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

Specification	LIGO-E950088-00 -E		10/3/95
Document Type	*Doc Number*	*Group-Id*	*Date*

Interface Control Document (ICD): Vacuum Equipment (VE) - Civil Construction (CC)

Title

D. Coyne

Authors(s)

This is an internal working note
of the LIGO Project
DRAFT

California Institute of Technology
LIGO Project - MS 102-33
Pasadena CA 91125
Phone (818) 395-2966
Fax (818) 304-9834
E-mail: info@ligo.caltech.edu
WWW: http://www.ligo.caltech.edu

ICD CHANGE RECORD			
REVISION	AUTHORITY	PAGES AFFECTED	ITEM(S) AFFECTED

Organization/Group	*Name*	*Signature*
Caltech		
Program Manager	Gary Sanders	
Integration and Systems Engineering	Albert Lazzarini	
Facilities	Mark Coles	
Vacuum Engineering	John Worden	
Civil Construction	Fred Asiri	
PSI		
Program Manager	?	
Parsons		
Program Manager	Tyler Jackson	

1 SCOPE

This document defines the interfaces between the Vacuum Equipment (VE) and the Civil Construction (CC). This ICD takes precedence over previous interface definitions between these systems.

1.1 Purpose

The purpose of this document is to define the interfaces required to insure compatibility between the Vacuum Equipment (VE) and the Civil Construction (CC) 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 contractors involved in the design and construction of the LIGO project; Caltech/MIT for integration and the detector system, Parsons for Architectural & Engineering of the Civil Construction (CC) package, PSI for Vacuum Equipment (VE) and Chicago Bridge & Iron (CB&I) for the Beam Tube (BT). Since a quadripartite ICD is impractical, the interfaces have been approached in a pairwise fashion. This ICD addresses only the interfaces between the VE and the CC. As a consequence, the complete interface definition for any system is the ensemble of (at most) three ICDs.

The interfaces between the Civil Construction (CC) and the Vacuum Equipment (VE) involve:

- electrical power and grounding
- structural and mechanical interfaces
- exclusion envelopes
- venting/exhausting
- coolant flow

The interfaces described in section 3.2 are organized at the top level by location in the following order:

- Corner Building: Laser Vacuum Equipment Area (LVEA)
- Corner Building: Mechanical Room
- Corner Building: LN2 Storage Tanks

- Mid-Station Building: Vacuum Equipment Area (VEA)
- Mid-Station Building: Mechanical Room
- Mid-Station Building: LN2 Storage Tanks
- End-Station Building: Vacuum Equipment Area (VEA)
- End-Station Building: Mechanical Room
- End-Station Building: LN2 Storage Tanks

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, then the definition is provided for both the Hanford, WA and the Livingston, LA sites; unless otherwise notes 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.

Table 2-1: Relevant Documents

DOCUMENT TITLE	DATE AND ID NUMBER
LIGO System Specification	pending; LIGO-E950084-00 -E
Design Configuration Control Document (DCCD)	*August 7, 1995; PAR-FDCM010AB1B03*
Vacuum Equipment Technical Specification, Exhibit I of the RFP	*January 23, 1995; Specification No. 1100003*
LIGO Master Schedule	Latest Revision
Interface Control Document (ICD): Detector - Vacuum Equipment	pending; LIGO-E95xxxx-00-E
Interface Control Document (ICD): Vacuum Equipment - Beam Tube	pending; LIGO-E95xxxx-00-E
Interface Control Document (ICD): Detector - Civil Construction	pending; LIGO-E95xxxx-00-E
Interface Control Document (ICD): Beam Tube - Civil Construction	pending; LIGO-E95xxxx-00-E

3 REQUIREMENTS FOR INTERFACE

3.1 General Requirements

3.1.1 Responsibilities

The LIGO program office is responsible for maintaining this ICD and for resolving interface conflicts which may arise between the involved subsystems and their contractors. The forum for interface conflict resolution is the Interface Control Working Group (ICWG). It is the responsibility of the contractors for each subsystem to 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. Contractors shall be responsible for updating the LIGO program office routinely (as called out in the contract), but also as soon as

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.

Table 2-1: Relevant Documents

DOCUMENT TITLE	DATE AND ID NUMBER
LIGO System Specification	pending; LIGO-E950084-00 -E
Design Configuration Control Document (DCCD)	*August 7, 1995; PAR-FDCM010AB1B03*
Vacuum Equipment Technical Specification, Exhibit I of the RFP	*January 23, 1995; Specification No. 1100003*
LIGO Master Schedule	Latest Revision
Interface Control Document (ICD): Detector - Vacuum Equipment	pending; LIGO-E95xxxx-00-E
Interface Control Document (ICD): Vacuum Equipment - Beam Tube	pending; LIGO-E95xxxx-00-E
Interface Control Document (ICD): Detector - Civil Construction	pending; LIGO-E95xxxx-00-E
Interface Control Document (ICD): Beam Tube - Civil Construction	pending; LIGO-E95xxxx-00-E

3 REQUIREMENTS FOR INTERFACE

3.1 General Requirements

3.1.1 Responsibilities

The LIGO program office is responsible for maintaining this ICD and for resolving interface conflicts which may arise between the involved subsystems and their contractors. The forum for interface conflict resolution is the Interface Control Working Group (ICWG). It is the responsibility of the contractors for each subsystem to 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. Contractors shall be responsible for updating the LIGO program office routinely (as called out in the contract), but also as soon as practical when a schedule issue which relates to an interface is involved.

3.1.3 Dimensioning

All interface drawings shall be dimensioned in metric units with english units in parentheses. LIGO civil construction is based upon english units.

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:

- z-axis aligned to the local vertical,
- x-axis aligned along the northwest beam tube centerline in Hanford, WA and along the south-west beam tube centerline in Livingston, LA and
- y-axis aligned along the southwest beam tube centerline in Hanford, WA and along the south-east beam tube centerline in Livingston, LA

3.2 Specific Requirements

The requirements are organized on the basis of where the interfaces occur; the Laser Vacuum Equipment Area (LVEA) in the corner building, the Mid-Station Vacuum Equipment Area (VEA) and the End-Station VEA.

3.2.1 Laser Vacuum Equipment Area (LVEA)

3.2.1.1 Mechanical Interfaces

3.2.1.1.1 Floor Surface Flatness & Finish

The VE in the LVEA rests upon a concrete slab which shall be a continuous smooth (class A) surface, flat relative to the local horizontal to within +/- 1/4 in. over the entire extent of the floor. The LVEA foundation slab shall be free of all obstructions and objects (such as drains, trenches, grooves, expansion joints, conduit openings, etc.) with the following exceptions:

(1) drains at the locations indicated in drawing LIGO-D95xxxx-a1.
(2) isolated LVEA floor slab gap as indicated in drawing LIGO-D95xxxx-a1.
(3) embedded electrical power conduit stubs at the locations defined in section 3.2.1.2.1.
(4) monuments for surveying within the LVEA as defined in section 3.2.1.1.4

The CC should permit placement of the VE chambers and connecting vacuum tubes, with their support structure, at any location on the LVEA foundation slab limited only by the above exceptions to the continuity and smoothness.

Surface treatment (e.g. paint or sealer), if any, on the LVEA floor shall be compatible with cement grout (used to support the VE chambers).

3.2.1.1.2 Mounting/Loads

The weight and differential pressure induced loads are within the capability of the LVEA foundation slab. The VE chambers and vacuum manifold support structure are to be attached to the building floor slabs via grouted anchor bolts and subsequently supported along the base by a grout layer; The anchor holes are to be diamond cored out of the steel reinforced, concrete slab at the time of installation by the VE contractor. The LVEA slab should not preclude this method of installation within the LVEA to a **TBD** embedment depth (e.g. by the shallow placement of embedded conduit). It is the VE contractor's responsibility to insure that the number, size, spacing and embedment depth of the anchors meet load capacity.

