TITLE

Cable Tray Installation for the LIGO Hanford Observatory

APPROVALS:	DATE	REV	DCN NO	BY	CHK	DCC	DATE
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1 Purpose

This document and four attached drawings specifies the technical requirements for multiple (up to four) separate cable tray systems to be installed by the contractor in each of five (5) buildings in the LIGO Observatory at Hanford, WA. The five buildings are:

- Corner Station
- Mid-X Station
- End-X Station
- Mid-Y Station
- End-Y Station

The Mid and End Stations are located within 2.5 miles of the Corner Station and all are accessible by paved roads.

The cable trays shall provide paths for cabling which will interconnect racks of electronics, vacuum chambers and sensors. The vacuum chambers and electronics racks will be in place when the cable trays are installed.

2 Scope

This document presents the technical requirements and layouts for the installation. The referenced drawings and photographs show locations of existing hardware and allowed (or prohibited) positions/placements of cable trays. The selection of a commercial cable tray consistent with this specification is left to the Installation Contractor (the Installer). The cable tray installation details are left to field installers

3 Applicable Documents

- National Electrical Code
- LIGO Drawings and Photographs

Note:
The released drawings referenced below accompany this specification.
The photographs referenced below are included in the back of this document.

Cable Tray Installation for the LIGO Hanford Observatory

Drawings and Electronic Photographs Referenced in This Specification

Drawing Title	*Drawing/Photo Number*	*Sheet Number*
Corner Station		
Vacuum Equipment Arrangement (ISO) Corner Station LVEA, Washington	D980267	1
Interferometer Cable Tray Layout-Hanford Site; Plan View, Laser Vacuum Equipment Area (LVEA)	D980266	Sheet 1
Interferometer Cable Tray Layout-Hanford Site-Elevation View Laser Vacuum Equipment Area (LVEA) **Section A-A:** Vertex X-Beam Manifold **Section B-B:** Vertex Y-Beam Manifold **Section C-C:** X Beam Manifold-Diagonal **Section D-D:** Y Beam Manifold-Diagonal	D980266 D980266 “ “ “	 Sheet 2 Sheet 3 Sheet 4 Sheet 5
Section E-E: Photograph Looking under HAM 1 Installation Areas for Cable Trays around Input HAMs (HAMs 1-3, 7-9)	D980266 Photo E20 D980266	 Sheet 6
Section F-F: Photograph of Mode Cleaner Area Mode Cleaner Area Looking from Laser Input Areas	D980266 Photo E22 D980266	 Sheet 7
Section G-G: Removable Spool Area	D980266 Photo E25	
Section H-H Cable Trays and Vacuum Plumbing under BSC 2 Cable Tray Installations for Corner BSC Chambers (BSCs 2, 4, 7, 8)	D980266 Photo E26 D980266-A	 Sheet 8
Section I-I: Photograph Looking under BSC 1 Cable Tray Routing under BSC Chambers 1 & 3	D980266 Photo E28 D980266	 Sheet *9*

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Cable Tray Installation for the LIGO Hanford Observatory

Drawings and Electronic Photographs Referenced in This Specification

Drawing Title	*Drawing/Photo Number*	*Sheet Number*
Section J-J: Photograph of Output HAM (undergoing bake-out) Installation Areas for Cable Trays under Output HAMs (HAMs 4 & 10) Looking towards Vertex	D980266 Photo E54 D980266	 Sheet 10
Section K-K: Photograph of X-Arm Manifold Cable Tray Installations near Vacuum Manifolds	D980266 PhotoE41 D980266	 Sheet 11
Section L-L: X-Arm Termination Slab in Background Close -Up of X-Arm Termination Slab X-Arm Termination Slab (Elevation) X-Arm Termination Slab (Plan View)	D980266 Photo E42 Photo E43 D980266 D980266	 Sheet 12 Sheet 13
Section M-M: Y-Arm Termination Slab (Elevation) Y-Arm Termination Slab (Plan View)	D980266 D980266 D980266	 Sheet 14 Sheet 15
Section N-N: Diagonal Beam Manifold (Y-Arm) Looking from BSC 4 towards BSC 8	D980266 D980266	 Sheet 16
Section O-O: Diagonal Beam Manifold ((X-Arm) Looking from BSC 4 towards BSC 7	D980266 D980266	 Sheet 17
Section P-P: Cable Tray Interfaces with PSL Tables and Electronics Racks	D980266 D980266	 Sheet 18
Section Q-Q: Overhead Cable Tray Bridge Concepts	D980266 D980266	 Sheet 19
View 1-1: Removable Cable Tray Zones around Input HAMs	D980266 D980266	 Sheet 20

Drawings and Electronic Photographs Referenced in This Specification

Drawing Title	*Drawing/Photo Number*	*Sheet Number*
View 2-2: Removable Cable Tray Zones around Dual HAM Installations	D980266 D980266	Sheet 21
Mid-Stations		
Interferometer Cable Tray Layout Hanford Site Mid-Station Plan View Vacuum Equipment Area (VEA)	D980270	Sheet 1
Section A-A: View under BSC (Typical for both Mid-Stations)	D980270 Photo E8	
Section B-B: Vacuum Plumbing under Cryopump (Typical)	D980270 Photo E9	
End Stations		
Chamber & Rack Designations, WA (End Station) (marked with cable tray paths)	D980271	Sheet 1
Section A-A: Area between Electronics Rack and Beam Tube	D980271 Photo E2	
Section B-B: Looking along Edge of Electronics Rack towards BSC Chamber	D980271 Photo E3	
Section C-C: Templates of 6”x 6” Cable Trays beside BSC Support	D980271 Photo E5	

4 Requirements

4.1 Number of Tray Systems

The contractor shall install four separate tray systems. These systems shall be called:

- Radio Frequency (RF) Tray (to be installed in the Corner Station only)
- Digital Signal Tray
- Analog Signal Tray
- Seismic Isolation (SEI) Tray

4.2 Layout

The four separate cable trays shall be installed per the drawings (listed in Section 3 above).

