEXT ASSY: | | ISSUE DESCRIPTION | | | | | | | | |

| DWG. NO. | DESCRIPTION | DWG. NO. | DESCRIPTION |
|---|---|---|---|
| REFERENCE DRAWINGS | | | |

LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY / MASSACHUSETTS INSTITUTE OF TECHNOLOGY

DETECTOR STAY-CLEAR ENVELOPES (RACKS, ACS) MID- & END-STATIONS WASHINGTON

DWG. NO. D960378-00-E REV. 00

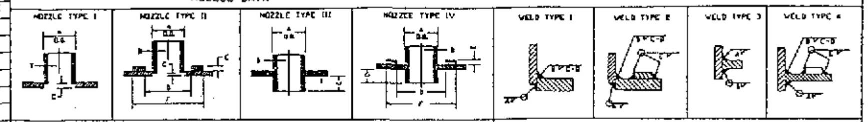
SCALE NTS

SHEET 2 OF 2

| NOZZLE SCHEDULE | | | | | | NOZZLE TYPE | | | | | | | WELD TYPE | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MARK | QTY | SIZE | RATING | TYPE | DESCRIPTION | TYPE | A | B | C | D | E | F | TYPE | A | B | C | D | E |
| A | 1 | 104 1/2" I.D. | | SEE NOTES 2, & 3 | MAJOR ACCESS | | | | | | | | | | | | | |
| B | 2 | 60 1/2" I.D. | | SEE NOTES 2, & 3 | LASER BEAM ACCESS MINIMIZE NECK LENGTH | | | | | | | | | | | | | |
| C | 2 | 60 1/2" I.D. | | SEE NOTES 2, & 3 | ACCESS MINIMIZE NECK LENGTH | | | | | | | | | | | | | |
| D | 4 | 14" O.D. TUBE | | 16 1/2" O.D. CONFLAT ** W/ BLIND FLANGE | SUPPORT BEAMS | I | 14" | .125 | | | | | I | 1/8" | NA | NA | NA | |
| E | 8 | 14" O.D. TUBE *** | | 16 1/2" O.D. CONFLAT ** W/ BLIND FLANGE | AIR SHWR, BACK-TO -AIR PURGE ROUGHING & ION PUMPS UTILITY | I | 14" | .125 | | | | | I | 1/8" | NA | NA | NA | |
| F | 4 | 10" O.D. TUBE *** | | 12" O.D. CONFLAT ** W/ BLIND FLANGE | ELECTRICAL FEEDTHROUGHS | I | 10" | .125 | | | | | I | 1/8" | NA | NA | NA | |
| G | 12 | 8" O.D. TUBE *** | | 10" O.D. CONFLAT ** W/ BLIND FLANGE | OBSERVATION, BEAM PICK-OFFS | I | 8.0 | .25 | | | | | I | 1/8" | NA | NA | NA | |

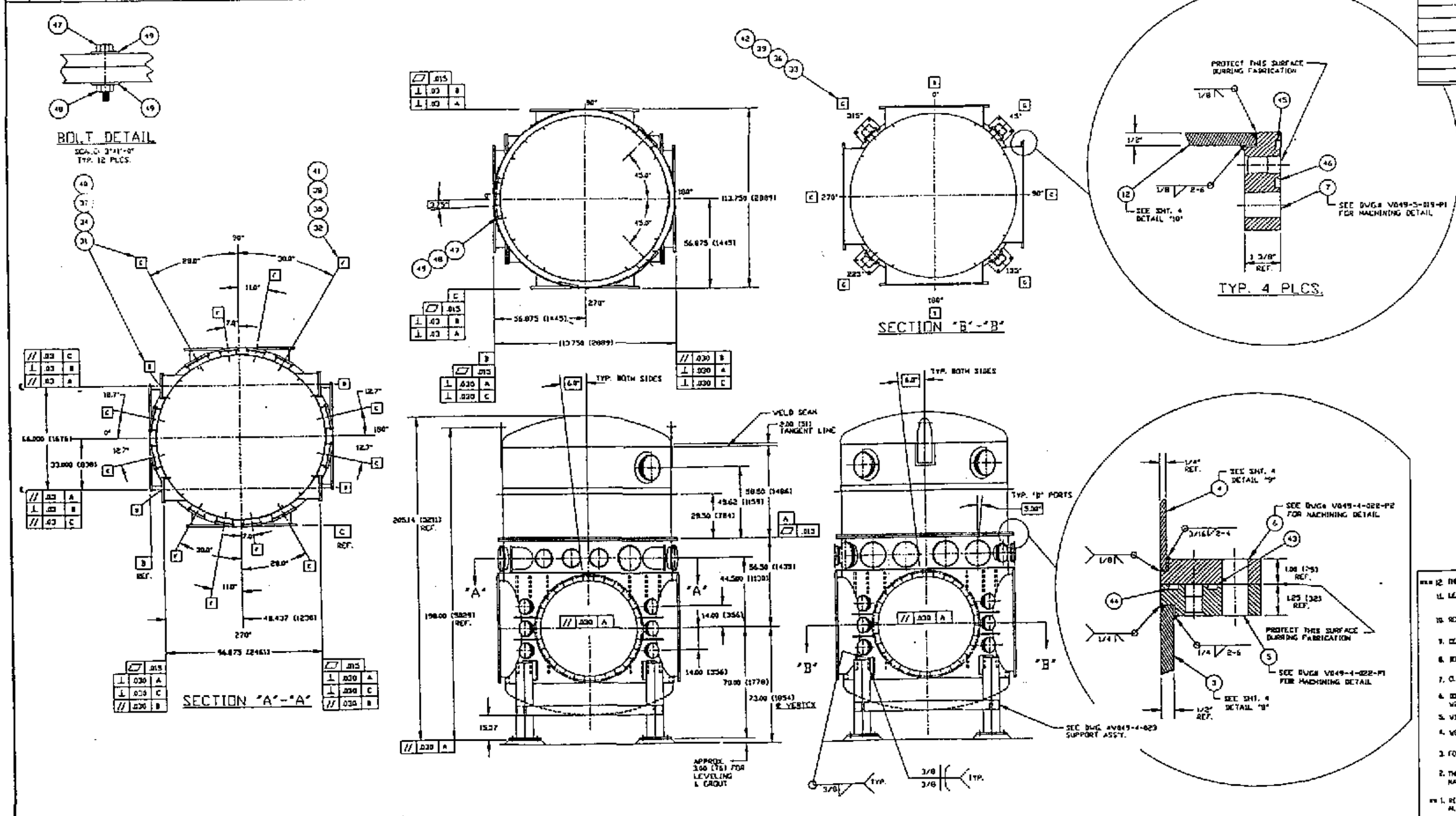
NOZZLE DATA

WELD DATA




WELDING PROCEDURES

| WPS NO. | PROCESS | MATERIAL | WPS NO. | PROCESS | MATERIAL |
|---|---|---|---|---|---|
| | | | | | |




| | |
|---|---|
| DESIGN DATA | CODE: ASME SEC. VIII 1992 W/ DEC. 1993 ADDENDA |
| TORR & TEMP. | |
| SPECIFICATION | |
| CORROSION ALLOWANCE: 0 | |
| POSTWELD HEAT TREATMENT: YES | |
| INSULATION: | (SEE NOTES) |
| FIREPROOFING: | N.A. |
| RADIOGRAPHING | |
| NOZZLES: | |
| HEAD/SHELL: | |
| SHELL: | |
| MATERIALS | |
| HEADS: | SA 240-304/304L |
| SHELL: | SA 240-304/304L |
| FLANGES: | SA 479-304/304L |
| PIPE NECKS: | SA 312-304/304L; SA 240-304/304L |
| REINFORCING | |
| BOLTS & NUTS: | SA 193-B7 |
| GASKETS: | (SEE NOTES) |
| WEIGHTS | |
| FABRICATED: | |
| EMPTY: | 14,000 LBS |
| OPERATING: | |
| TEST: | |

## NOTES

*** 12. THESE FLANGES ARE TO BE TANGENT TO THE SHELL O.D.

11. LEAK TEST & METHOD PER PSI SPEC: V049-2-014

10. REFERENCE CODE CALCULATIONS PER SPEC:

9. CERTIFIED MANUFACTURER'S MATERIAL TEST REPORTS REQUIRED.

8. BOLT HOLES TO STRADDLE CENTERLINES OF VESSEL AS SHOWN

7. CLEAN PER SPEC: V049-2-015

6. DO NOT USE CARBON STEEL BRUSHES OR BRUSHES CONTAMINATED WITH CARBON STEEL ON STAINLESS OR ALUMINUM MATERIAL.

5. VISUAL INSPECTION PER SPEC:

4. WELD EFFICIENCY FACTOR: SHELL, LONG & CIRC. SEAMS / HEAD & SHELL SEAM

3. FOR FLANGE DETAILS SEE DWG. V049-4-019 & V049-4-022.

2. THESE FLANGES EACH INCLUDE AN ANNULAR CHANNEL BETWEEN O-RINGS, MANIFOLD TO A SINGLE PUMPOUT PORT ON EACH CHAMBER, WITH CONFLAT** SEAL.