3.2.1.1.3 Location of the LVEA Foundation Slab and Walls Relative to the Beam Lines

The plane defined by the two BT arm centerlines is tipped and tilted (i.e. pitched and rolled) relative to the plane defined by the LVEA slab. The beam tube centerline is at 1.07 m above the BTE slab and the termination foundation slab at both of the beam tube entrances to the LVEA. The LVEA slab relative vertical dimensions are given in drawing LIGO-D95xxxx-a2 for both the Hanford and the Livingston sites. This drawing gives the following five dimensions:

- The height of the intersection of the projected beam tube centerlines (the vertex) above the LVEA foundation slab.
- The height of the termination slab above the LVEA slab for each of the two beam tube arms.

- The angle (with respect to the local horizontal) of each of the two projected beam tube centerlines.

Any three of these dimensions is sufficient to define the projected beam tube centerlines (given the constraint that they intersect at the vertex) and any one of the three linear dimensions is sufficient to define the LVEA foundation slab height (given the constraint that the floor is level). All the dimensions are self-consistent.

The placement of the building walls relative to the x- and y- beam centerlines shall be such that the minimum distances given in drawing LIGO-D95xxxx-a2 are achieved.

3.2.1.1.4 Survey Reference Monuments

Monuments are to be provided by the CC within the LVEA for use in positioning the VE. The location of these monuments is given in drawing LIGO-D95xxxx-a3.
TBD method/requirements

3.2.1.1.5 Liquid Nitrogen Supply Piping

Liquid nitrogen (LN2) is supplied to cryo-pumps in the LVEA via piping from two external storage tanks. The Civil Construction contractor shall provide two unobstructed feed-through holes of 300 mm (12 in.) dia. (**TBR**) as provision for the (VE contractor provided) LN2 pipes to traverse the building wall (outer sheathing, insulation and inner finished wall) at the locations indicated in drawing LIGO-D95xxxx-a4. The VE contractor shall install the LN2 supply pipes including seals at the outer wall as an insulation and moisture barrier and seals at the inner wall which is compatible with clean room practices.

3.2.1.1.6 Pipe Bridge

A pipe bridge used to carry VE plumbing from VE in the mechanical room to the VE vacuum manifold in the LVEA is to be provided by the CC, as indicated in drawing LIGO-D95xxxx-a5. The bridge crosses over the aisle-way between the LVEA wall and the vacuum manifold and extends into the LVEA perpendicularly from the wall between the Mechanical Room and the LVEA. The CC shall provide the method and materials for sealing the VE pipes which cross the bridge, at the wall portal consistent with clean room practices; the VE contractor shall seal the pipes during VE installation.

The CC pipe bridge shall be designed to:

- accommodate a pipe bundle with a cross-sectional envelope of 1829 mm (6'-0") wide by 762 mm (2'-6") high
- have provision for attaching pipe supports and hangers
- withstand the following total pipe loads:

TBD Table of Pipe Loads, including dead weight, seismic, dynamic pumping loads?, and pumping thrust?

3.2.1.2 Electrical Interfaces

3.2.1.2.1 Power/Ground Distribution

In addition to perimeter wall outlets within the LVEA, electrical power and "green wire" safety ground will be provided at circuit breaker panels by the CC at the locations along the interior walls of the LVEA, as indicated in drawing LIGO-D95xxxx-a6, for the purpose of routing power to the VE and the Detector equipment. The CC contractor shall also provide multiple embedded conduits from the wall near the breaker panels to the floor regions near the vacuum manifold, as indicated in drawing LIGO-D95xxxx-a6. The conduit stub shall extend to at least 300 mm (12 in) above the floor. The number of embedded conduit and their diameter(s) shall be sufficient for the required capacity (defined in section 3.2.1.2.1) of the VE and the LIGO Detector System with 100% spare capacity for pulling future power cables.

The distribution of electrical power and ground, along the vacuum manifold, for use by the VE as well as the LIGO Detector System, shall be via cable trays mounted beneath the VE per the Detector - VE Interface Control Document. The VE contractor shall provide the electrical power and grounding distribution from the circuit breaker panels through the embedded conduit and along the conduits or cable trays under the vacuum tubes and vacuum chambers.

3.2.1.2.2 Power Capacity

The voltages, power capacities and number of circuits required at each of the circuit breaker panel locations, referred to in section 3.2.1.2.1, with locations labeled in drawing LIGO-D95xxxx-a6, is as follows:

Figure 3-1: Power Required at Circuit Breaker/Distribution Panels in the LVEA

	120V, 1φ		*208Y/120V, 3φ*		*480Y/277V, 3φ*	
Location[a]	*No.*[b]	*KVA*	*No.*	*KVA*	*No.*	*KVA*
1	**TBD**					
2						
3						
4						
5						
6						
7						
8						
9						
10						

Figure 3-1: Power Required at Circuit Breaker/Distribution Panels in the LVEA

	120V, 1φ		*208Y/120V, 3φ*		*480Y/277V, 3φ*	
Location[a]	*No.*[b]	*KVA*	*No.*	*KVA*	*No.*	*KVA*
11						
12						
13						

a. Locations are indicated in drawing LIGO-D95xxxx-00-E

b. No. of separate circuits required.

3.2.1.2.3 Technical Ground

In accordance with the civil construction Design Configuration Control Document, there is a quiet technical ground separate from the "green wire" safety ground. It is **TBD** whether or not the VE interface to the technical ground.

3.2.2 Corner Building Mechanical Room

3.2.2.1 Mechanical Interfaces

3.2.2.1.1 Envelope

The space allocated for the placement of VE in the mechanical room of the corner building is a 6096 mm (20 ft.) by 18288 mm (60 ft.) area at the end of the mechanical room nearest to the vertex, as indicated in drawing LIGO-D95xxx-00-a5. This region abuts the pipe bridge between the LVEA and the mechanical room (as described in section 3.2.1.1.6).

3.2.2.1.2 Chilled Water

Cooling for some of the VE pumps in the LVEA is accomplished with a chilled fluid loop which dumps it's heat load into the CC chilled water (or water-glycol) system, either directly or indirectly (e.g. through an intermediate water-water heat exchanger). The derived requirements (for the purpose of VE pump cooling only) on the chilled water system provided by the Civil Construction contractor are as follows:

1) The inlet and outlet plant (chilled) water connections in the Mechanical Room of the Corner Building shall be 3 in. dia., threaded (**TBR**) pipe connections at valved ports. These ports must be accessible for the purpose of running supply and return pipes to the VE in the mechanical room.

2) Civil Construction chilled water supply temperature (under all load conditions) must be in the range of **TBD** C (**TBD** F) to **TBD** C (**TBD** F) at the supply port in the mechanical room.

3) The chiller system must be able to handle the heat load of the VE pump systems (in addition to other loads such as the HVAC). The maximum total heat load dumped directly into the chilled water by the VE is 20 kW (**TBR**).

4) The chilled water supply port provided for the VE shall be capable of delivering at least **TBD** gpm with no applied back pressure.

5) The chilled water return port provided for the VE shall be capable of taking TBD gpm with a pressure head of less than **TBD** psi.

6) The static pressure at the VE supply connection must be at least 60 psi (**TBR**) (under nominal building water demand), but no more than 125 psi (**TBR**) (with no other building water demands).

7) There are no special requirements on the CC chilled water quality used for cooling the VE. However, no additives (other than glycol) are to be used without consultation and approval.