4.3 Cable Tray Configurations

All cable trays shall have open configurations.

4.4 Minimum Cable Tray Dimensions

The minimum cable tray dimensions of the four systems shall be as follows to the nearest standard sizes:

4.4.1 Radio Frequency (RF) Trays

The external dimensions of the RF Cable Trays shall not be less than 3 inches (deep) x 6 inches (width) or an equivalent area when the cable trays are taken through restricted areas.

4.4.2 Digital Signal Trays

The external dimensions of the digital signal trays shall not be less than 3 inches (deep) x 12 inches (width) or an equivalent area when the cable trays are taken through restricted areas.

4.4.3 Analog Signal Trays

The external dimensions of the analog signal trays shall not be less than 3 inches (deep) x 12 inches (width) or an equivalent area when the cable trays are taken through restricted areas.

4.4.4 Seismic Isolation Trays

The external dimensions of the Seismic Isolation trays shall not be less than 3 inches x 3 inches or an equivalent area when the cable trays are taken through restricted areas.

4.5 Transitions in Cable Tray Geometry

Transitions in Cable Tray geometry or size around space-restricted areas shall have electrical and mechanical characteristics in accordance with the NEC.

4.6 Installation

4.6.1 Attachment to the Floor

The cable trays shall be attached to the floor via support structures to be provided by the installer. These supports shall comply with the space restrictions defined in Section 5.

4.6.1.1 Separation from the Floor

The cable trays shall be mounted with at least 6 inches separation between the buildings' floors and the bottoms of the cable trays.

4.6.2 Attachment to Vacuum Equipment

The Cable Trays may be attached to the Vacuum Equipment Supports long as their attachment does not degrade the structural integrity of the Vacuum Equipment Supports. The cable trays shall not be attached to or touch the Vacuum Equipment and its plumbing.

4.6.3 Strength

All installed cable trays shall be strong enough to permit a 300-pound man to stand on the cable tray between supports and not buckle the tray or the cable tray support. This strength requirement shall not apply to the installation described in Section 5.1.5.

4.6.4 Rerouting of Power and Instrumentation Wiring

If it is desirable, the Installer may reroute existing 115 vac and vacuum instrumentation wiring with the approval of responsible resident LIGO engineer.

4.6.5 Grounding

4.6.5.1 Techniques

The trays shall be grounded to the Vacuum Equipment ground using the same techniques used for the Vacuum Equipment Cable Trays installed by others.

Note:
The Vacuum Equipment trays are grounded to the Vacuum Equipment Supports by a short length of 2/0 cable. Another length of 2/0 cable connects the Support to the vacuum equipment ground wire that runs the length of the vacuum equipment. **See photos in this document.**

4.6.5.2 Location of Ground Contacts

The installed cable trays shall be grounded at the same points as the existing cable trays.

4.7 Current Carrying Capacity of the Trays

The current carrying capacity of all cable trays when used as a ground shall be equal to or greater than 150 amperes.

4.7.1 Deburring

The Installer shall remove all burrs and sharp edges from the cable trays before installing them.

4.8 Material

The trays shall be made of aluminum.

4.9 Surface Coating

The cable trays shall be either uncoated, have an anodized coating, or have low-VOC paint suitable for this application.

4.10 Pull Ropes

In areas where access to the cable trays is limited, the Cable Tray Installer shall leave pull ropes in the trays to assist the cable installers.

4.11 Cleanliness

4.11.1 General Requirements

The cable tray installation areas (LVEA, VEAs) shall be maintained as a Class 100,000 clean room during the cable tray installation. Hence all parts brought into these areas shall be handled and cleaned per the techniques defined below.

4.11.2 Parts Cleaning

Before the cable tray parts are brought into the LIGO Buildings they must be degreased and bagged.

If solvents are used to clean and degrease the cable trays the following solvents are permitted:

- Acetone
- Isopropyl Alcohol
- Toluene

All other candidate cleaning fluids must be approved by Caltech.

4.11.3 Parts Inspection

Prior to installation the trays shall be inspected for grease contamination.

4.11.4 Clean-Up

After Cable Trays have been installed in each building, the Installer shall remove all debris and scraps of material from the job site.

4.12 Safety

4.12.1 Clothing

All Installer personnel shall wear hard hats, safety glasses, and safety shoes when in LIGO buildings.

4.12.2 Installation

The installed cable trays shall not present a tripping or other safety hazard (sharp edges, points, burrs, and rough edges).

4.12.3 Safety Plan and Procedures

The Installer shall furnish an On-Site Safety Plan and safety procedures which the Installer shall comply with during the performance of this work.

4.12.4 Quality Assurance

The Contractor shall furnish supplier’s certifications of compliance to specifications for all purchased

materials.

4.12.4.1 Cleanliness

All finished hardware assemblies shall be subject to cleanliness inspection by a LIGO representative prior to moving them into the LVEA and the VEAs.

4.12.4.2 Certification of Work

The Installer shall provide evidence of acceptance of all work and compliance with this specification and requirements.

5 Baseline Cable Tray Installations

This section presents baseline cable tray installation requirements for the Hanford Observatory. The requirements are presented by building, the physical extent of the installation, and finally the details of the installations by vacuum chamber or other specific places in each building. The detailed requirements are presented via electronic photographs of the actual vacuum equipment (in the back of this document) plus drawings and sketches of the hardware and keep-out zones for the new cable trays.

5.1 Corner Station

Drawing D980267 is a dimensioned isometric view of the vacuum equipment in the Corner Station's Laser Vacuum Equipment Area (LVEA). Also shown on this drawing are the complete names of the vacuum chambers i.e. WBSC 1 etc. and WHAM1-6. A shortened form of these names i.e. BSC or HAM will be used in describing the cable tray installations to follow.

Drawing D980266, Sheet 1 is a color-coded plan view drawing of the building's LVEA which shows the coverage and approximate routing of the cable tray networks to be installed. The color key for the cable tray installations is on the drawing.