** 1. REGISTERED TRADEMARK, VARIAN VACUUM PRODUCTS; COMPATIBLE ALTERNATIVES ARE ACCEPTABLE.



| DWG. NO. | DESCRIPTION | DWG. NO. | DESCRIPTION |
|---|---|---|---|
| | | 1101009 | LIGO BEAM SPLITTER CHAMBER |

REFERENCE DRAWINGS

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES

DO NOT SCALE THIS DRAWING

USED ON:

NEXT ASS'Y:

| REV | DESCRIPTION | CHKD | DRWN | DATE | DECN |
|---|---|---|---|---|---|
| P5 | RELEASE FOR PROTOTYPE FABRICATION | | PV | 12/26/95 | |
| P4 | RELEASE FOR QUOTATION | | KAR | 12/11/95 | |
| P3 | PRELIMINARY DESIGN UPDATE | | KAR | 12/5/95 | |
| P2 | DESIGN UPDATE | | KAR | 11/14/95 | |
| P1 | PRELIMINARY DESIGN UPDATE | | RRN | 9/22/95 | |

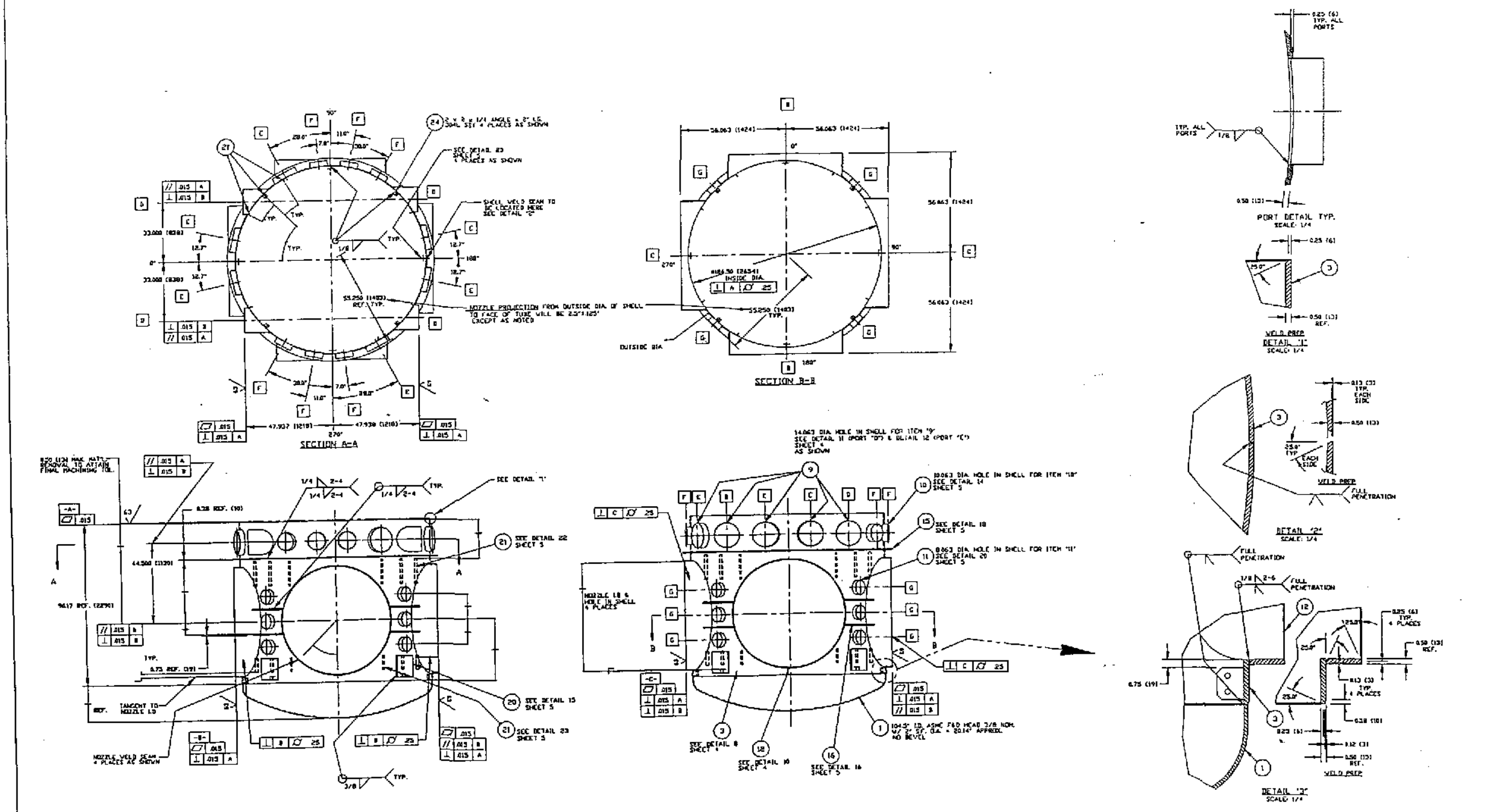
ISSUE DESCRIPTION

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

BEAM SPLITTER CHAMBER (BSC)
LIGO VACUUM EQUIPMENT

| CAD FILE | SIZE | DWG. NO. | REV. |
|---|---|---|---|
| V0494001/4001S1 | D | V049-4-001 | P5 |
| SCALE 3/8"=1'-0" | | SHEET 1 OF 5 | |

Jan 10 1996 - 10:36:30

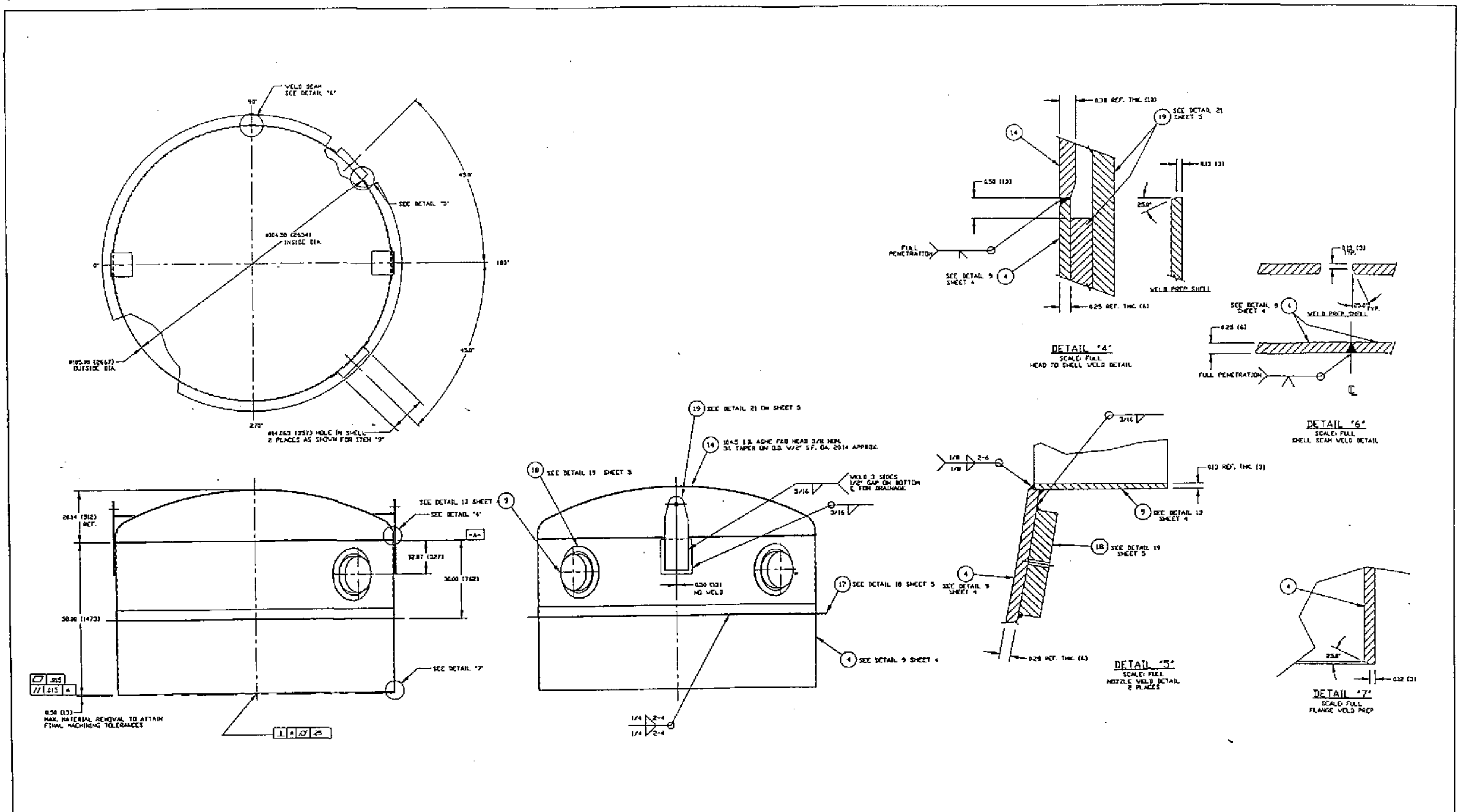



PROCESS SYSTEMS INTERNATIONAL, INC.

BEAM SPLITTER CHAMBER (BSC)
LOWER SHELL WELDMENT/MACHINING
LIGO VACUUM EQUIPMENT

| | | | |
|---|---|---|---|
| CAD FILE 400152 | SIZE D | DWG. NO. V049-4-001 | REV. P5 |
| SCALE 1"=24" | | SHEET 2 OF 5 | |