The supply and return plumbing from the chilled water ports to the VE equipment in the mechanical room is the responsibility of the VE contractor. If the pressure losses in the VE coolant manifold or an intermediate water-water heat exchanger necessitate a boost pump, it shall be the VE contractor's responsibility to provide this pump.

3.2.2.2 Electrical Interfaces

3.2.2.2.1 Power/Ground Distribution

The CC shall provide a single circuit breaker/distribution panel within the allocated VE space (described in section 3.2.2.1.1) in the mechanical room as located in drawing LIGO-D95xxxx-00-a6.

3.2.2.2.2 Power Capacity

The voltages, power capacities and no. of circuits required at the VE circuit breaker/distribution panel in the mechanical room of the corner building is defined in Table 3-1 above.

3.2.3 Corner Building: LN2 Storage Tanks

3.2.3.1 Mechanical Interfaces

3.2.3.1.1 LN2 Storage Tank Foundation Slab

Two large, external Liquid Nitrogen (LN2) storage tanks (provided by the VE contractor) are required in the vicinity of the entrances of the two beam tube arms into the LVEA to supply LN2 to cryogenic vacuum pumps. Each of these LN2 tanks require a foundation slab, to be provided by the CC contractor. The required planform dimensions of the slab are shown in drawing LIGO-D95xxxx-00-a7.

The foundation slab, including cast-in-place anchor bolts, shall be designed by the CC contractor to support the tanks under applicable building codes and practices. The integrity of the LN2 tank shall be the responsibility of the VE contractor. The attachment bolt pattern is defined in drawing LIGO-D95xxxx-00-a7.

3.2.3.1.2 LN2 Storage Tank Foundation Slab Loads

The maximum loads required to be reacted by the foundation slab are indicated in drawing LIGO-D95xxxx-00-a7.

3.2.3.2 Electrical Interfaces

3.2.3.2.1 Power/Ground Distribution

TBD -- is there any external power outlets provided around the perimeter of the corner bldg?

3.2.3.2.2 Power Capacity

TBD

3.2.4 Mid-Station Building: Vacuum Equipment Area (VEA)

3.2.4.1 Mechanical Interfaces

3.2.4.1.1 Floor Surface Flatness & Finish

The VE in the VEA rests upon a concrete slab which shall be a continuous smooth (class A) surface, flat relative to the local horizontal to within +/- 1/4 in. over the entire extent of the floor. The VEA foundation slab shall be free of all obstructions and objects (such as drains, trenches, grooves, expansion joints, conduit openings, etc.) with the following exceptions:

(1) drains at the locations indicated in drawing LIGO-D95xxxx-a8.
(2) isolated LVEA floor slab gap as indicated in drawing LIGO-D95xxxx-a8.
(3) embedded electrical power conduit stubs at the locations defined in section 3.2.3.2.1.
(4) monuments for surveying within the VEA as defined in section 3.2.3.1.4

The CC should permit placement of the VE chambers and connecting vacuum tubes, with their support structure, at any location on the LVEA foundation slab limited only by the above exceptions to the continuity and smoothness.

Surface treatment (e.g. paint or sealer), if any, on the VEA floor shall be compatible with cement grout (used to support the VE chambers).

3.2.4.1.2 Mounting/Loads

The weight and differential pressure induced loads are within the capability of the VEA foundation slab. The VE chambers and vacuum manifold support structure are to be attached to the building floor slabs via grouted anchor bolts and subsequently supported along the base by a grout layer; The anchor holes are to be diamond cored out of the steel reinforced, concrete slab at the time of installation by the VE contractor. The VEA slab should not preclude this method of installation within the VEA to a **TBD** embedment depth (e.g. by shallow placement of embedded conduit). It is the VE contractor's responsibility to insure that the number, size, spacing and embedment depth of the anchors meet load capacity.

3.2.4.1.3 Location of the VEA Foundation Slab and Walls Relative to the Beam Line

The BT centerline is pitched relative to the plane defined by the VEA slab, which is nominally horizontal. The beam tube centerline is at 1.07 m above the BTE slab and the termination foundation slab at both of the beam tube entrances to the VEA. The VEA slab relative vertical dimensions are given in drawing LIGO-D95xxxx-a9 for both the Hanford and the Livingston sites. This drawing gives the following three dimensions:

- The height of the termination slab above the VEA slab for each of the two beam tube entrances.
- The angle (with respect to the local horizontal) of the projected beam tube centerline.

Any two of these dimensions is sufficient to define the projected beam tube centerline and to define the VEA foundation slab height (given the constraint that the floor is level). All the dimensions are self-consistent.

The placement of the building walls relative to the beam centerline shall be such that the minimum distances given in drawing LIGO-D95xxxx-a9 are achieved.

3.2.4.1.4 Survey Reference Monuments

Monuments are to be provided by the CC within the Hanford, WA mid-station VEA for use in positioning the VE. (This is not required for the Livingston, LA site.) The location of these monuments is given in drawing LIGO-D95xxxx-a10.
TBD method/requirements

3.2.4.1.5 Liquid Nitrogen Supply Piping

Liquid nitrogen (LN2) is supplied to cryo-pumps in the Mid-Station VEA (at Hanford, WA only) via piping from two external storage tanks (section 3.2.6). The Civil Construction contractor shall provide two unobstructed feed-through holes of 300 mm (12 in) diameter (**TBR**) as provision for the (VE contractor provided) LN2 pipe to traverse the building wall (outer sheathing, insulation and inner finished wall) at the locations indicated in drawing LIGO-D95xxxx-a11. The VE contractor shall install the LN2 supply pipes including seals at the outer wall as an insulation and moisture barrier and seals at the inner wall which is compatible with clean room practices.

3.2.4.1.6 Pipe Bridge

A pipe bridge used to carry VE plumbing from VE in the mechanical room to the VE vacuum tube in the VEA is to be provided by the CC, as indicated in drawing LIGO-D95xxxx-a12. The bridge crosses over the aisle-way between the VEA wall and the vacuum tube and extends into the VEA perpendicularly from the wall between the Mechanical Room and the VEA. The CC shall provide the method and materials for sealing the VE pipes which cross the bridge, at the wall portal consistent with clean room practices; the VE contractor shall seal the pipes during VE installation.

The CC pipe bridge shall be designed to:

- accommodate a pipe bundle with a cross-sectional envelope of 1829 mm (6'-0") wide by 762 mm (2'-6") high
- have provision for attaching pipe supports and hangers
- withstand the following total pipe loads:

TBD Table of Pipe Loads, including dead weight, seismic, dynamic pumping loads?, and pumping thrust?

3.2.4.2 Electrical Interfaces

3.2.4.2.1 Power/Ground Distribution

Electrical power and "green wire" safety ground will be provided at a single breaker panel by the CC on the interior wall of the VEA at the location indicated in drawing LIGO-D95xxxx-a13. The VE contractor shall run conduit from the distribution panel (via accessible knock-outs) to the pipe bridge and across to conduit or cable trays running under the vacuum tube for distribution to the VE as well as the Detector equipment. The capacity of the circuit breaker/distribution panel (in number of breakers and conduit knock-outs and their diameters) shall be sufficient for the required capacity (see section 3.2.4.2.2) of the VE and the LIGO Detector System with 100% spare capacity.

The distribution of electrical power and ground, along the vacuum tube, for use by the VE as well as the LIGO Detector System, shall be via cable trays or conduit mounted beneath the VE per the Detector - VE Interface Control Document. The VE contractor shall provide the electrical power and grounding distribution from the circuit breaker/distribution panel, over the bridge and along the conduits or cable trays under the vacuum tubes and vacuum chambers to termination points defined in the Detector - VE ICD.

3.2.4.2.2 Power Capacity

The voltages, current capacities and total power required at for the VE and Detector equipment at the circuit breaker panel location defined in section 3.2.4.2.1 is given in drawing LIGO-D95xxxx-a13.