This drawing also includes a table of Vacuum Chamber/ Seismic Rack Assignments which lists the Seismic Racks and the chambers they support.

Also shown on this drawing are sectional view callouts that provide elevation views of the vacuum equipment and cable tray routes as well as callouts for sectional views that provide more-detailed information about the cable tray installations in specific areas. When a given section view applies to more than one location, all applicable locations are called out.

The drawing also contains cross-hatched areas which indicate areas in which the cable trays shall be removable to support other integration activities. This drawing also locates the electronic rack clusters.

The following features can be noted in this drawing:

1. The Analog and the Digital trays run throughout almost the entire installation.
2. The RF network has more limited coverage.

3. Four separate Seismic Tray systems run from four Seismic Electronics Racks.
4. The BSC chambers at the corners of the installation (BSCs 2, 4, 7, & 8) require octagonal cable tray belts (for the Analog and the Digital systems) around their Support Stands.
5. Cable trays are removable around HAMs and between the HAM group and the nearest BSC chamber to facilitate the assembly of seismic gear in the HAMs.
6. Two other removable sections are required between the BSCs and the Manifolds (both X and Y) to facil - itate the alignment of the LIGO optics within the Vacuum Equipment.

Drawing D980266, Sheets 2-5 present elevation views of the four branches. References in Sheets 2-5 designate detailed Section views provided in Sheets 6-16 which give details about the actual heights and locations of the cable trays to be routed around the chambers.

Drawing D980266, Sheets 18 and 19 provide typical details of the cable tray installations at the lasers and several concepts for cable tray installations at the electronics rack clusters, respectively.

In the following sections, installation details and requirements are illustrated with photographs of the existing equipment and sketches of the cable tray installations at these section areas.

5.1.1 Input HAMs (HAMs 1-3 and HAMs 7-9) (Section E-E)

Section E-E is an axial view of HAM 1. The electronic photo shows the existing hardware. Typical cable tray installations requirements for the Analog, Digital, Seismic, and RF Cable trays are presented in the Sheet 6 which shall apply to HAMs 1-3 and HAMs 7-9.

5.1.1.1 Reconfiguration

The cable tray installations near all HAM chambers shall be removable with common hand tools. Drawing D980266, Sheet 20 shows the removable sections under HAMs 1 and HAM 7. Sheet 21 of the same drawing shows similar installation requirements under the clustered chambers HAMs 2 &3, HAMs 4 & 5, HAMs 8 & 9, and HAMs 10 & 11.

5.1.1.2 Seismic Tray

The Seismic Tray shall end under HAMs 1 and 7.

5.1.2 Mode Cleaner Manifolds (Section F-F)

Section F-F presents installation requirements for the cable trays in the Mode Cleaner Manifold areas of the vacuum equipment. Note that there are two Mode Cleaner Manifold areas in the building (See Drawing D980266, Sheet 1.) The electronic photograph shows the existing vacuum equipment in that area and Drawing D980266, Sheet 7 shows the installation envelope for routing the Analog, Digital, and RF cable trays through this area. The cable trays may be attached to the Vacuum Equipment Supports with bolts or clamps made for this purpose provided that the attachment method does not compromise the structural integrity of the Vacuum Equipment Supports. Interfaces between these cable trays and the nearby electronic racks shall be per Section 5.1.14.

5.1.3 Adapter Zones (Section G-G)

5.1.3.1 Adapters near HAMs

Section G-G presents an electronic photograph of the vacuum plumbing going between HAM 3 and BSC 2 under an vacuum equipment adapter. The cable trays to be installed in this area shall be removable with common hand tools as shall the trays under the HAMs 1 and 2 (see Sheet 1 of the drawing). As can be seen in Drawing D980266, Sheet 1, removable cable trays are required on two sides of BSCs 2 and 4.

5.1.3.2 Adapters between BSCs and Manifolds

Cable trays installed under the vacuum equipment adapters between BSC 7 and the X-Arm Manifold and between BSC 8 and the Y-Arm Manifold shall be removable with common hand tools as shown by cross-hatching in Drawing D980266, Sheet 1. The removable zones shall extend from the Cable Tray Belts around the BSC Chambers to the supports of the Vacuum Equipment Adapters.

5.1.4 Cable Tray Belts around Corner BSCs (BSCs 2, 4, 7, & 8) (Section H-H)

Four BSC chambers (BSCs 2, 4, 7, & 8) are located at the corners of a square (See plan views) and are the junctions for vacuum plumbing, cable trays, and the new tray systems to be installed. The regions under these chambers can be quite crowded. To minimize the crowding and to afford the maximum flexibility in installing wires and cables, the Analog and Digital Trays shall be configured as belts around the Chamber Support Stands as shown in Section H-H, Drawing D980266, Sheet 8. These belts shall fit between the BSC Support and the Seismic Isolation Columns as shown in the figure.

5.1.4.1 Cross Sectional Area

The trays in the Cable Tray Belts shall have the same cross-sectional area as those used along the X and Y Arms.

5.1.4.2 Junctions

As a goal the junctions between the belts and the tray runs along the arms shall be installed at the areas marked with large Xs in Drawing D980266, Sheet 8.

5.1.4.3 Mounting

The trays shall be firmly mounted to the BSC Supports to minimize vibrations. The trays shall not touch the vacuum chambers or the Seismic Isolation Columns.

5.1.4.4 RF Trays

The elevation view shows a narrow region under the BSC Support for the installation of the RF trays.

5.1.4.5 Seismic Tray

The Seismic Tray shall end under the chamber.

5.1.5 Change of Size/Orientation of Cable Tray

The Contractor shall recommend one or more techniques for interfacing runs of rectangular cable trays

between chambers to square-shaped runs around the BSC Chamber. These transitions shall meet the requirements of Section 4 except for Paragraph 4.6.3.

5.1.6 Fabrication of Cable Tray Junctions and Size Transitions

All Analog and Digital cable tray runs along the X an Y arms shall intersect their respective belts around the corner chambers (BSCs 2, 4, 7, and 8) in the Vertex/Diagonal sections. The contractor may purchase or fabricate these interconnections. These joints shall meet the requirements of Section 4 except for Paragraph 4.6.3.