JAN 03, 1996 - 16:37:18



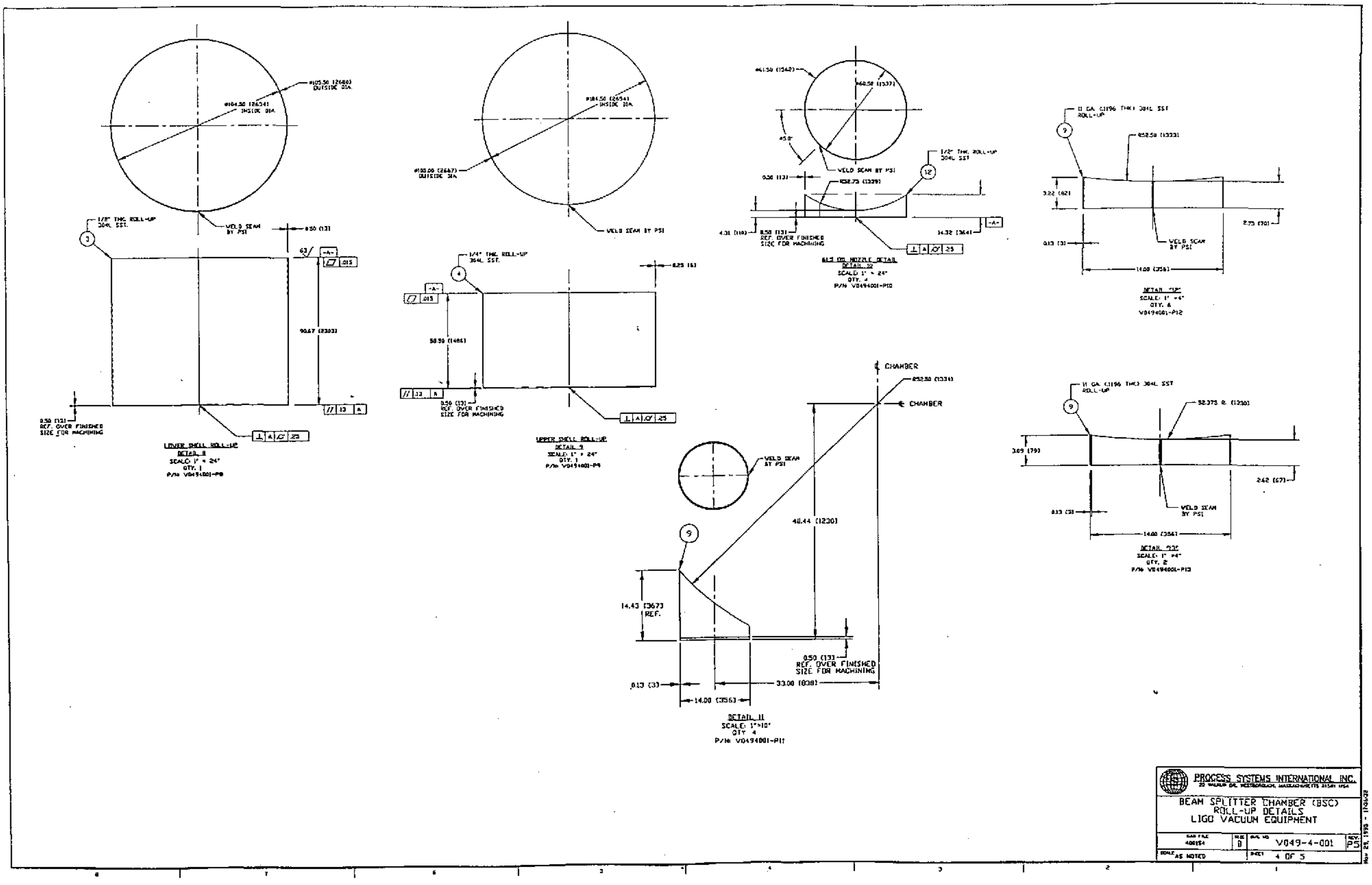

PROCESS SYSTEMS INTERNATIONAL INC.

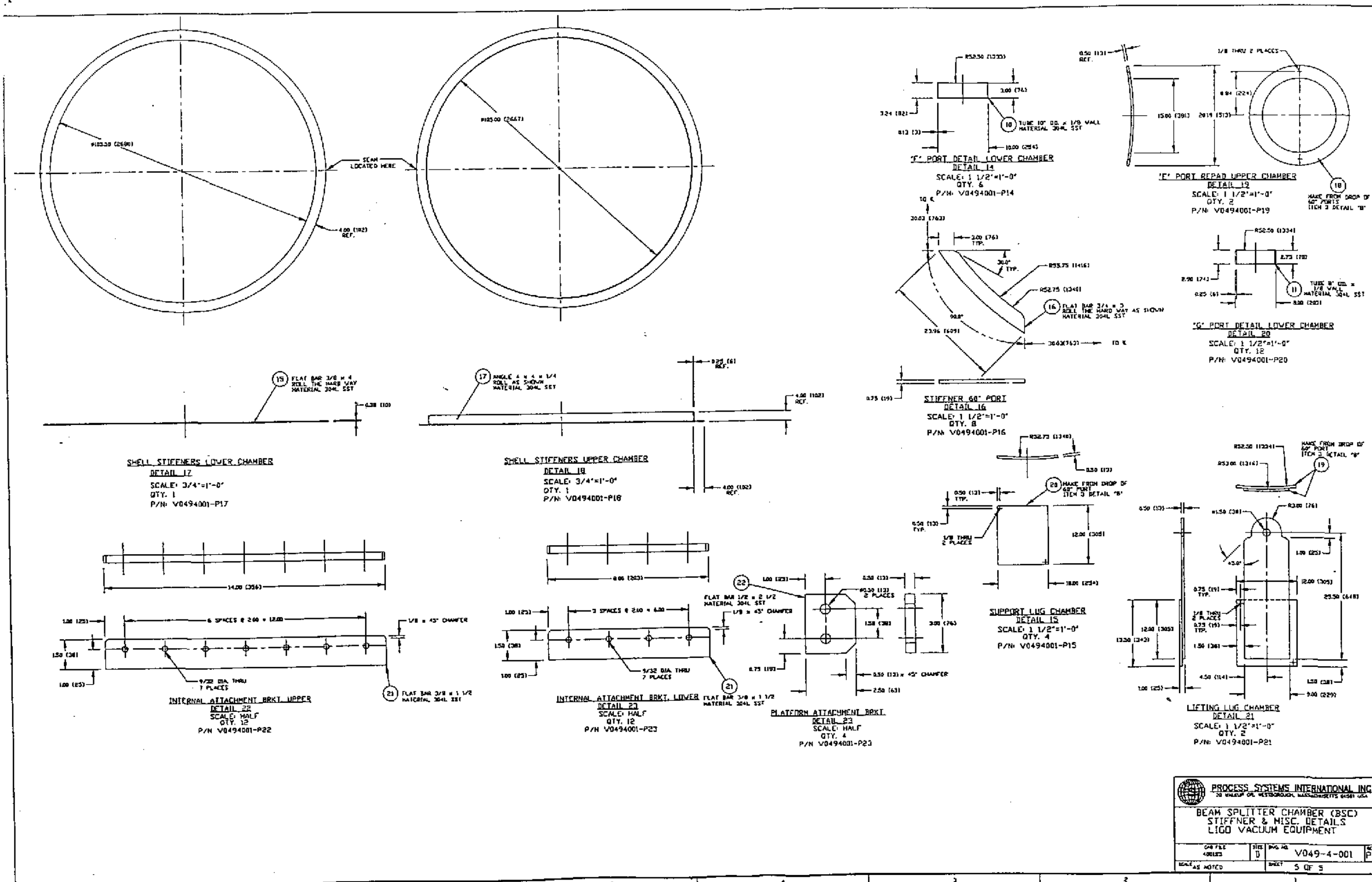
BEAM SPLITTER CHAMBER (BSC)
UPPER SHELL WELDMENT/ MACHINING
LIGO VACUUM EQUIPMENT

| CAD FILE | SIZE | DWG NO. | REV. |
| --- | --- | --- | --- |
| 400153 | D | V049-4-001 | P5 |
| SCALE 1/16 | | SHEET 3 OF 5 | |

DEC 24 1995 - 13:49:10

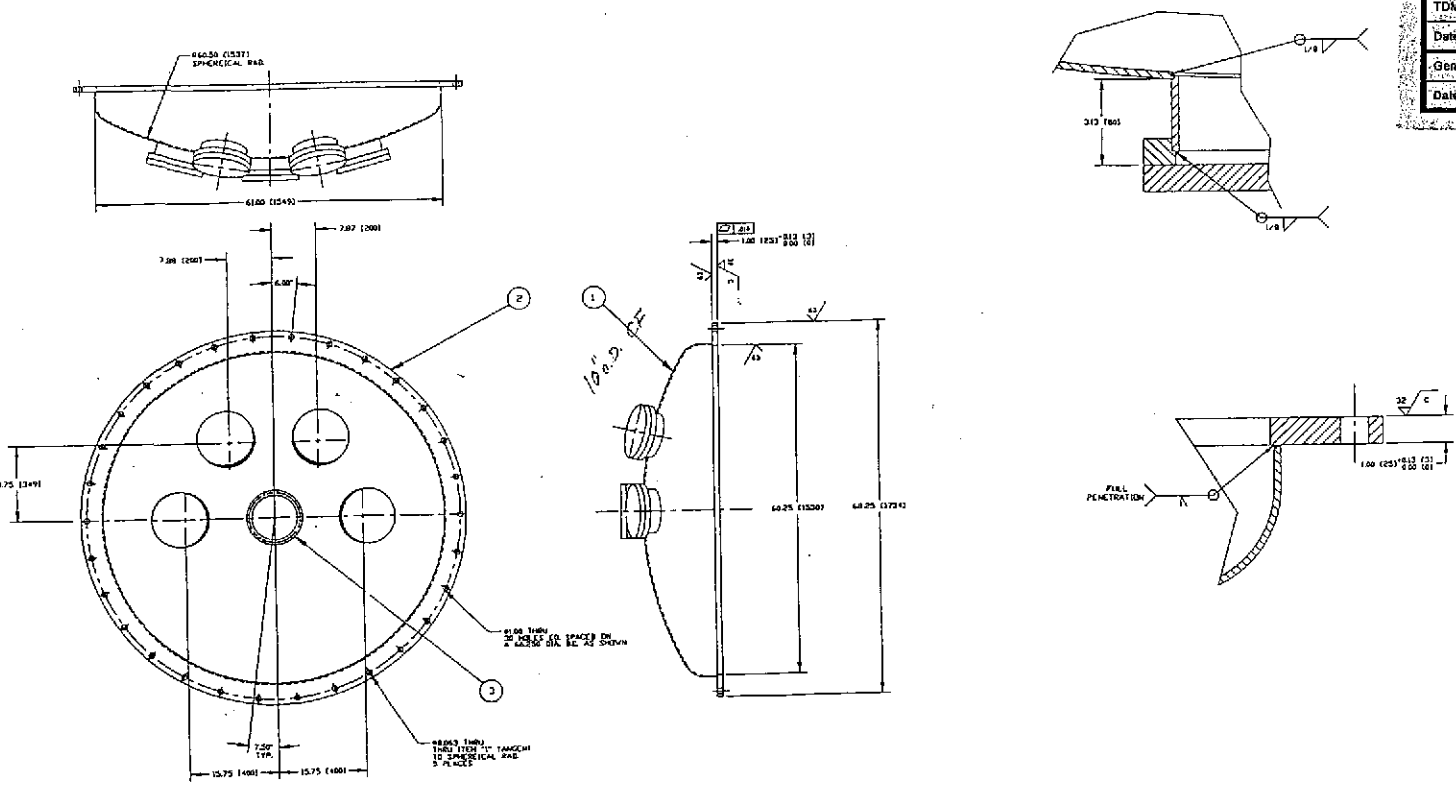
LIGO- Approved:
Geri Transmittal Date:
TDM- Date:
Title:


LOWER SHELL ROLL-UP
DETAIL 8
SCALE: 1" = 24"
QTY. 1
P/N V0494001-P8
UPPER SHELL ROLL-UP
DETAIL 9
SCALE: 1" = 24"
QTY. 1
P/N V0494001-P9
DETAIL 10
SCALE: 1" = 24"
QTY. 4
P/N V0494001-P10
DETAIL "12"
SCALE: 1" = 4"
QTY. 6
V0494001-P12
DETAIL "13"
SCALE: 1" = 4"
QTY. 2
P/N V0494001-P13
DETAIL 11
SCALE: 1"=10"
QTY 4
P/N V0494001-P11
CHAMBER
WELD SEAM BY PSI
REF. OVER FINISHED SIZE FOR MACHINING
48.44 (1230)
14.43 (367) REF.
0.50 (13)
.013 (3)
14.00 (356)
33.00 (838)
PROCESS SYSTEMS INTERNATIONAL INC.
BEAM SPLITTER CHAMBER (BSC)
ROLL-UP DETAILS
LIGO VACUUM EQUIPMENT
D
V049-4-001
P5
AS NOTED
4 OF 5



SEAM LOCATED HERE
'F' PORT DETAIL LOWER CHAMBER
DETAIL 14
SCALE: 1 1/2"=1'-0"
QTY. 6
P/N: V0494001-P14
TUBE 10" OD. x 1/8 WALL MATERIAL 304L SST
'F' PORT REPAD UPPER CHAMBER
DETAIL 19
SCALE: 1 1/2"=1'-0"
QTY. 2
P/N: V0494001-P19
1/8 THRU 2 PLACES
STIFFENER 60" PORT
DETAIL 16
SCALE: 1 1/2"=1'-0"
QTY. 8
P/N: V0494001-P16
FLAT BAR 3/4 x 3 ROLL THE HARD WAY AS SHOWN MATERIAL 304L SST
'G' PORT DETAIL LOWER CHAMBER
DETAIL 20
SCALE: 1 1/2"=1'-0"
QTY. 12
P/N: V0494001-P20
TUBE 8" OD. x 1/8 WALL MATERIAL 304L SST
FLAT BAR 3/8 x 4 ROLL THE HARD WAY MATERIAL 304L SST
SHELL STIFFENERS LOWER CHAMBER
DETAIL 17
SCALE: 3/4"=1'-0"
QTY. 1
P/N: V0494001-P17
ANGLE 4 x 4 x 1/4 ROLL AS SHOWN MATERIAL 304L SST
SHELL STIFFENERS UPPER CHAMBER
DETAIL 18
SCALE: 3/4"=1'-0"
QTY. 1
P/N: V0494001-P18
SUPPORT LUG CHAMBER
DETAIL 15
SCALE: 1 1/2"=1'-0"
QTY. 4
P/N: V0494001-P15
LIFTING LUG CHAMBER
DETAIL 21
SCALE: 1 1/2"=1'-0"
QTY. 2
P/N: V0494001-P21
6 SPACES @ 2.00 = 12.00
1/8 x 45° CHAMFER
9/32 DIA. THRU 7 PLACES
FLAT BAR 3/8 x 1 1/2 MATERIAL 304L SST
INTERNAL ATTACHMENT BRKT. UPPER
DETAIL 22
SCALE: HALF
QTY. 12
P/N V0494001-P22
3 SPACES @ 2.00 = 6.00
INTERNAL ATTACHMENT BRKT. LOWER
DETAIL 23
SCALE: HALF
QTY. 12
P/N V0494001-P23
FLAT BAR 1/2 x 2 1/2 MATERIAL 304L SST
PLATFORM ATTACHMENT BRKT.
DETAIL 23
SCALE: HALF
QTY. 4
P/N V0494001-P23
PROCESS SYSTEMS INTERNATIONAL, INC.
BEAM SPLITTER CHAMBER (BSC)
STIFFNER & MISC. DETAILS
LIGO VACUUM EQUIPMENT
V049-4-001
P5
AS NOTED
5 OF 5

| | |
|---|---|
| Date Received: 1/8/95 | LIGO- V049-4-014 P1<br>Contractor #: D960377-00-V |
| TIM #: | LIGO- |
| Date: / / | Approved: |
| TDM #: | LIGO- |
| Date: / / | Approved: |
| Gen'l Transmittal | LIGO- |
| Date: / / | Approved: |




DEC 1 5 1995

## NOTES

21. PRESSURE TEST & METHOD PER PSI SPEC.
20. REFERENCE CODE CALCULATIONS PER SPEC.
19. MATERIALS TO BE LEGIBLY STAMPED OR STENCILED PER SPEC.
18. CERTIFIED MANUFACTURER'S MATERIAL TEST REPORTS REQUIRED.
17. FLANGE BOLT HOLES TO STRADDLE NATURAL CENTERLINES OF VESSEL UNLESS NOTED.
16. CLEAN PER SPEC.
15. ALL NOZZLES TO BE CONTOURED TO OUTSIDE DIAMETER OF SHELL OR TO CURVATURE OF HEAD UNLESS OTHERWISE NOTED.
14. DEVIATION FROM STRAIGHT ALONG COLUMN AXIS -1/8" PER 10'-0" OF SHELL LENGTH, -3/4" MAXIMUM OVERALL.
13. DO NOT USE CARBON STEEL BRUSHES OR BRUSHES CONTAMINATED WITH CARBON STEEL ON STAINLESS OR ALUMINUM MATERIAL.
12. VISUAL INSPECTION PER SPEC.
11.
10.
13. WELD EFFICIENCY FACTOR: SHELL LONG & CIRC. SEAMS / HEAD & SHELL SEAM
9. LIQUID PENETRANT EXAMINATION REQUIRED AROUND ALL NOZZLES AND AT ATTACHMENTS WITH FILLET WELDS 3/8" OR LARGER PER SPEC.
8.
7.
6. HEADS ARE ASME F&D.
5.
4. TOLERANCES, UNLESS OTHERWISE SPECIFIED: LINEAR ± .025 CM; ANGULAR ± 1 DEGREE
* 3.
2.
** 1. REGISTERED TRADEMARK, VARIAN VACUUM PRODUCTS; COMPATIBLE ALTERNATIVES ARE ACCEPTABLE.