3.2.4.2.3 Technical Ground

In accordance with the civil construction Design Configuration Control Document, there is a quiet technical ground separate from the "green wire" safety ground. It is **TBD** whether or not the VE interface to the technical ground.

3.2.5 Mid-Station Building Mechanical Room

3.2.5.1 Mechanical Interfaces

3.2.5.1.1 Envelope

The space allocated for the placement of VE in the mechanical room of the mid-station building is a 6096 mm (20 ft.) by 1829 mm (6 ft.) area at the end of the mechanical room nearest to the VEA, as indicated in drawing LIGO-D95xxx-00-a12. This region abuts the pipe bridge between the LVEA and the mechanical room (as described in section 3.2.4.1.6).

3.2.5.1.2 Chilled Water

Cooling for some of the VE pumps in the VEA is accomplished with a chilled fluid loop which dumps it's heat load into the CC chilled water (or water-glycol) system, either directly or indirectly (e.g. through an intermediate water-water heat exchanger). The derived requirements (for the purpose of VE pump cooling <u>only</u>) on the chilled water system provided by the Civil Construction contractor are as follows:

1) The inlet and outlet plant (chilled) water connections in the Mechanical Room shall be 3 in. dia., threaded (**TBR**) pipe connections at valved ports. These ports must be accessible for the purpose of running supply and return pipes to the VE in the mechanical room.
2) Civil Construction chilled water supply temperature (under all load conditions) must be in the range of **TBD** C (TBD F) to **TBD** C (TBD F) at the supply port in the mechanical room.
3) The chiller system must be able to handle the heat load of the VE pump systems (in addition to other loads such as the HVAC). The maximum total heat load dumped directly into the chilled water by the VE is **TBD** kW.
4) The chilled water supply port provided for the VE shall be capable of delivering at least **TBD** gpm with no applied back pressure.
5) The chilled water return port provided for the VE shall be capable of taking **TBD** gpm with a pressure head of *less than* ***TBD** psi.*
6) The static pressure at the VE supply connection must be at least 60 psi (**TBR**) (under nominal building water demand), but no more than 125 psi (**TBR**) (with no other building water demands).
7) There are no special requirements on the CC chilled water quality used for cooling the VE. However, no additives (other than glycol) are to be used without consultation and approval.

The supply and return plumbing from the chilled water ports to the VE equipment in the mechanical room is the responsibility of the VE contractor. If the pressure losses in the VE coolant manifold or an intermediate water-water heat exchanger necessitate a boost pump, it shall be the VE contractor's responsibility to provide this pump.

3.2.5.2 Electrical Interfaces

3.2.5.2.1 Power/Ground Distribution

The CC shall provide a single circuit breaker/distribution panel within the allocated VE space (described in section 3.2.5.1.1) in the mechanical room as located in drawing LIGO-D95xxxx-00-a13.

3.2.5.2.2 Power Capacity

The voltages, power capacities and no. of circuits required at the VE circuit breaker/distribution panel in the mechanical room of the mid-station building is defined in drawing LIGO-D95xxxx-00-a13.

3.2.6 Mid-Station Building: LN2 Storage Tanks

3.2.6.1 Mechanical Interfaces

3.2.6.1.1 LN2 Storage Tank Foundation Slab

At the Hanford, WA site only: Two large, external Liquid Nitrogen (LN2) storage tanks (provided by the VE contractor) are required in the vicinity of the entrances of the two beam tube arms into the VEA to supply LN2 to cryogenic vacuum pumps. Each of these LN2 tanks require a foundation slab, to be provided by the CC contractor. The required planform dimensions of the slab are shown in drawing LIGO-D95xxxx-00-a14.

The foundation slab, including cast-in-place anchor bolts, shall be designed by the CC contractor to support the tanks under applicable building codes and practices. The integrity of the LN2 tank shall be the responsibility of the VE contractor. The attachment bolt pattern is defined in drawing LIGO-D95xxxx-00-a14.

3.2.6.1.2 LN2 Storage Tank Foundation Slab Loads

At the Hanford, WA site only: The maximum loads required to be reacted by the foundation slab are indicated in drawing LIGO-D95xxxx-00-a14.

3.2.6.2 Electrical Interfaces

3.2.6.2.1 Power/Ground Distribution

At the Hanford, WA site only: **TBD** -- is there any external power outlets provided around the perimeter of the corner bldg?

3.2.6.2.2 Power Capacity

At the Hanford, WA site only: **TBD**

3.2.7 End-Station Building: Vacuum Equipment Area (VEA)

3.2.7.1 Mechanical Interfaces

3.2.7.1.1 Floor Surface Flatness & Finish

The VE in the VEA rests upon a concrete slab which shall be a continuous smooth (class A) surface, flat relative to the local horizontal to within +/- 1/4 in. over the entire extent of the floor. The VEA foundation slab shall be free of all obstructions and objects (such as drains, trenches, grooves, expansion joints, conduit openings, etc.) with the following exceptions:

(1) drains at the locations indicated in drawing LIGO-D95xxxx-a15.
(2) isolated LVEA floor slab gap as indicated in drawing LIGO-D95xxxx-a15.
(3) embedded electrical power conduit stubs at the locations defined in section 3.2.3.2.1.
(4) monuments for surveying within the VEA as defined in section 3.2.3.1.4

The CC should permit placement of the VE chambers and connecting vacuum tubes, with their support structure, at any location on the LVEA foundation slab limited only by the above exceptions to the continuity and smoothness.

Surface treatment (e.g. paint or sealer), if any, on the VEA floor shall be compatible with cement grout (used to support the VE chambers).

3.2.7.1.2 Mounting/Loads

The weight and differential pressure induced loads are within the capability of the VEA foundation slab. The VE chambers and vacuum manifold support structure are to be attached to the building floor slabs via grouted anchor bolts and subsequently supported along the base by a grout layer; The anchor holes are to be diamond cored out of the steel reinforced, concrete slab at the time of installation by the VE contractor. The VEA slab should not preclude this method of installation within the VEA to a **TBD** embedment depth (e.g. by shallow placement of embedded conduit). It is the VE contractor's responsibility to insure that the number, size, spacing and embedment depth of the anchors meet load capacity.

3.2.7.1.3 Location of the VEA Foundation Slab and Walls Relative to the Beam Line

The BT centerline is pitched relative to the plane defined by the VEA slab, which is nominally horizontal. The beam tube centerline is at 1.07 m above the BTE slab and the termination foundation slab at the beam tube entrance to the VEA. The VEA slab relative vertical dimensions are given in drawing LIGO-D95xxxx-a16 for both the Hanford and the Livingston sites. This drawing gives the following three dimensions:

- The height of the termination slab above the VEA slab for each of the two beam tube entrances.
- The angle (with respect to the local horizontal) of the projected beam tube centerline.

Any two of these dimensions is sufficient to define the projected beam tube centerline and to define the VEA foundation slab height (given the constraint that the floor is level). All the dimensions are self-consistent.

The placement of the building walls relative to the beam centerline shall be such that the minimum distances given in drawing LIGO-D95xxxx-a16 are achieved.

3.2.7.1.4 Survey Reference Monuments

Monuments are to be provided by the CC within the end-station VEA for use in positioning the VE. The location of these monuments is given in drawing LIGO-D95xxxx-a17.
TBD method/requirements

3.2.7.1.5 Liquid Nitrogen Supply Piping

Liquid nitrogen (LN2) is supplied to cryo-pumps in the End-Station VEA via piping from an external storage tank. The Civil Construction contractor shall provide an unobstructed feed-through hole of 300 mm (12 in) diameter (**TBR**) as provision for the (VE contractor provided) LN2 pipe to traverse the building wall (outer sheathing, insulation and inner finished wall) at the location indicated in drawing LIGO-D95xxxx-a18. The VE contractor shall install the LN2 supply pipes including seals at the outer wall as an insulation and moisture barrier and seals at the inner wall which is compatible with clean room practices.