5.1.7 BSCs 1 and 3

5.1.7.1 Placement

Section I-I shows possible installation concepts under BSCs 1 and 3.

5.1.7.2 Seismic Tray

The Seismic Tray shall end under the chamber as indicated.

5.1.8 Output HAMs (HAMs 4 & 5 and HAMs 10 & 11) (Section J-J)

5.1.8.1 Placement

Section J-J presents the available installation areas under these chambers. The installed RF and Seismic Trays shall be located relatively high up on the HAM chamber supports to avoid existing installations (See the sketch).

5.1.8.2 Reconfiguration

Cable trays installed in these areas shall be removable with common hand tools. (See Drawing D980266, View 2-2.)

5.1.8.3 Seismic Tray

The Seismic Tray shall end under the chamber as indicated.

5.1.9 Cable Tray Runs along X and Y Manifolds

Section K-K shows the concept for running the Digital and the Analog cable trays along the large X and Y manifolds of the LIGO instrument. The photograph (along the X-Arm) shows the vacuum hardware in this area. The installation along the Y-Arm Manifold shall be a horizontal inversion of the X-arm installation.

5.1.9.1 Placement

The cable trays shall be mounted on the inside of the manifold supports above the vacuum plumbing as shown in Drawing D980266, Sheet 11. The trays shall be mounted high enough to be above existing vacuum plumbing fittings by others. The Installer shall reroute the installed AC power conduits if required.

5.1.9.2 Analog Trays

The Analog Trays shall run all the way out to the Termination Slab as discussed in Section 5.1.10 of this document.

5.1.9.3 Digital Trays

The Digital trays shall terminate at the Electronics Rack Clusters along the Manifolds as shown in Drawing D980266, Sheet 1.

5.1.10 Cable Tray Interface with the Termination Slab and the Beam Tube Bulkheads (Sections L-L and M-M)

5.1.10.1 Placement

At the X and Y termination slabs, the Analog Cable Trays shall be routed around the edge of the slabs and taken near the metal bulkheads as shown in **Section L-L** and **Section M-M.** Photograph E42 (X-Arm) shows the cryopump (left foreground) with the Termination Slab in the background. The Analog Cable Tray shall run under the cryopump to the Termination Slab then turn right and run above the existing cable tray shown both in photographs E42 and E43. An elevation and plan views of the X-Termination Slab is shown in Drawing D980266, Sheets 12 and 13. Note that the keep-out and the installation zones are shown in this figure.

5.1.10.2 Y-Arm Installation

The installation on the Y-Arm (Section I-I) shall be identical except for the horizontal rotation between the two axes. Drawing D980266, Sheets 14 and 15 are sketches of the installation.

5.1.11 Diagonal Manifold Section (Y-Arm) (Section N-N)

The Analog, Digital, and Seismic cable trays shall run along the short diagonal manifold section between BSC 4 and BSC 8. This section is characterized by significant keep-out zones as shown in Drawing D980266, Sheet 16.

The cable trays shall be mounted high, between the vacuum equipment supports as shown. The trays may be attached securely to the supports with bolts or clamps made for this purpose. The tray placement shall not limit access to any of the trays.

5.1.12 Diagonal Manifold Section (X-Arm) (Section O-O)

This requirements for the cable tray installation between BSC 4 and BSC 7 shall be identical to that presented above for the X-Arm except for a horizontal rotation as shown in Drawing D980266, Sheet 17.

5.1.13 PSL/Electronics Installations (Section P-P)

This section discusses the requirements for the cable tray routing in the areas of the two laser tables. The locations of the laser tables are shown in Drawing D980266, Sheet 1. In the figure, one table is located to the left of HAM 1. The other table is located to the right of HAM 7.

5.1.13.1 Configuration

Drawing D980266, Sheet 18 shows the typical cable tray installations that shall interface the electronics racks with the cable trays described in the previous sections. The cable trays shall be installed above the electronics racks via an Overhead Cable Tray Bridge described in Section 5.1.14 to follow. The trays shall run overhead to the edge of the laser table descend towards the floor and be routed under the table as shown to intersect the trays installed under the input HAM chambers (HAMs 1 and 7). See Section 5.1.1.

5.1.13.2 Overhead Cable Tray Bridges

The Overhead Cable Tray Bridges shall carry Analog, Digital, RF, and power conduits (by others).

5.1.13.3 Tray Placement under Laser Tables

The cable tray installations under the PSL tables shall be spaced no more than 6 inches above the floor. Neither cable trays nor their supports shall touch the PSL table nor its legs.

The laser tables may be placed when the cable tray installation starts.

5.1.13.4 Pull Ropes

The Installer shall leave Pull Ropes in the installed cable trays under the PSL table.

5.1.14 Cable Tray Interfaces to Electronics Racks

Electronics Racks are clustered throughout the Corner Station near power and computer network conduit stub-ups. Most of the Electronics Racks will be in place when the cable trays and the overhead bridges are installed.

Drawing D980266, Sheet 11 shows the interface between the Analog/Digital trays that run the length of the Manifolds and the feeds to the Electronics Racks. The installer shall supply the **cable tray mounts** for this installation.

The Installer shall build Overhead Cable Tray Bridges to support cable trays that will distribute power and communications within each rack group.

5.1.14.1 Overhead Cable Tray Bridges (Section Q-Q)

Drawing D980266, Sheet 19 shows a typical Overhead Cable Tray Bridge over the Electronics Racks. The Overhead Cable Tray Bridges shall have the following characteristics:

5.1.14.1.1 Electronics Cabinet Access

The Overhead Cable Tray Bridges shall allow at least 3-feet of clearance at the front, sides and back of the Electronics Cabinets. For long rack clusters the installer may use intermediate supports, but these supports shall maintain the three foot clearance around the racks.