PROPRIETARY AND CONFIDENTIAL

UNLESS OTHERWISE SPECIFIED

DO NOT SCALE THIS DRAWING

| REV | DESCRIPTION | CHKD | DRWN | DATE | DCB# |
|---|---|---|---|---|---|
| P1 | PRELIMINARY | | X | X | 028 |

ISSUE DESCRIPTION

USED ON

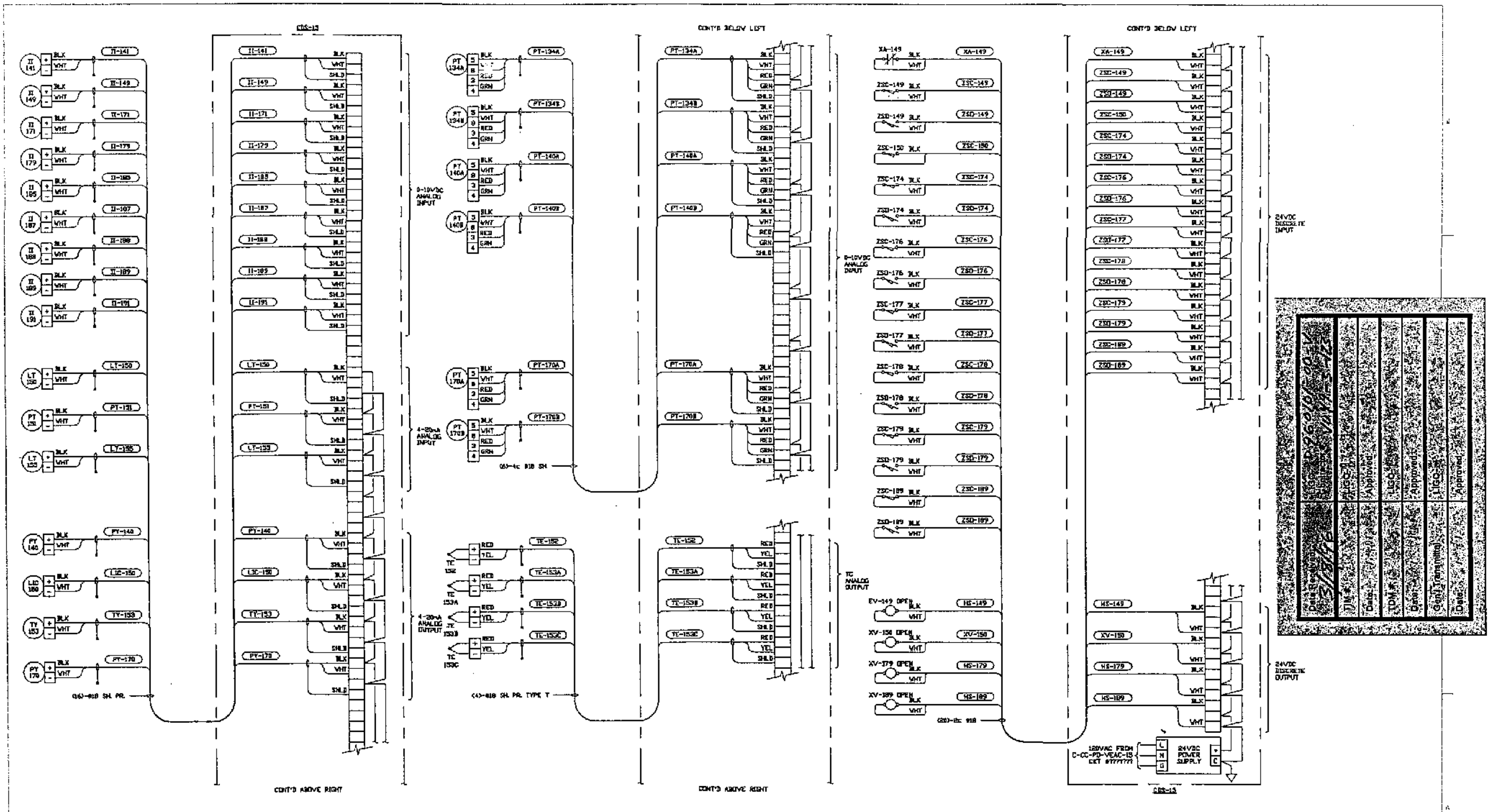
NEXT ASS'Y

**PROCESS SYSTEMS INTERNATIONAL INC.**

COVER, TYPE 1
BEAM SPLITTER CHAMBER
LIGO VACUUM EQUIPMENT

CAD FILE: V8494014 | SIZE: D | DWG NO: V049-4-014 | REV: P1
SCALE: 1=10 | SHEET 1 OF 1

Dec 08, 1995 - 08:35:27



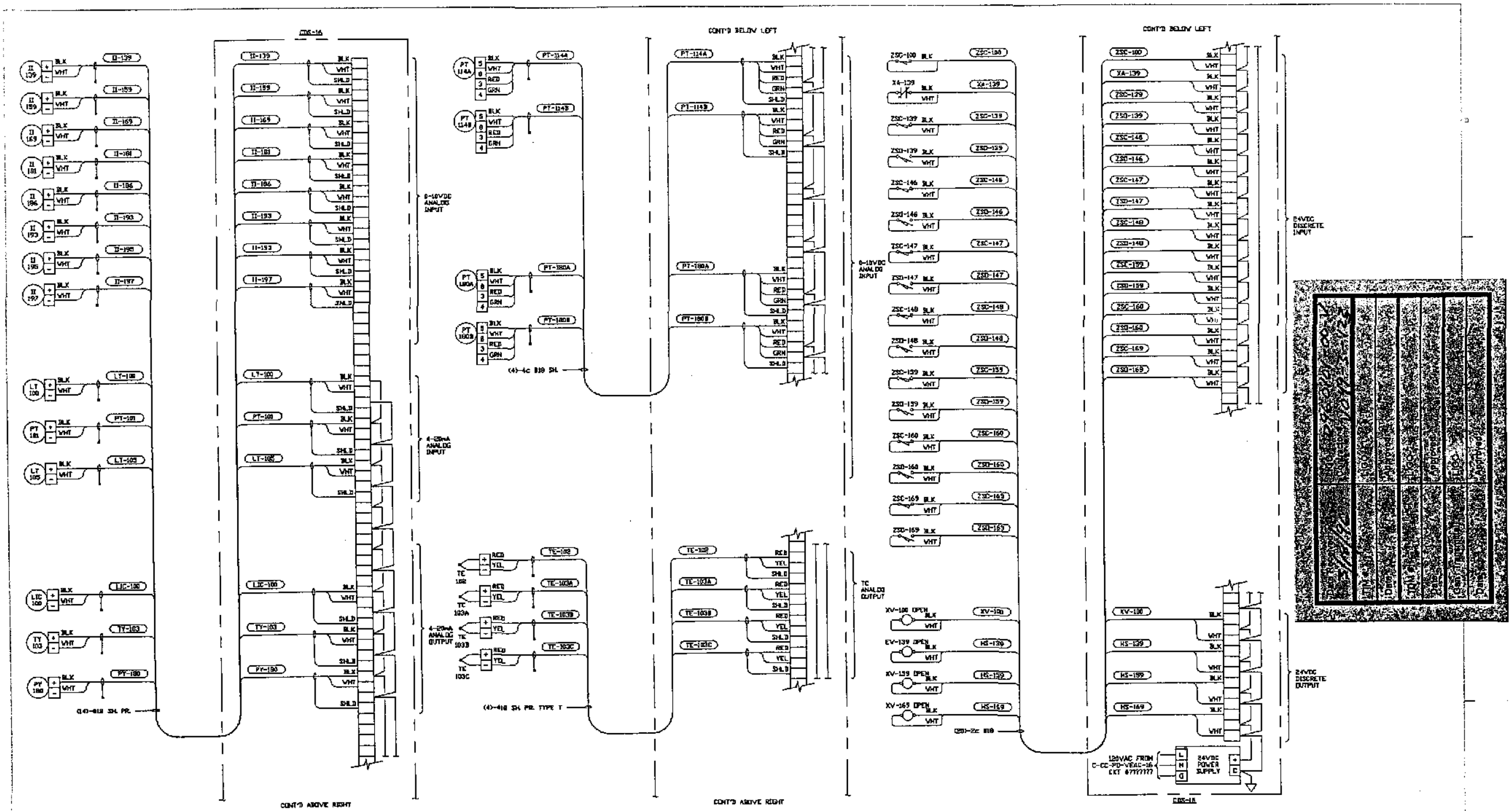

| | | | | | |
|---|---|---|---|---|---|
| DO NOT SCALE THIS DRAWING | P1 | PRELIMINARY | 03.06.96 | | |
| USED ON | REV | DESCRIPTION | DATE | | |

PROCESS SYSTEMS INTERNATIONAL INC.