3.2.7.1.6 Pipe Bridge

A pipe bridge used to carry VE plumbing from VE in the mechanical room to the VE vacuum tube in the VEA is to be provided by the CC, as indicated in drawing LIGO-D95xxxx-a19. The bridge crosses over the aisle-way between the VEA wall and the vacuum tube and extends into the VEA perpendicularly from the wall between the Mechanical Room and the VEA. The CC shall provide the method and materials for sealing the VE pipes which cross the bridge, at the wall portal consistent with clean room practices; the VE contractor shall seal the pipes during VE installation.

The CC pipe bridge shall be designed to:

- accommodate a pipe bundle with a cross-sectional envelope of 1829 mm (6'-0") wide by 762 mm (2'-6") high
- have provision for attaching pipe supports and hangers
- withstand the following total pipe loads:

TBD Table of Pipe Loads, including dead weight, seismic, dynamic pumping loads?, and pumping thrust?

3.2.7.2 Electrical Interfaces

3.2.7.2.1 Power/Ground Distribution

Electrical power and "green wire" safety ground will be provided at a single breaker panel by the CC on the interior wall of the VEA at the location indicated in drawing LIGO-D95xxxx-a20. The VE contractor shall run conduit from the distribution panel (via accessible knock-outs) to the pipe bridge and across to conduit or cable trays running under the vacuum tube for distribution to the VE as well as the Detector equipment. The capacity of the circuit breaker/distribution panel (in number of breakers and conduit knock-outs and their diameters) shall be sufficient for the required capacity (see section 3.2.7.2.2) of the VE and the LIGO Detector System with 100% spare capacity.

The distribution of electrical power and ground, along the vacuum tube, for use by the VE as well as the LIGO Detector System, shall be via cable trays or conduit mounted beneath the VE per the Detector - VE Interface Control Document. The VE contractor shall provide the electrical power and grounding distribution from the circuit breaker/distribution panel, over the bridge and along the conduits or cable trays under the vacuum tubes and vacuum chambers to termination points defined in the Detector - VE ICD.

3.2.7.2.2 Power Capacity

The voltages, current capacities and total power required at for the VE and Detector equipment at the circuit breaker panel location defined in section 3.2.7.2.1 is given in drawing LIGO-D95xxxx-a20.

3.2.7.2.3 Technical Ground

In accordance with the civil construction Design Configuration Control Document, there is a quiet technical ground separate from the "green wire" safety ground. It is **TBD** whether or not the VE interface to the technical ground.

3.2.8 End-Station Building Mechanical Room

3.2.8.1 Mechanical Interfaces

3.2.8.1.1 Envelope

The space allocated for the placement of VE in the mechanical room of the end-station building is a 6096 mm (20 ft.) by 1829 mm (6 ft.) area at the end of the mechanical room nearest to the VEA, as indicated in drawing LIGO-D95xxx-00-a19. This region abuts the pipe bridge between the LVEA and the mechanical room (as described in section 3.2.7.1.6).

3.2.8.1.2 Chilled Water

Cooling for some of the VE pumps in the VEA is accomplished with a chilled fluid loop which dumps it's heat load into the CC chilled water (or water-glycol) system, either directly or indirectly (e.g. through an intermediate water-water heat exchanger). The derived requirements (for the purpose of VE pump cooling <u>only</u>) on the chilled water system provided by the Civil Construction contractor are as follows:

1) The inlet and outlet plant (chilled) water connections in the Mechanical Room shall be 3 in. dia., threaded (**TBR**) pipe connections at valved ports. These ports must be accessible for the purpose of running supply and return pipes to the VE in the mechanical room.

2) Civil Construction chilled water supply temperature (under all load conditions) must be in the range of **TBD** C (TBD F) to **TBD** C (TBD F) at the supply port in the mechanical room.

3) The chiller system must be able to handle the heat load of the VE pump systems (in addition to other loads such as the HVAC). The maximum total heat load dumped directly into the chilled water by the VE is **TBD** kW.

4) The chilled water supply port provided for the VE shall be capable of delivering at least **TBD** gpm with no applied back pressure.

5) The chilled water return port provided for the VE shall be capable of taking **TBD** gpm with a pressure head of less than **TBD** psi.

6) The static pressure at the VE supply connection must be at least 60 psi (**TBR**) (under nominal building water demand), but no more than 125 psi (**TBR**) (with no other building water demands).

7) There are no special requirements on the CC chilled water quality used for cooling the VE. However, no additives (other than glycol) are to be used without consultation and approval.

The supply and return plumbing from the chilled water ports to the VE equipment in the mechanical room is the responsibility of the VE contractor. If the pressure losses in the VE coolant manifold or an intermediate water-water heat exchanger necessitate a boost pump, it shall be the VE contractor's responsibility to provide this pump.

3.2.8.2 Electrical Interfaces

3.2.8.2.1 Power/Ground Distribution

The CC shall provide a single circuit breaker/distribution panel within the allocated VE space (described in section 3.2.5.1.1) in the mechanical room as located in drawing LIGO-D95xxxx-00-a20.

3.2.8.2.2 Power Capacity

The voltages, power capacities and no. of circuits required at the VE circuit breaker/distribution panel in the mechanical room of the mid-station building is defined in drawing LIGO-D95xxxx-00-a20.

3.2.9 End-Station Building: LN2 Storage Tanks

3.2.9.1 Mechanical Interfaces

3.2.9.1.1 LN2 Storage Tank Foundation Slab

A large, external Liquid Nitrogen (LN2) storage tank (provided by the VE contractor) is required in the vicinity of the entrance of the beam tube into the VEA to supply LN2 to cryogenic vacuum pump. This LN2 tank requires a foundation slab, to be provided by the CC contractor. The required planform dimensions of the slab are shown in drawing LIGO-D95xxxx-00-a21.

The foundation slab, including cast-in-place anchor bolts, shall be designed by the CC contractor to support the tanks under applicable building codes and practices. The integrity of the LN2 tank shall be the responsibility of the VE contractor. The attachment bolt pattern is defined in drawing LIGO-D95xxxx-00-a21.

3.2.9.1.2 LN2 Storage Tank Foundation Slab Loads

The maximum loads required to be reacted by the foundation slab are indicated in drawing LIGO-D95xxxx-00-a21.

3.2.9.2 Electrical Interfaces

3.2.9.2.1 Power/Ground Distribution

TBD -- is there any external power outlets provided around the perimeter of the corner bldg?