5.1.14.1.2 Height

The Overhead Bridge shall clear the Electronics Racks (84 inches tall) by at least one foot to enable installers to

install cables from the cable trays overhead down to the racks.

5.1.14.1.3 Contact between Cable Trays, Cabinets and Cable Tray Bridges

No part of the Cable Tray Bridge nor the Cable Trays shall contact the Electronics Racks when the doors on the cabinets are either open or closed.

5.1.14.1.4 Anchors

The Cable Tray Bridges shall be firmly anchored to the floor. The anchoring scheme shall not be a trip hazard.

5.1.14.1.5 Cable Trays on Bridge

Typically Overhead Cable Tray Bridges shall support racks for Analog and Digital Signal Trays plus the AC Power Conduits to be installed in the future (by others). Several near the Laser Tables shall support all of these trays plus the RF Tray.

5.1.14.1.5.1 Tray Sizes

Analog and Digital Trays. The size of the Analog and Digital Signal Trays shall be 3in x 12 in or trays having equivalent cross-sectional areas.

RF Trays. The cross sectional dimensions of the RF trays on the Overhead Cable Tray Bridges racks shall be 3 in x 6 in or an equivalent area.

5.1.14.1.5.2 Footprint for AC Power Conduits

The width of the footprint for the AC Power Conduit to be installed by others shall be 12 inches on the Cable Tray Bridges over the 5-6 rack groups and 6 inches for all other rack groups.

5.1.14.1.6 Lengths of Trays

The cable trays shall run the full lengths of each Cable Tray Bridge.

5.2 Mid-Stations

Drawing D980270, Sheet 1 is a plan view of the X-Arm Mid-Station that shows the typical cable tray routes (Analog and Digital) for the Mid-Stations. [The Y-Arm Mid Station is a mirror image about the beam tube axis for the X Arm.] There will be no RF cable tray system in the Mid-Stations. Requirements for this installation are presented below.

5.2.1 Installation Requirements

The Installation Requirements presented in Section 4 shall apply to Mid-Station Installations. Sections A-A and B-B are photographs of the vacuum hardware in the Mid-Station. Note that there is less clutter than in the Corner Stations described in the previous section.

5.2.1.1 Cable Tray Interfaces to Electronics Racks

5.2.1.2 Overhead Cable Tray Bridges

The Overhead Cable Tray Bridges for the Electronics Rack pairs next to the Vacuum Equipment shall be built and installed per Section 5.1.14 above. The Mid Stations' Cable Tray Bridges shall be installed with the Analog and the Digital trays and leave 6 inches for the later installation of the Electrical Power Conduits (See Section 5.1.14.1.5.2 above.)

5.2.1.3 Seismic Tray

The Overhead Cable Tray installation for the single Seismic Electronics racks in the Mid-Stations shall be similar to those done for the single racks in the Corner Station.

5.2.2 Cable Tray Interfaces with Vacuum Chambers

The Analog and Digital Cable Tray belts around the BSC chambers shall be similar to those installations around BSCs 2, 4, 7, and 8 in the Corner Station.

5.2.3 Cable Tray Height

Cable Trays that cross the Clean Room boundary shall be no higher from the floor than the existing cable trays crossing the boundary.

5.3 End Stations

Drawing D980271 is a plan view of the X-Arm End Station that shows the typical cable tray routes (Analog and Digital.) The Y-Arm End Station is mirrored about the beam tube Axis and shall have a similar configuration.

5.3.1 Requirements

The requirements presented in Section 5.1.14 shall apply to the End Station installations. See Drawing D980271, Sections A-A, B-B, and C-C for photographs of the Vacuum Hardware in the X-Arm End-Station.

5.3.2 Cable Tray Interfaces with Electronics Racks

5.3.2.1 Overhead Cable Tray Bridges

The Overhead Cable Tray Bridges for the Electronics Rack pairs next to the Vacuum Equipment shall be built and installed per Section 5.2.1.2.

5.3.2.2 Seismic Rack

The Overhead Cable Tray installation for the single Seismic Electronics rack shall be as done for those single racks in the Corner Station.

5.3.3 Cable Tray Interfaces With Vacuum Chambers

The Analog and Digital Cable Tray belts around the BSC chambers similar to those installations around BSCs 2, 4, 7, and 8 in the Corner Station.

5.3.4 Cable Tray Height

Cable Trays that cross the clean room boundary shall be no higher from the floor than the existing cable trays crossing the boundary.

6 Site Conditions

6.1 Water

No potable water service is available at the site. The Contractor is responsible for any potable water needs.

6.2 Sanitation

No sanitation facilities will be available to the Contractor. The Contractor shall be responsible for providing all sanitation facilities required.

6.3 Electrical Service

Electrical service will be available to the Installer**.** The Installer shall be responsible for providing any electrical service required for the work prior to assembly installation. It shall be the Installer's responsibility to coordinate with LIGO personnel to gain access to the electrical equipment inside the Corner, Mid and End stations. Any modifications to the existing electrical service determined necessary by the Installer shall be approved by LIGO. Upon completion of the contract, electrical equipment shall be returned to a satisfactory state as required by LIGO.

6.4 Telephone Service

No telephone service is available on site. If determined necessary by the Installer, additional temporary telephone service may be installed entirely at the Installer's expense. Cellular telephone service is suggested.

6.5 Underground Utilities

The drawings and specifications may not give the precise location of all drainage systems, electrical conduit, ground grids or other structures. It shall be the responsibility of the Installer to ensure that no damage to said utilities or foundations be incurred. If any damage does occur it shall be the responsibility of the Installer, at his expense, to repair or replace at the discretion of LIGO, damaged systems.

6.6 Fasteners

No charge or powder driven fasteners shall be used at this site. Other fastener systems shall be approved and coordinated with LIGO prior to installation. Drilling within LIGO LVEAs and VEAs shall be done with dustless core drill systems that utilize both water and vacuum to minimize dust.

6.7 Laydown Areas

A laydown area near the corner station, approximately 5 acres in size, is available to the Installer (See Appendix A.)