CDS INTERFACE DIAGRAM
LIGO VACUUM EQUIPMENT
WASHINGTON SITE
CORNER STATION

SIZE B | DWG NO. V049-3-123 | REV P1

SCALE NONE | SHEET 1 OF 4



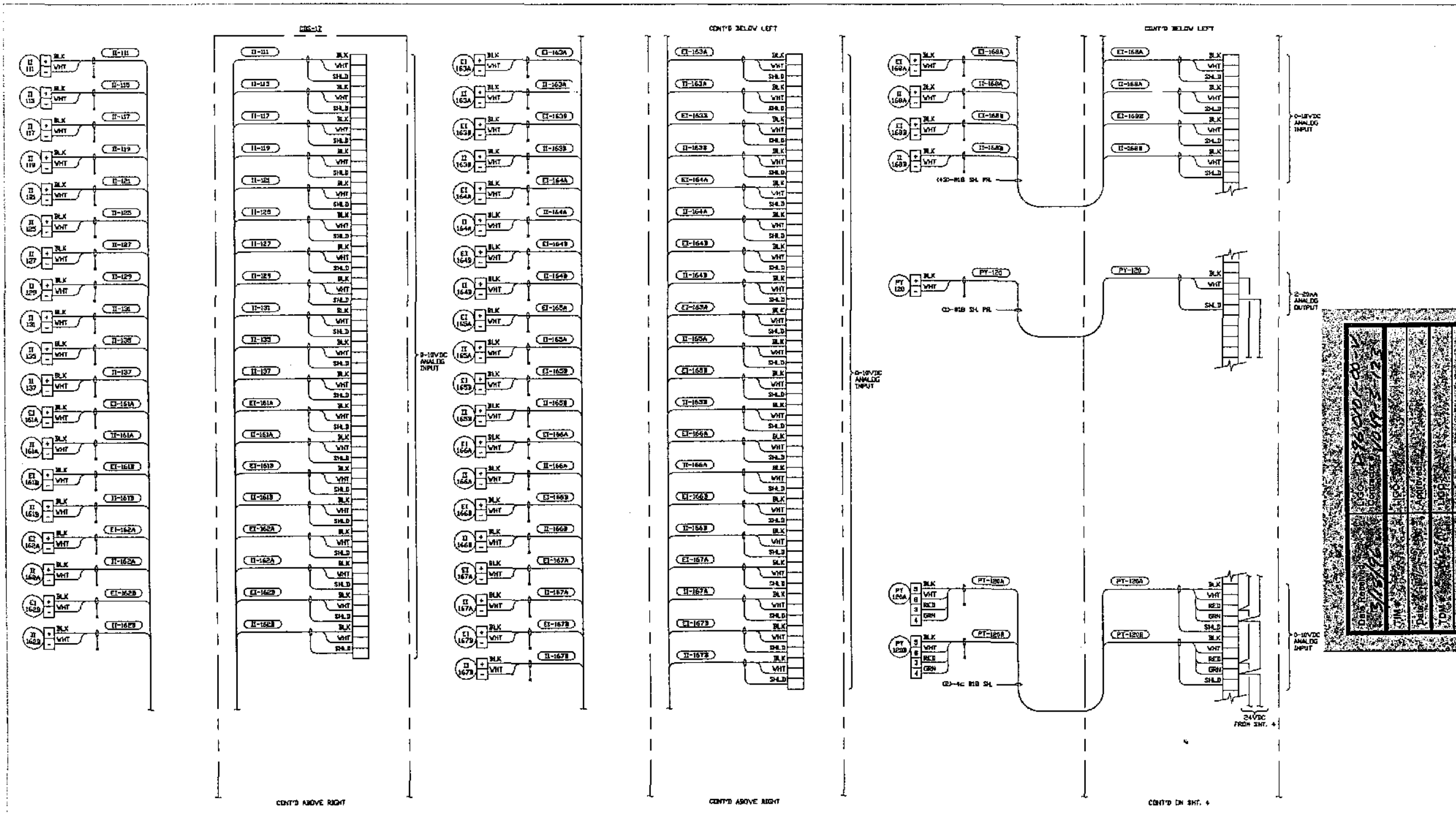

SEE SHEET 1 FOR REVISIONS

**PROCESS SYSTEMS INTERNATIONAL, INC.**

CDS INTERFACE DIAGRAM
LIGO VACUUM EQUIPMENT
WASHINGTON SITE
CORNER STATION

| CAD FILE | SIZE | DWG NO. | REV |
|---|---|---|---|
| | D | V049-2-123 | P1 |

SCALE NONE

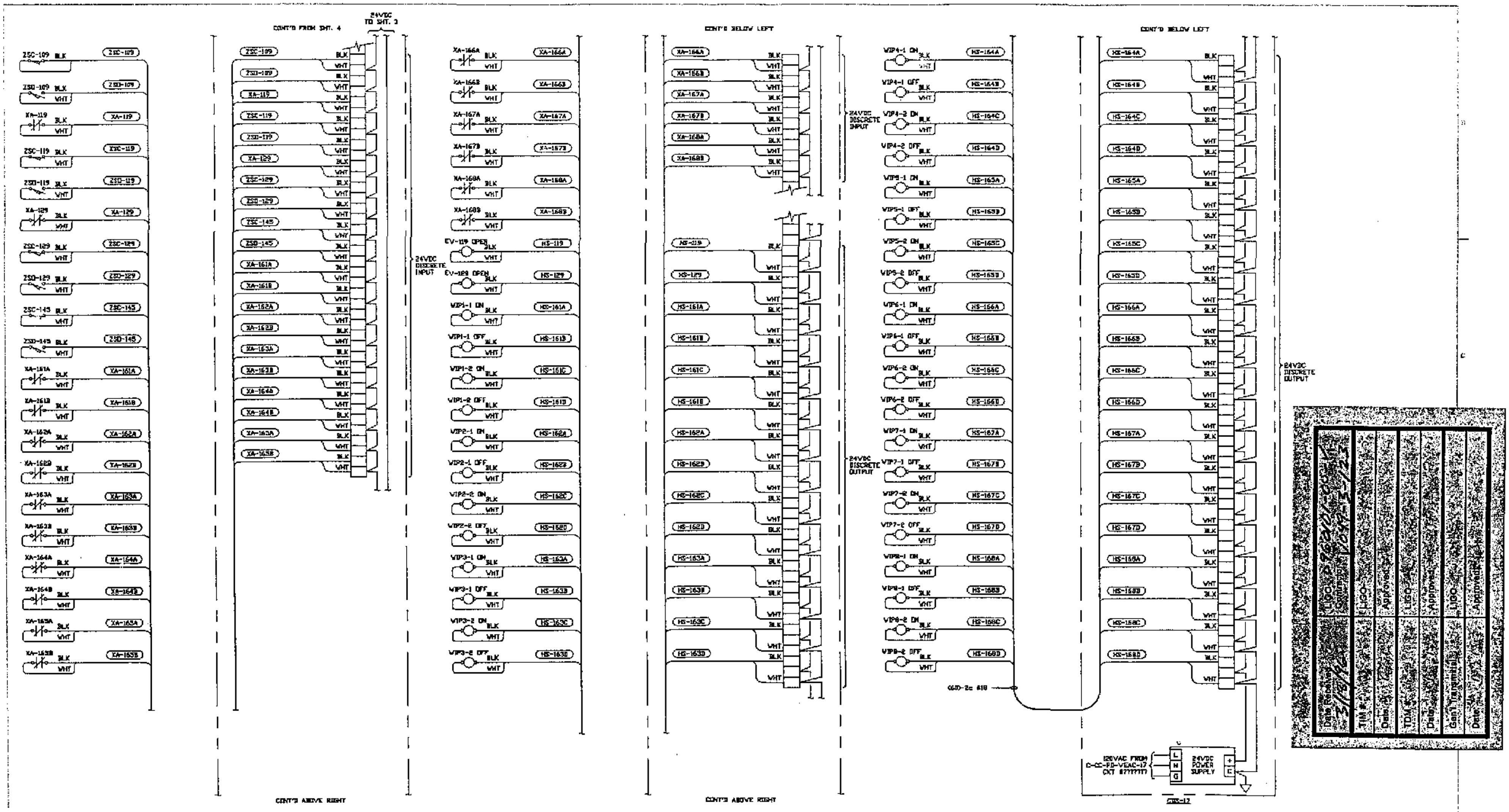



SEE SHEET 1 FOR REVISIONS

CDS INTERFACE DIAGRAM
LIGO VACUUM EQUIPMENT
WASHINGTON SITE
CORNER STATION

V049-3-123 P1

3 OF 4



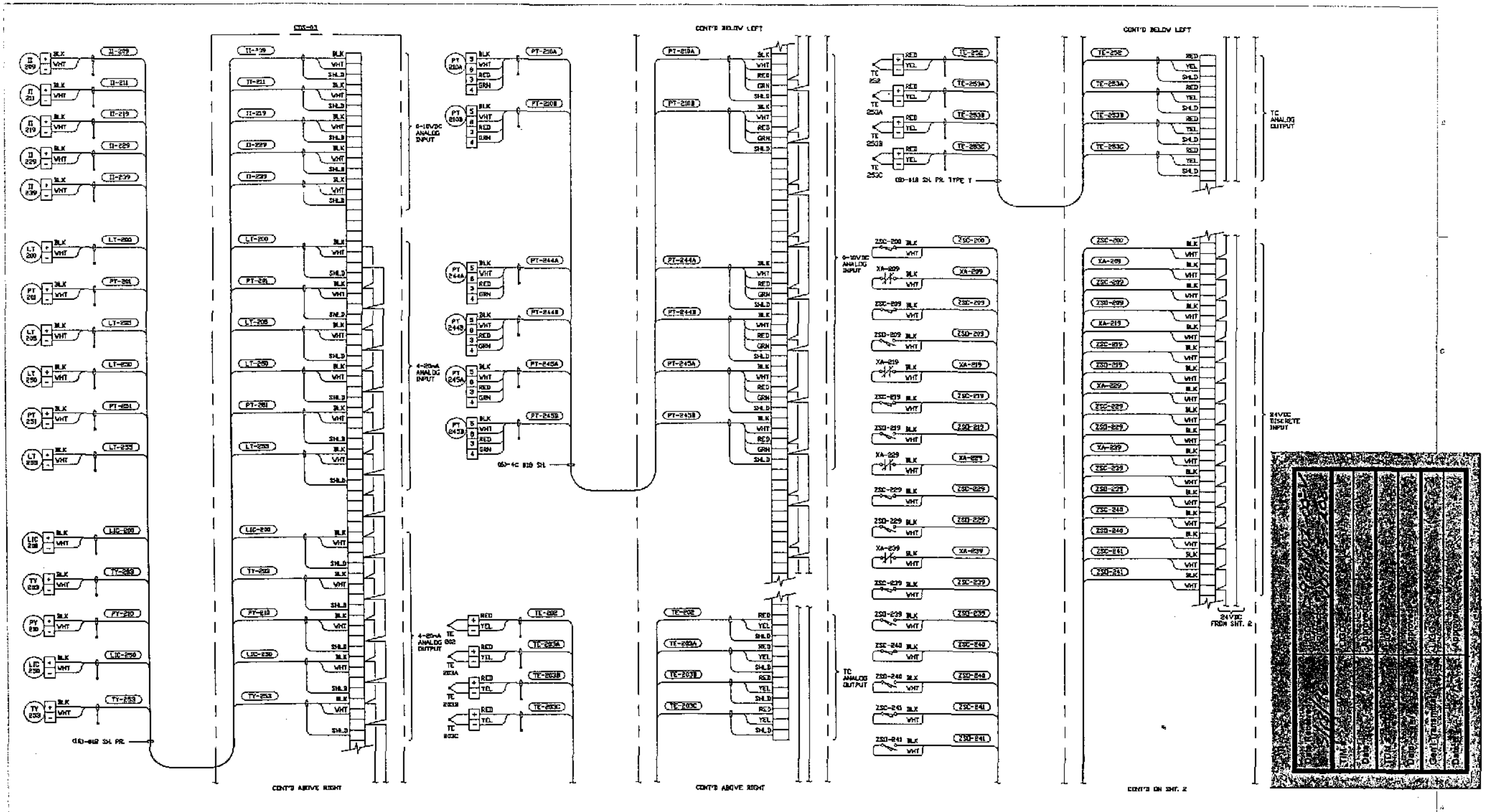

SEE SHEET 1 FOR REVISIONS

ACCESS SYSTEMS INTERNATIONAL INC.