3.2.9.2.2 Power Capacity

TBD

4 INTERFACE VERIFICATION

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

- Test
  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*	*Inspection*	*Analysis*	*Similarity*

Table 4-1: Verification Matrix

Para.	*Requirement Title*	*Test*	*Inspection*	*Analysis*	*Similarity*

5 NOMENCLATURE AND ACRONYMS

to be completed

6 DRAWINGS:

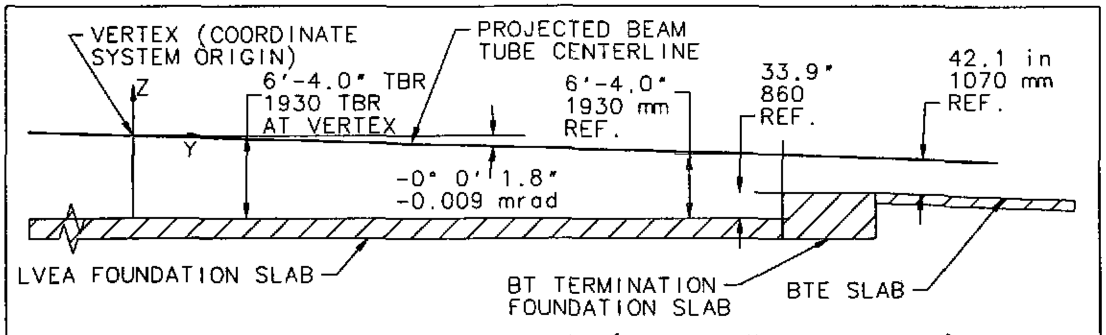
LIGO Dwg	*Title*	*No. of Sheets*	*Completed?*
D95xxxx-00-a1	LVEA Foundation Surface Features: Drains, Isolation Gap	1	N
D95xxxx-00-a2	LVEA Slab Relative to Beam Line -- Hanford, WA and Livingston, LA	2	Y
D95xxxx-00-a3	LVEA Survey Reference Monuments	1	N
D95xxxx-00-a4	Corner Station LN2 Supply Piping Interface	1	N
D95xxxx-00-a5	LVEA - Mechanical Room Pipe Bridge & VE Envelope	1	Y
D95xxxx-00-a6	LVEA Electrical Power Interface	1	Y
D95xxxx-00-a7	Corner Station LN2 Storage Tank Foundation Slab Dimensions, Bolt Pattern and Loads	1	N
D95xxxx-00-a8	Mid-Station VEA Foundation Surface Features: Drains, Isolation Gap	1	N
D95xxxx-00-a9	Mid-Station VEA Slab Relative to Beam Line -- Hanford, WA and Livingston, LA	2	N
D95xxxx-00-a10	Mid-Station VEA Survey Reference Monuments	1	N
D95xxxx-00-a11	Mid-Station LN2 Supply Piping Interface	1	N
D95xxxx-00-a12	Mid-Station VEA - Mechanical Room Pipe Bridge & VE Envelope	1	N
D95xxxx-00-a13	Mid-Station VEA Electrical Power Interface	1	N
D95xxxx-00-a14	Mid-Station LN2 Storage Tank Foundation Slab Dimensions, Bolt Pattern and Loads	1	N
D95xxxx-00-a15	End-Station VEA Foundation Surface Features: Drains, Isolation Gap	1	N
D95xxxx-00-a16	End-Station VEA Slab Relative to Beam Line -- Hanford, WA and Livingston, LA	1	N
D95xxxx-00-a17	End-Station VEA Survey Reference Monuments		
D95xxxx-00-a18	End-Station LN2 Supply Piping Interface		

LIGO Dwg	*Title*	*No. of Sheets*	*Completed?*
D95xxxx-00-a19	End-Station VEA - Mechanical Room Pipe Bridge & VE Envelope		
D95xxxx-00-a20	End-Station VEA Electrical Power Interface		
D95xxxx-00-a21	End-Station LN2 Storage Tank Foundation Slab Dimensions, Bolt Pattern and Loads		

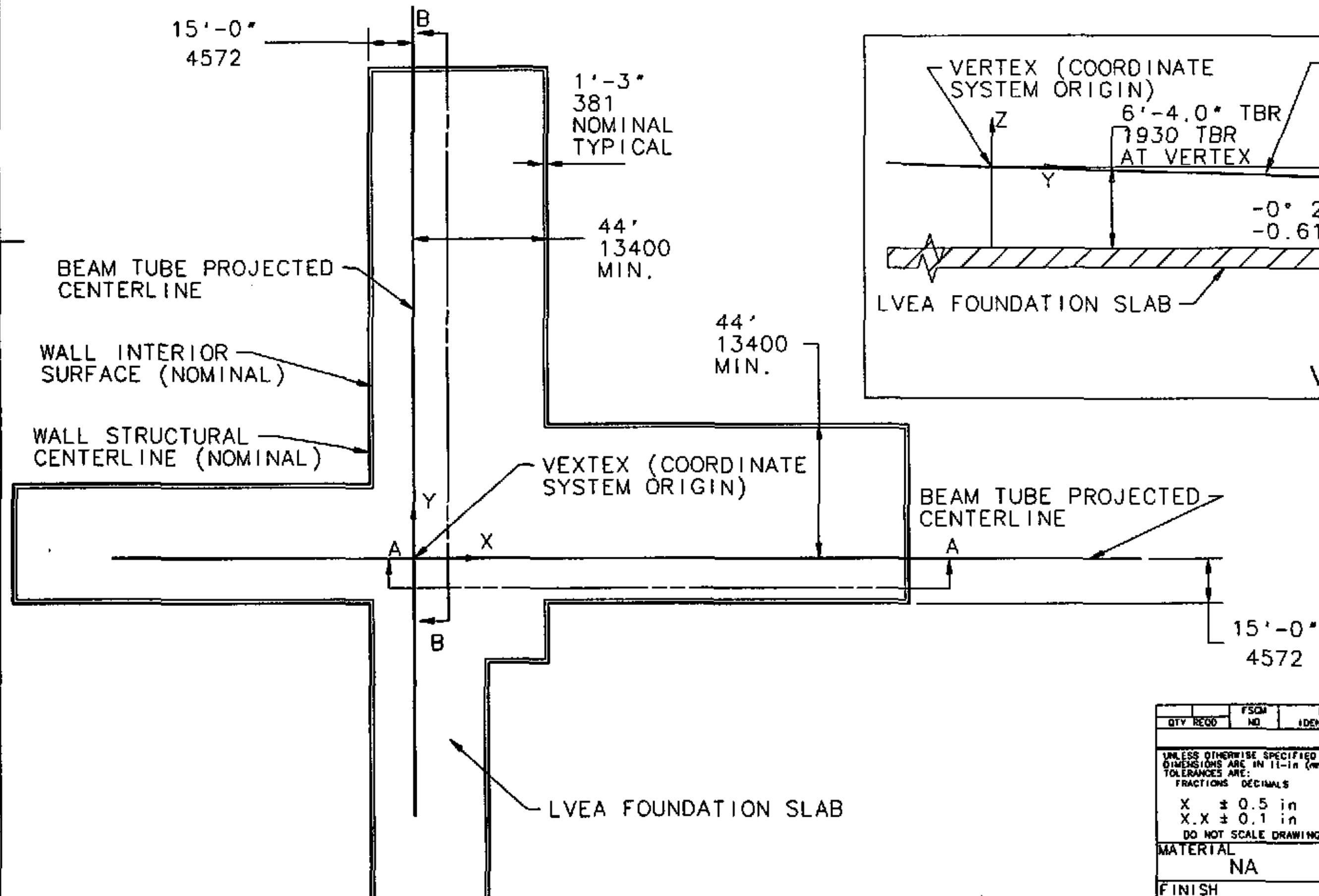
NOTES: (UNLESS OTHERWISE SPECIFIED)

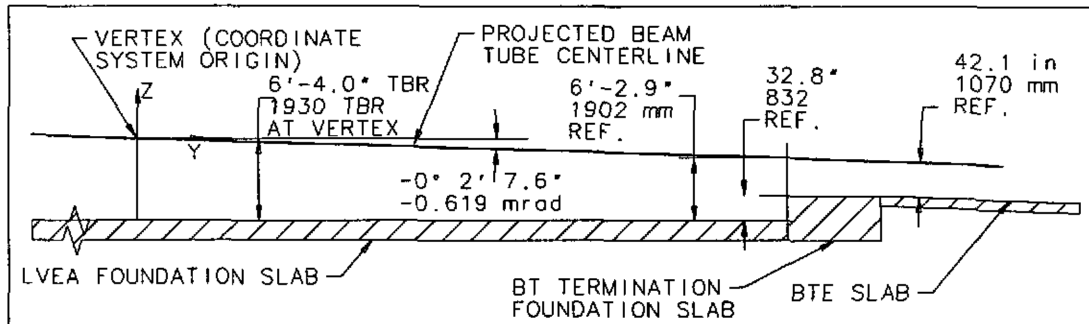
(1) ICD INFORMATION:
This drawing contains interface information.