Additional smaller areas nearer the mid and end stations may be made available upon request from the LIGO Construction Manager on site. The laydown area may be available for a job site trailer if desired by the Installer.

6.8 Lighting

LIGO buildings are lighted. The Installer may supplement this lighting with temporary lighting if he chooses.

6.9 Coordination of Activities

The Contractor is required to coordinate his activities with the other Contractors on site and with the LIGO staff. The Contractor shall not block the roadways at any time. LIGO facilities are unique. All activities which physically modify the facilities shall be coordinated with LIGO to prevent inadvertent damage or compromise in the function of the project.

6.10 Indoor Assembly Area

The Contractor will be provided use of an approximate 20’x 50’ work area near the corner station. The work area is in a maintenance building at the mechanical equipment area near the water tower. As units are assembled, they should be moved to their respective staging areas. The Contractor shall be responsible for maintenance of the assembly area in an orderly manner while in use. The area shall be cleared once assembly is complete and returned in the same condition as which it was received. 120 V power is available for use in the assembly area.

6.11 Tobacco Products

Installer personnel shall not use any tobacco products while on-site at LIGO facilities.

6.12 Clean Up

The Contractor shall remove all debris and scraps of material from the job site and return the LIGO facilities to an as-found condition before leaving.

6.13 Safety

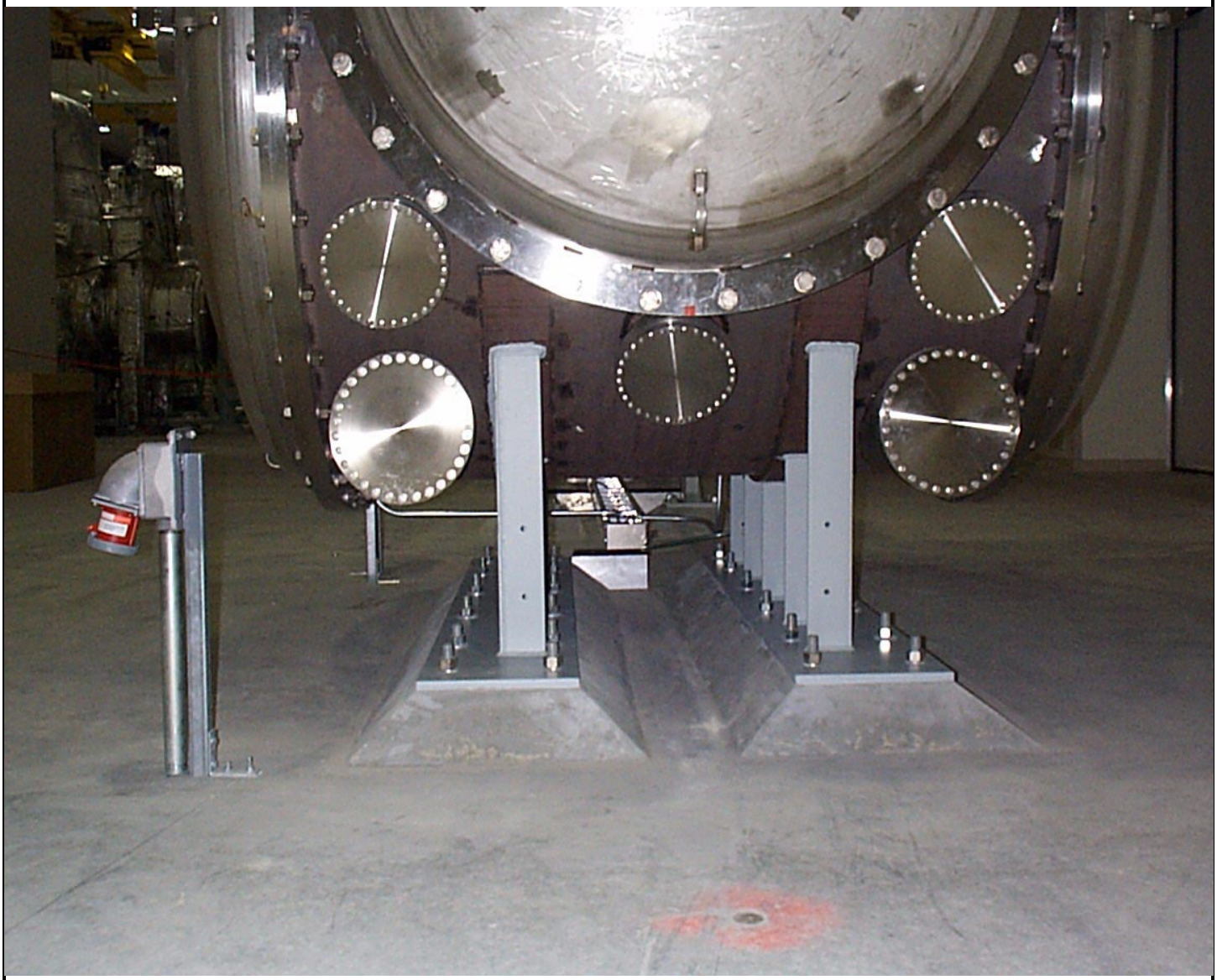
The Contractor shall furnish his On-site Safety Plan for review and approval by LIGO prior to the start of on-site work. While on-site, the Contractor shall abide by all LIGO Lock-Out, Tag-Out Safety procedures.