CDS INTERFACE DIAGRAM
LIGO VACUUM EQUIPMENT
WASHINGTON SITE
CORNER STATION

V049-3-123 | P1

SCALE NONE




DO NOT SCALE THIS DRAWING

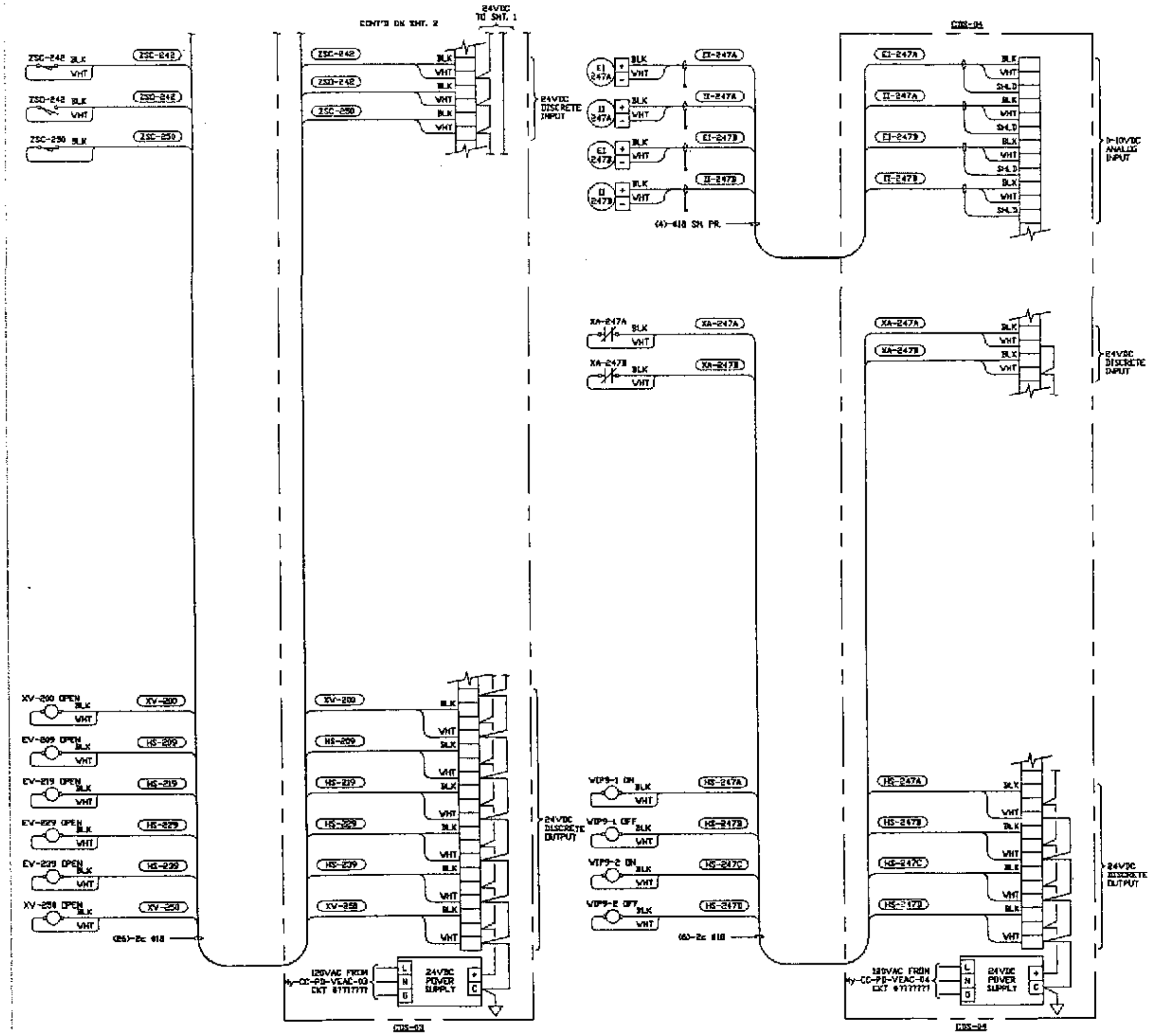
| REV | DESCRIPTION | DATE | DWN |
|---|---|---|---|
| P1 | PRELIMINARY | 03.06.96 | 0084 |

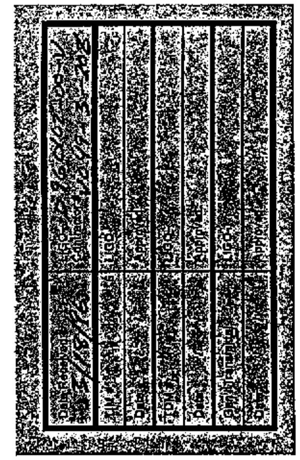
PROCESS SYSTEMS INTERNATIONAL INC.

CDS INTERFACE DIAGRAM
LIGO VACUUM EQUIPMENT
WASHINGTON SITE
LEFT MID STATION

SIZE: D | DWG NO: V049-3-208 | REV: P1

SCALE: NONE | SHEET: 1 OF 3



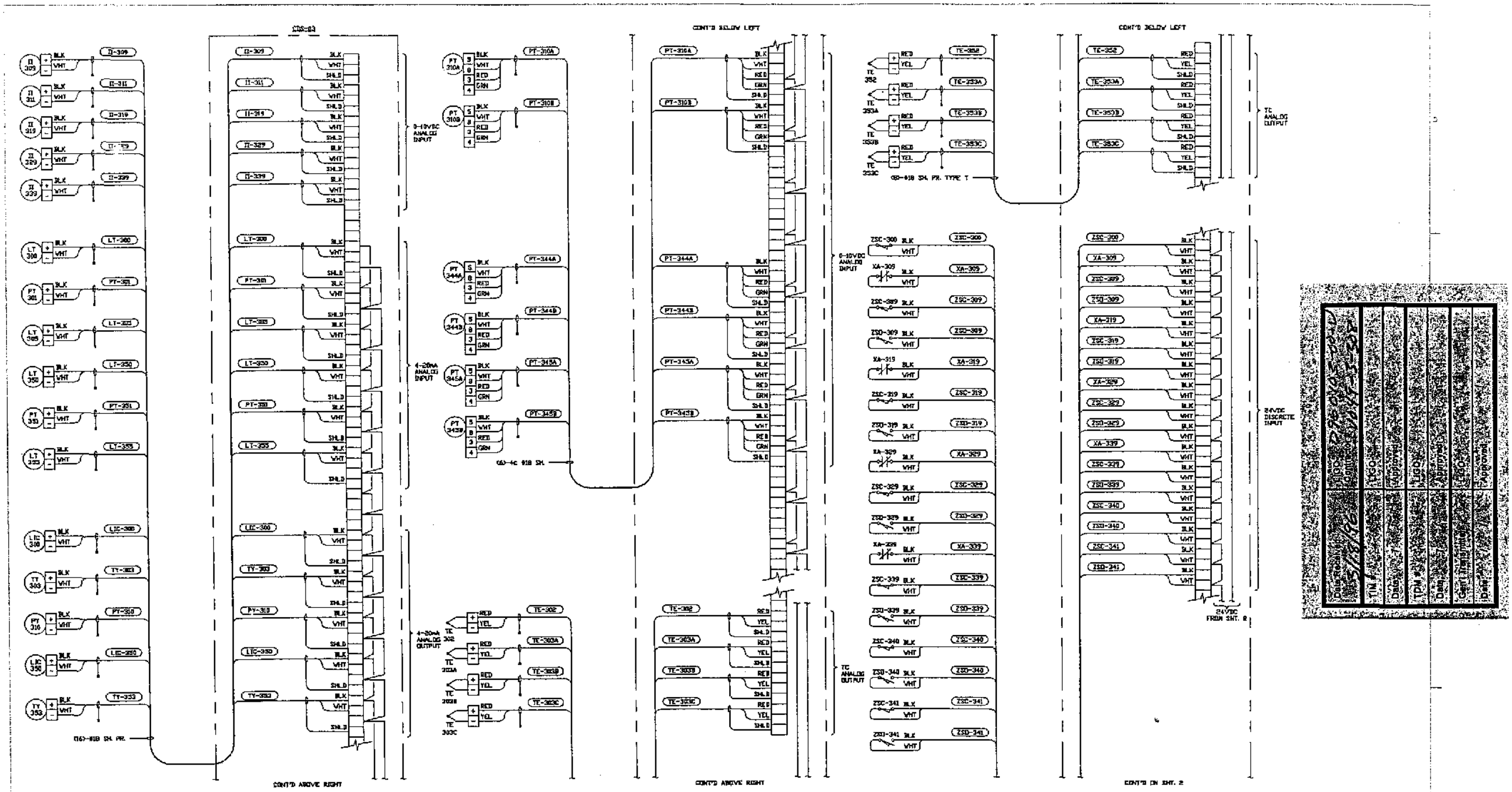
SEE SHEET 1 FOR REVISIONS

CDS INTERFACE DIAGRAM
LIGO VACUUM EQUIPMENT
WASHINGTON SITE
LEFT MID STATION

V049-3-208

P1

2 OF 2



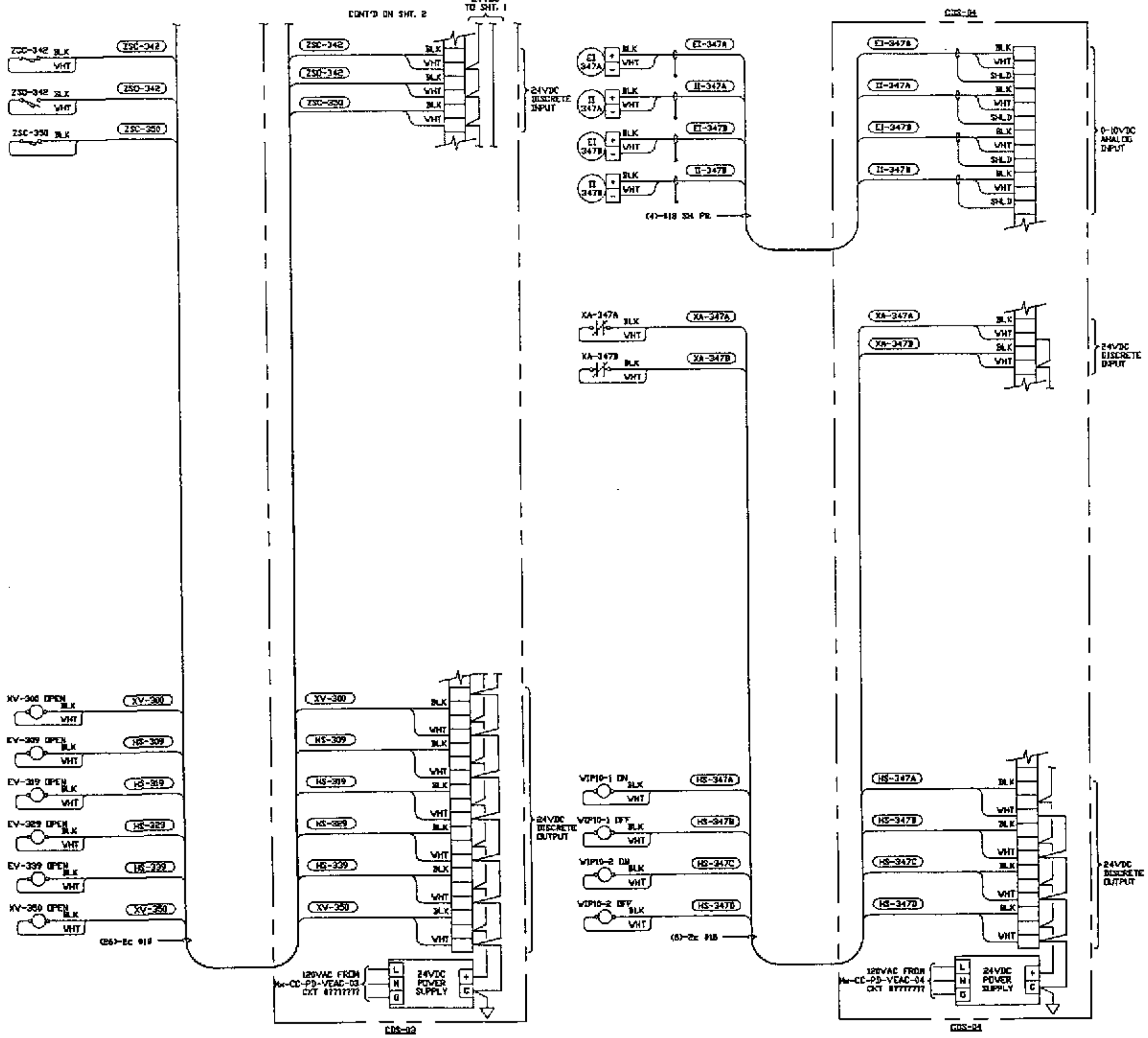

| | | |
|---|---|---|
| DO NOT SCALE THIS DRAWING | P1 | PRELIMINARY 02.06.96 0084 |
| USED ON | REV | DESCRIPTION |
| NEXT ASSY | | ISSUE DESCRIPTION |