REV	DESCRIPTION OF CHANGE	APPROVAL	DATE
0	ORIGINAL		



VIEW B-B (SOUTHWEST, Y ARM)





VIEW A-A (NORTHWEST, X ARM)

QTY REQD		FSCM NO	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL SPECIFICATION	ITEM NO

PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN ft-in (mm)
TOLERANCES ARE:
FRACTIONS DECIMALS
X ± 0.5 in
X.X ± 0.1 in
DO NOT SCALE DRAWING

MATERIAL: NA

FINISH: NA

APPROVALS		DATE
DRAWN D. Coyne		11/2/95
CHECKED A. Lazzarini		
M. Coles		
J. Worden		
F. Asiri		

LIGO — CALIFORNIA INSTITUTE OF TECHNOLOGY, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

TITLE: LVEA AND VEA FOUNDATIONS RELATIVE TO THE BEAM LINE - HANFORD, WA CORNER STATION

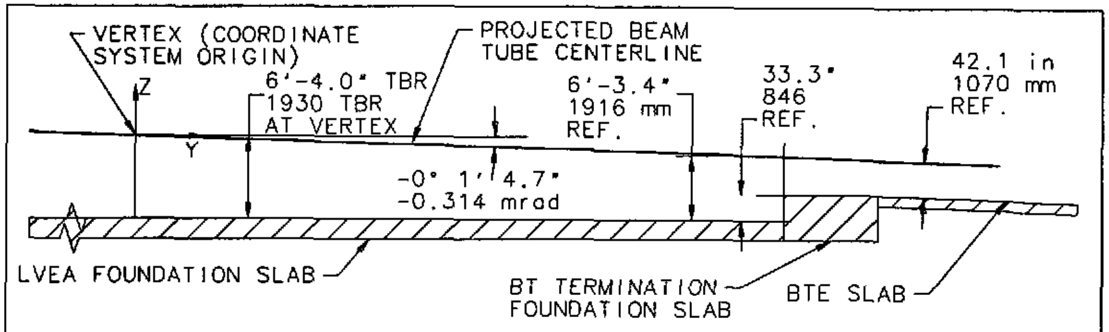
SIZE A3 | DWG NO. 0950148-00-E | REV 0

SCALE NTS | SHEET 1 of 6

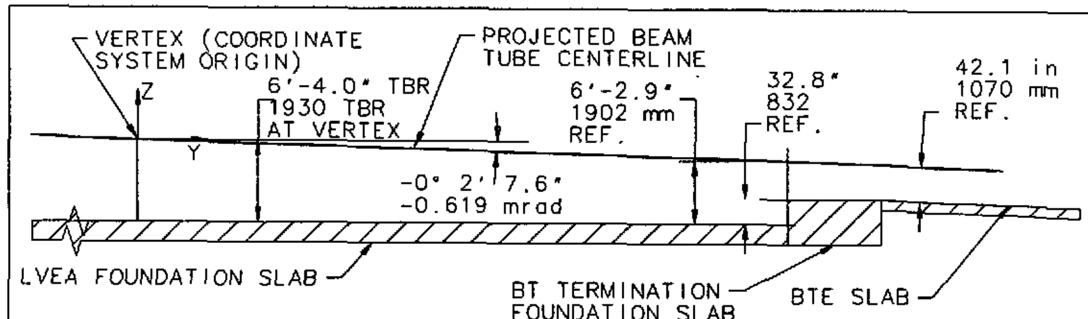
NOTES: (UNLESS OTHERWISE SPECIFIED)

(1) ICD INFORMATION:
This drawing contains interface information.

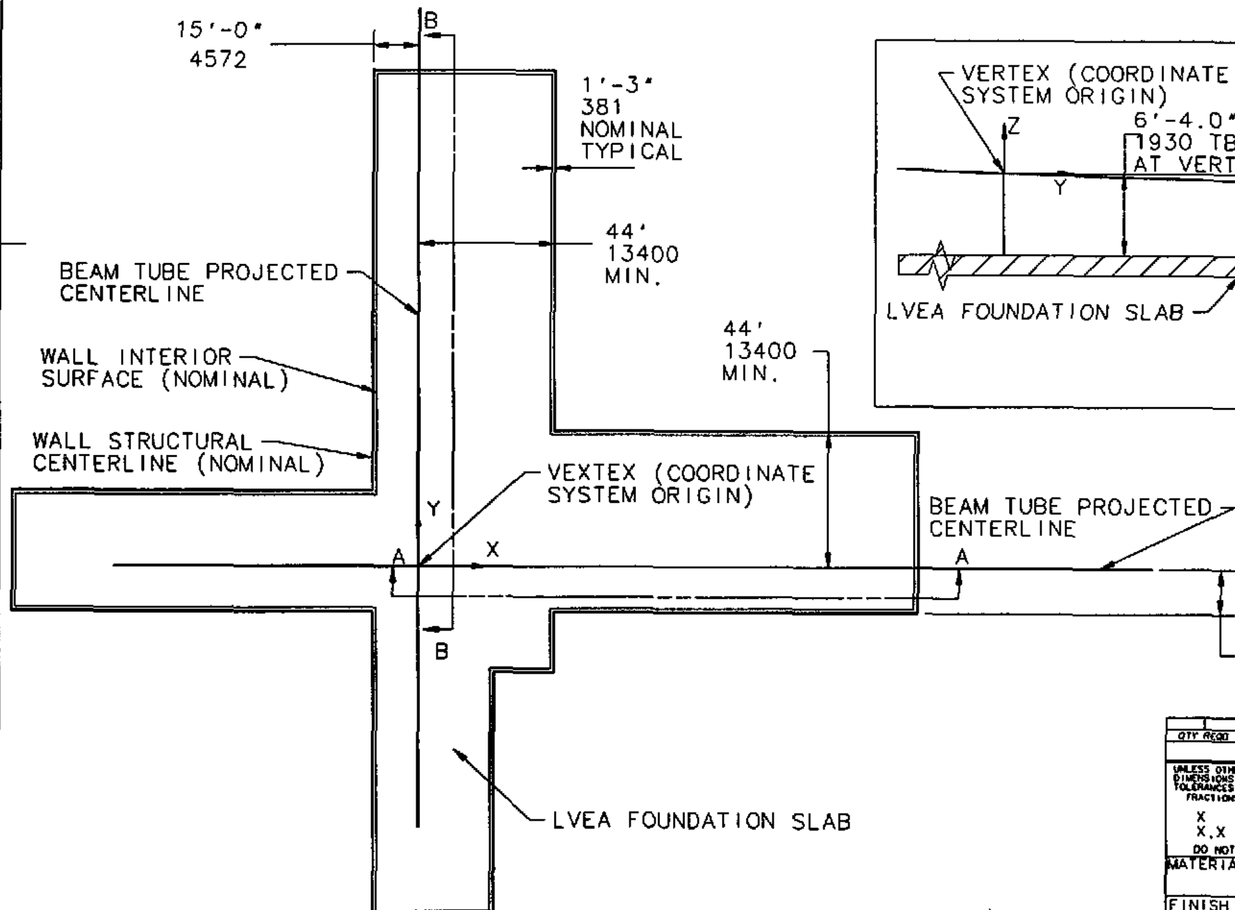
REV	DESCRIPTION OF CHANGE	APPROVAL	DATE
0	ORIGINAL		