TITLE

Cable Tray Installation for the LIGO Hanford Observatory

Electronic Photographs Referenced in Section 3

Drawing D980266, Section E-E: Photograph (E20) Looking under HAM 1



TITLE

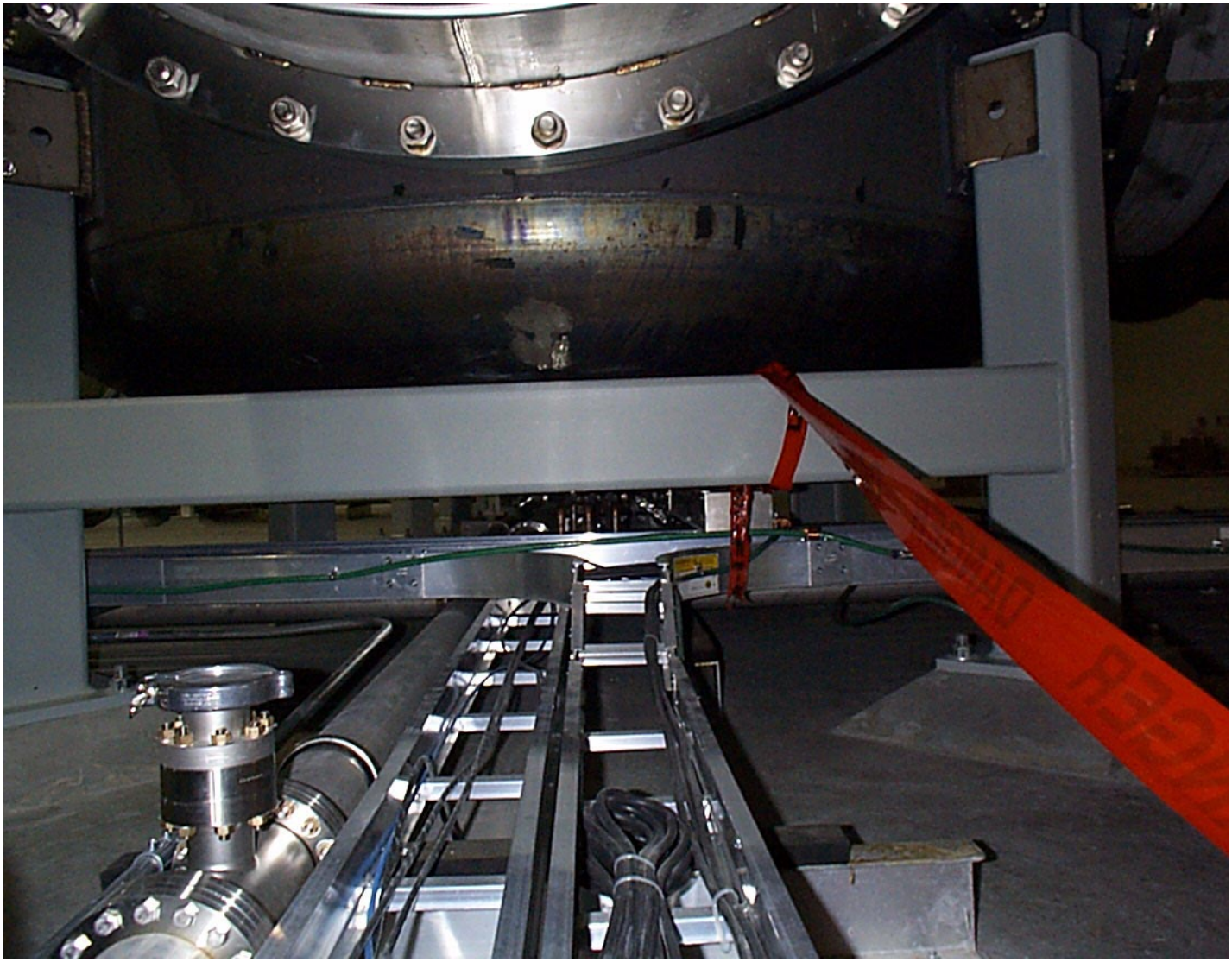
Cable Tray Installation for the LIGO Hanford Observatory

Drawing D980266, Section F-F: Photograph (E22) of Mode Cleaner Area

TITLE

Cable Tray Installation for the LIGO Hanford Observatory

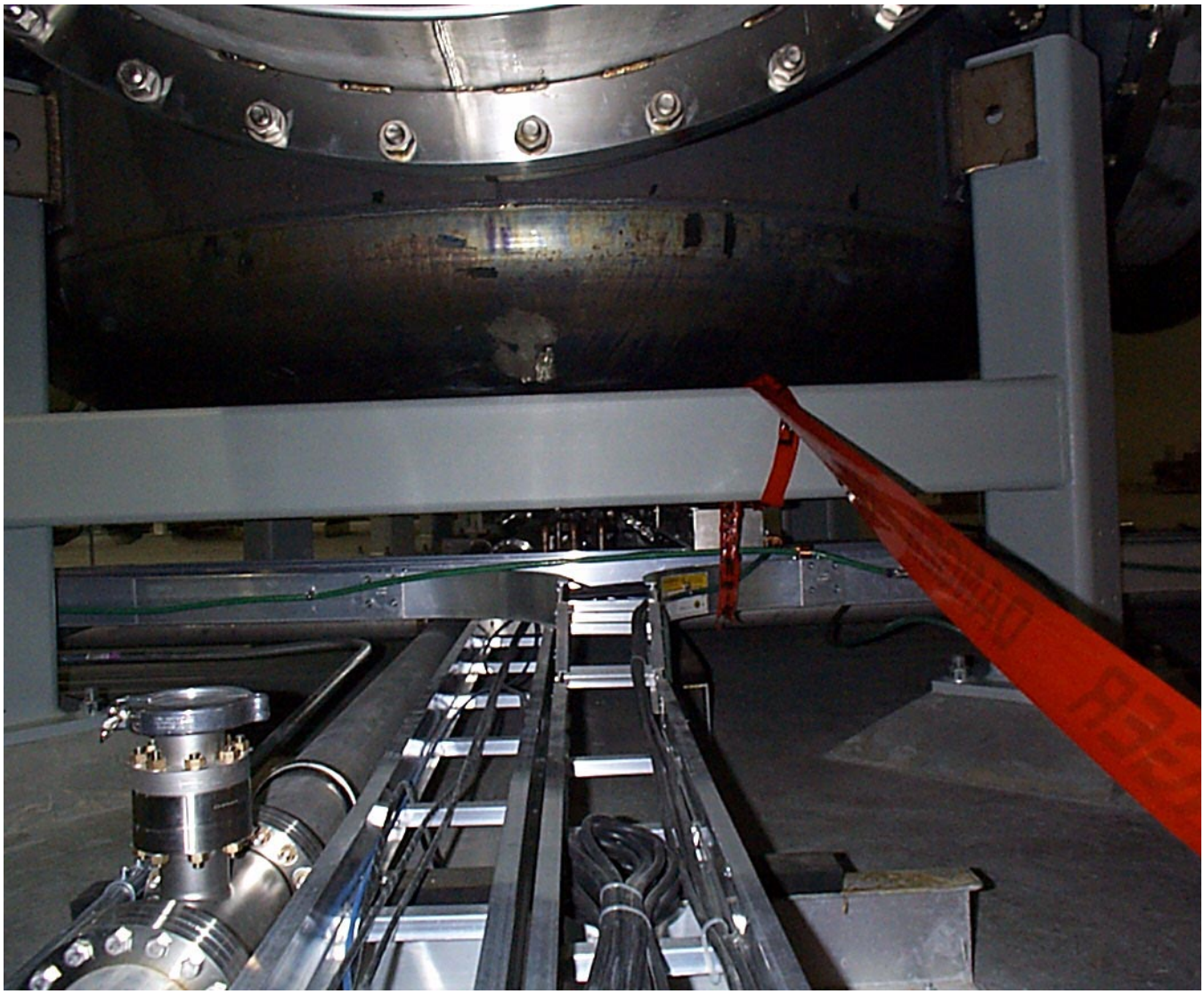
Drawing D980266, Section G-G: Photograph (E25) Removable Spool Area