REFERENCE DRAWINGS

CDS INTERFACE DIAGRAM
LIGO VACUUM EQUIPMENT
WASHINGTON SITE
RIGHT MID STATION

V049-3-003 REV P1

1 OF 2

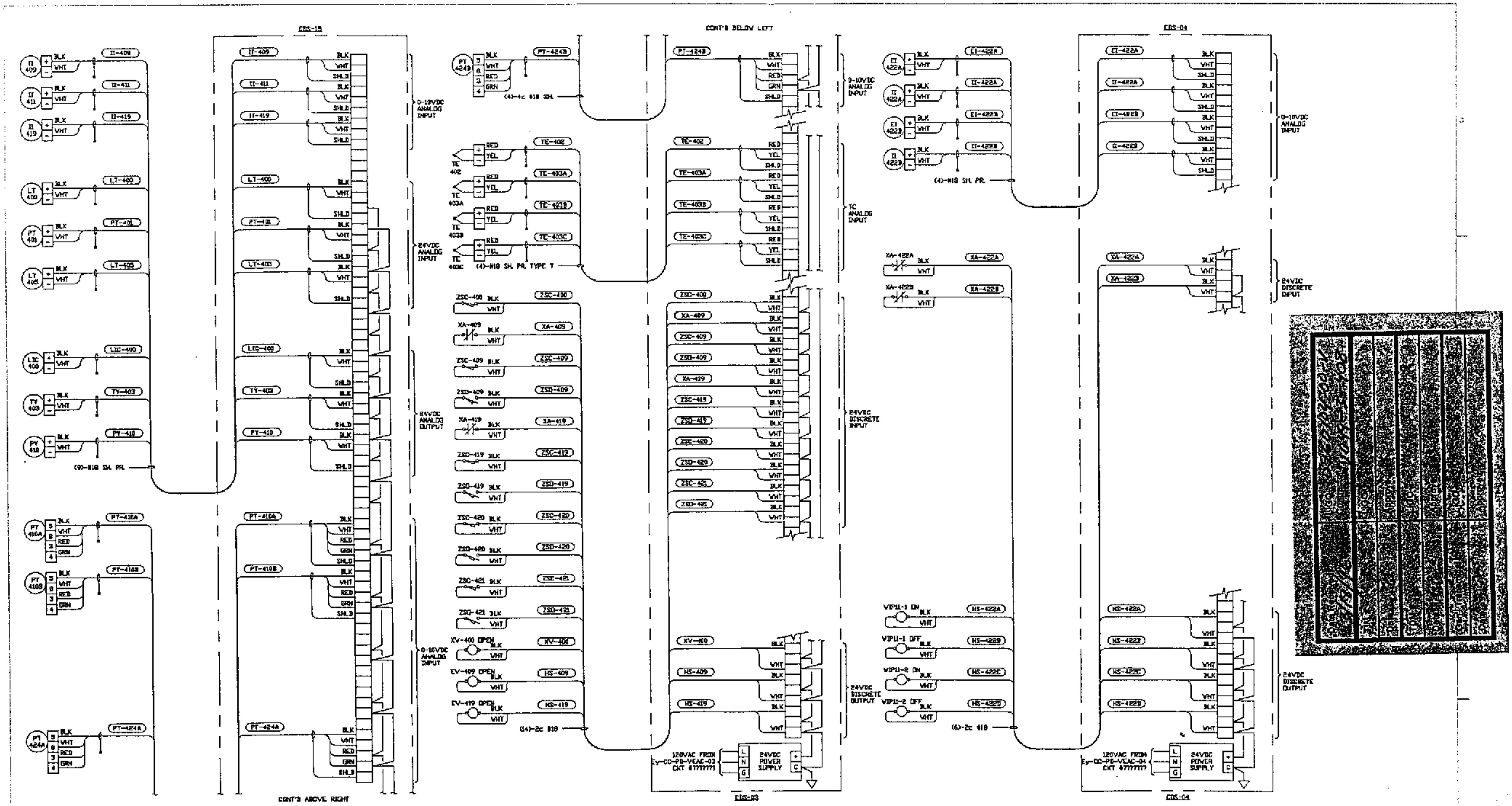



SEE SHEET 1 FOR REVISIONS

CDS INTERFACE DIAGRAM
LIGO VACUUM EQUIPMENT
WASHINGTON SITE
RIGHT MID STATION

V049-3-308

2 OF 2




DO NOT SCALE THIS DRAWING

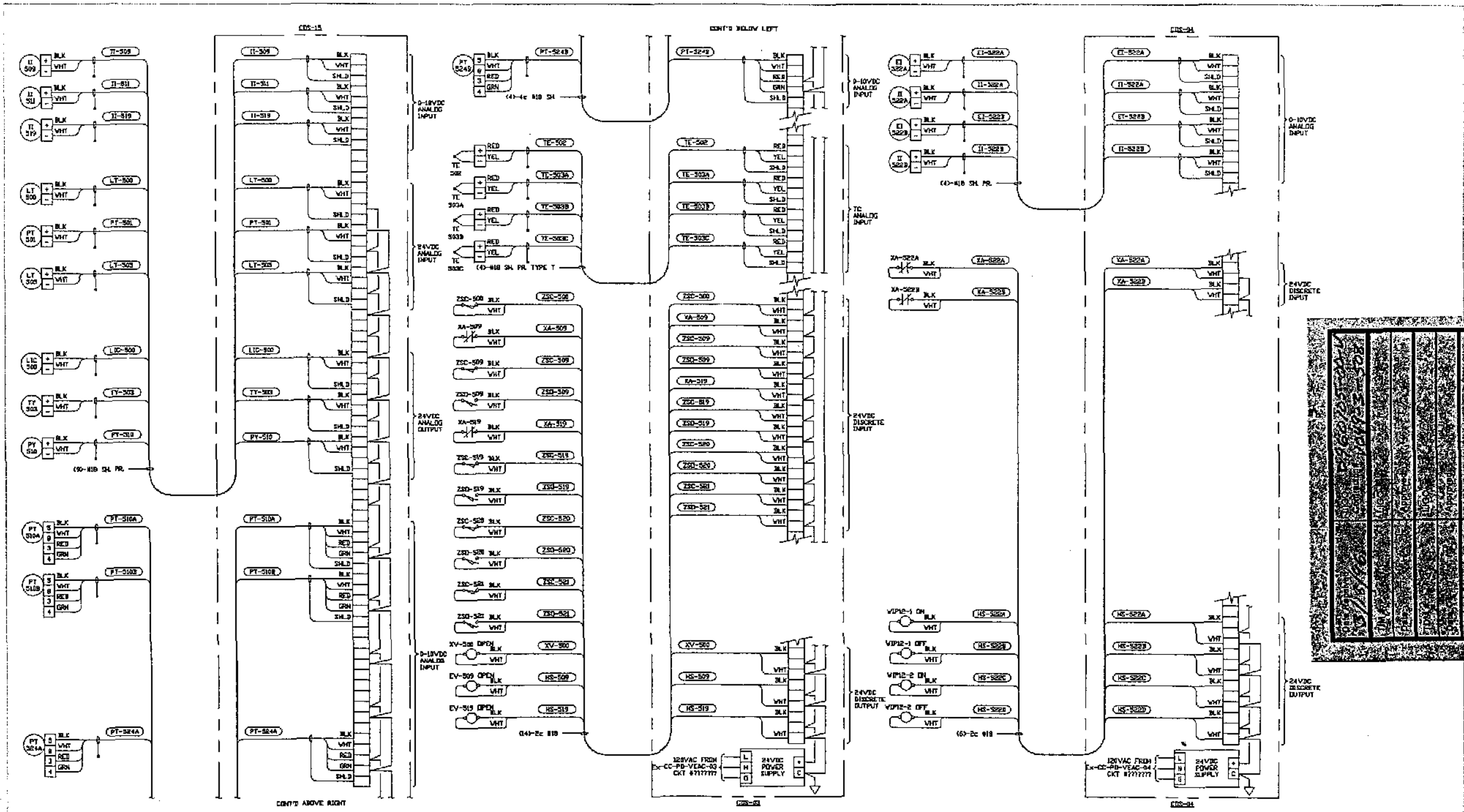
P1 PRELIMINARY

PROCESS SYSTEMS INTERNATIONAL INC.

CDS INTERFACE DIAGRAM
LIGO VACUUM EQUIPMENT
WASHINGTON SITE
LEFT END STATION

SIZE D — DWG. NO. V049-3-409 — REV. P1

SCALE NONE — SHEET 1 OF 1




DO NOT SCALE THIS DRAWING

| P1 | PRELIMINARY | 03.06.96 | 0094 |
|---|---|---|---|

PROCESS SYSTEMS INTERNATIONAL, INC.

CDS INTERFACE DIAGRAM
LIGO VACUUM EQUIPMENT
WASHINGTON SITE
RIGHT END STATION

V049-3-308

REV P1