VIEW B-B (SOUTHEAST, Y ARM)



VIEW A-A (SOUTHWEST, X ARM)



QTY REQD	FSCM NO	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL SPECIFICATION	ITEM NO

PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN ft-in (mm) TOLERANCES ARE: FRACTIONS DECIMALS X ± 0.5 in X.X ± 0.1 in DO NOT SCALE DRAWING	APPROVALS	DATE
	DRAWN D. Coyne	11/2/85
	CHECKED A. Lazzarini	
MATERIAL NA	M. Coles	
	J. Worden	
FINISH NA	F. Asiri	

LIGO — CALIFORNIA INSTITUTE OF TECHNOLOGY / MASSACHUSETTS INSTITUTE OF TECHNOLOGY

TITLE LVEA AND VEA FOUNDATIONS RELATIVE TO THE BEAM LINE LIVINGSTON, LA CORNER STATION

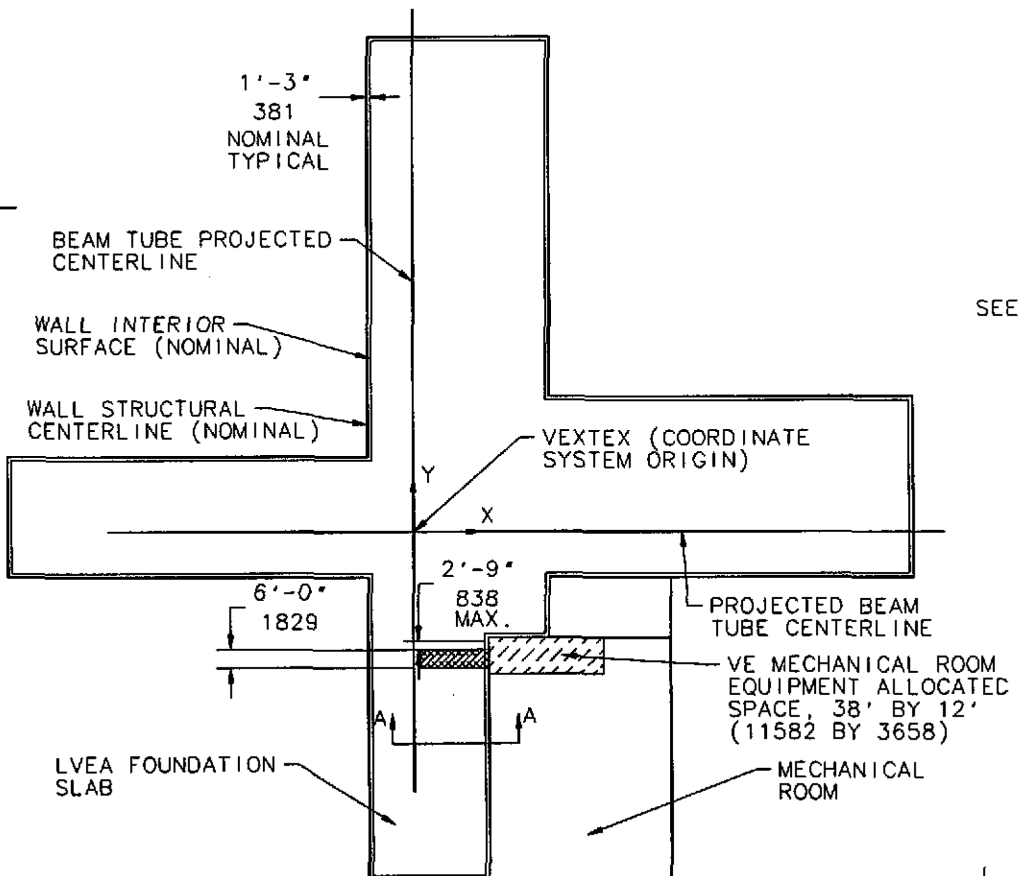
SIZE	DWG NO.	REV
A3	D950148-00-E	0

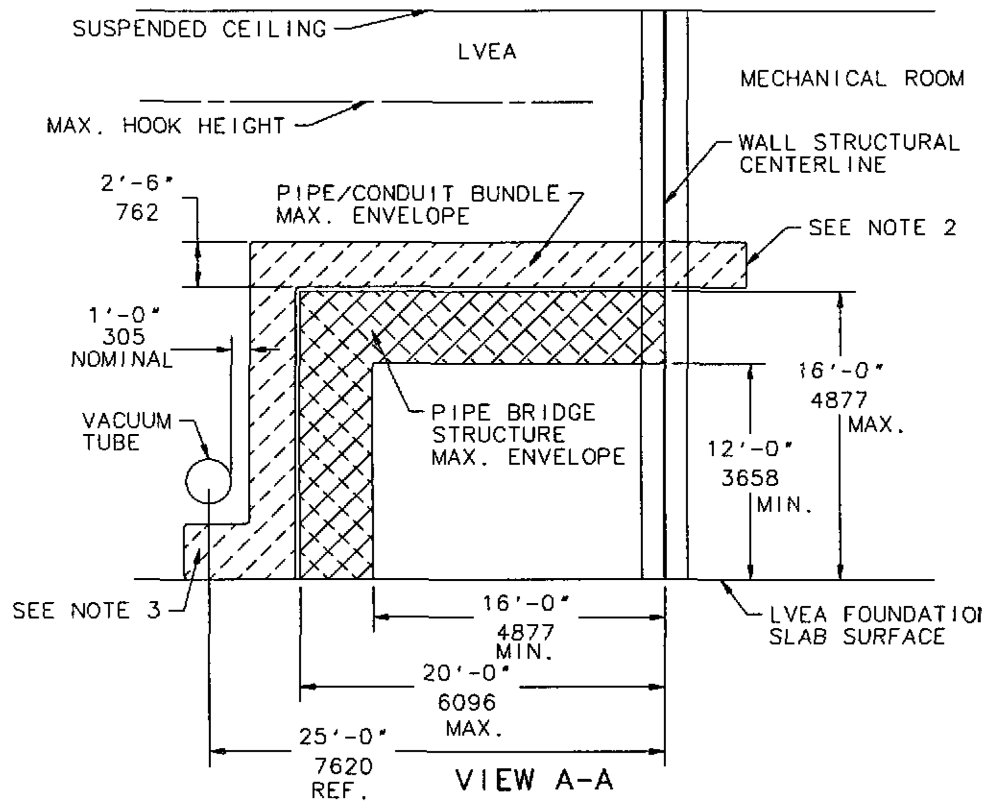
SCALE NTS — SHEET 2 of 6

NOTES: (UNLESS OTHERWISE SPECIFIED)

(1) ICD INFORMATION: This drawing contains interface information.
(2) Support and routing of VE pipe/conduit within the mechanical room to VE equipment is per VE contractor design.
(3) Support and routing of VE pipe/conduit under the vacuum tube is per VE contractor design.

REV	DESCRIPTION OF CHANGE	APPROVAL	DATE
0	ORIGINAL		





VIEW A-A

QTY REQD	FSCM NO	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL SPECIFICATION	ITEM NO

PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN ft-in (mm) TOLERANCES ARE: FRACTIONS DECIMALS	APPROVALS	DATE	LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY
DO NOT SCALE DRAWING	DRAWN D. Coyne	11/2/95	TITLE LVEA/VEA - MECHANICAL ROOM PIPE ROUTING INTERFACES AND VE ENVELOPE: CORNER STATION
MATERIAL NA	CHECKED A. Lazzarini		
	M. Coles		
	J. Worden		SIZE A3 DWG NO. D950151-00-E REV 0
FINISH NA	F. Asiri		SCALE NTS SHEET 1 of 3