TITLE

Cable Tray Installation for the LIGO Hanford Observatory

Drawing D980266, Section H-H: Photo (E26) Cable Trays and Vacuum Plumbing under BSC 2



TITLE

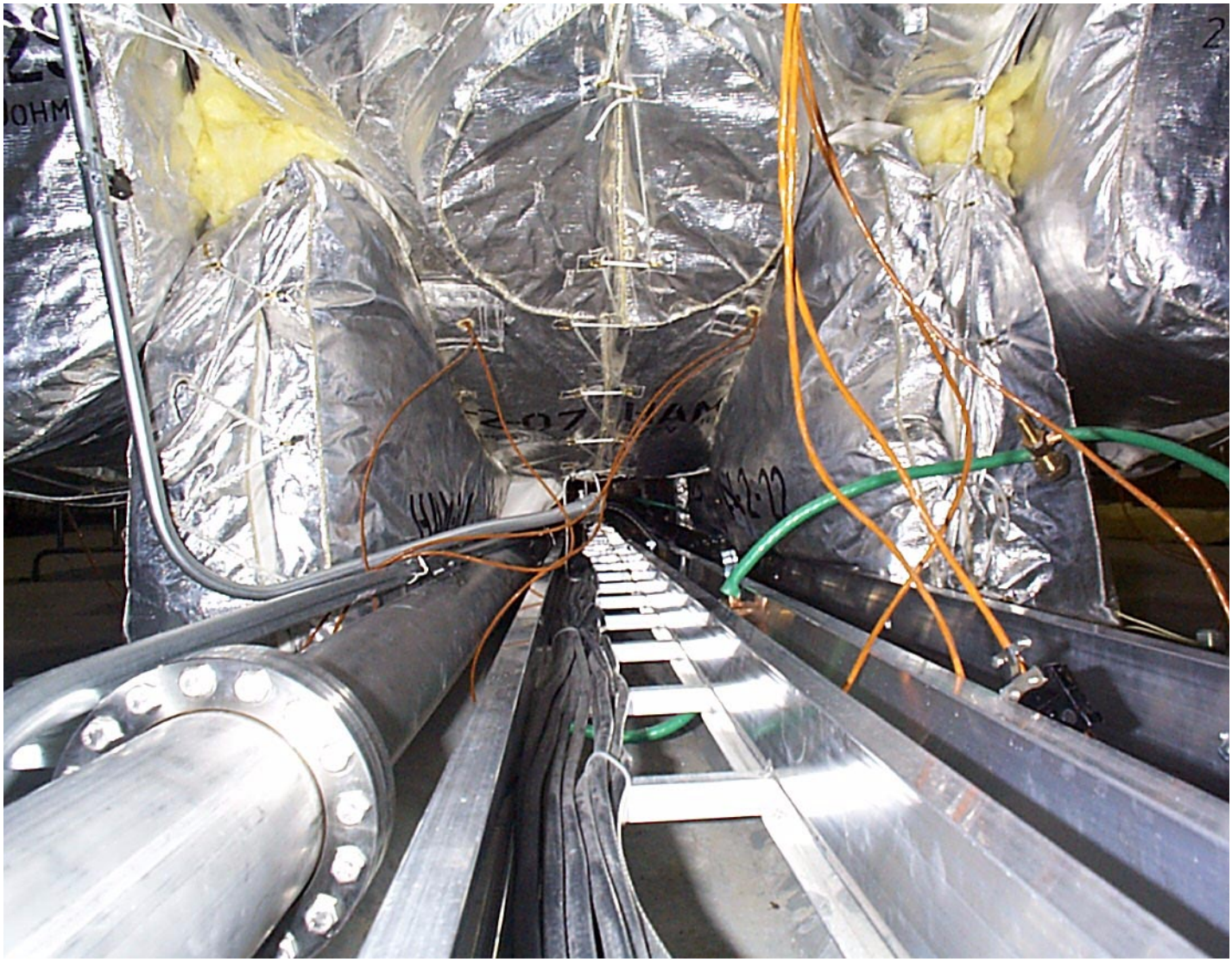
Cable Tray Installation for the LIGO Hanford Observatory

Drawing D980266, Section I-I: Photograph (E28) Looking under BSC1

TITLE

Cable Tray Installation for the LIGO Hanford Observatory

Drawing D980266, Section J-J: Photograph (E54) Output HAM



TITLE

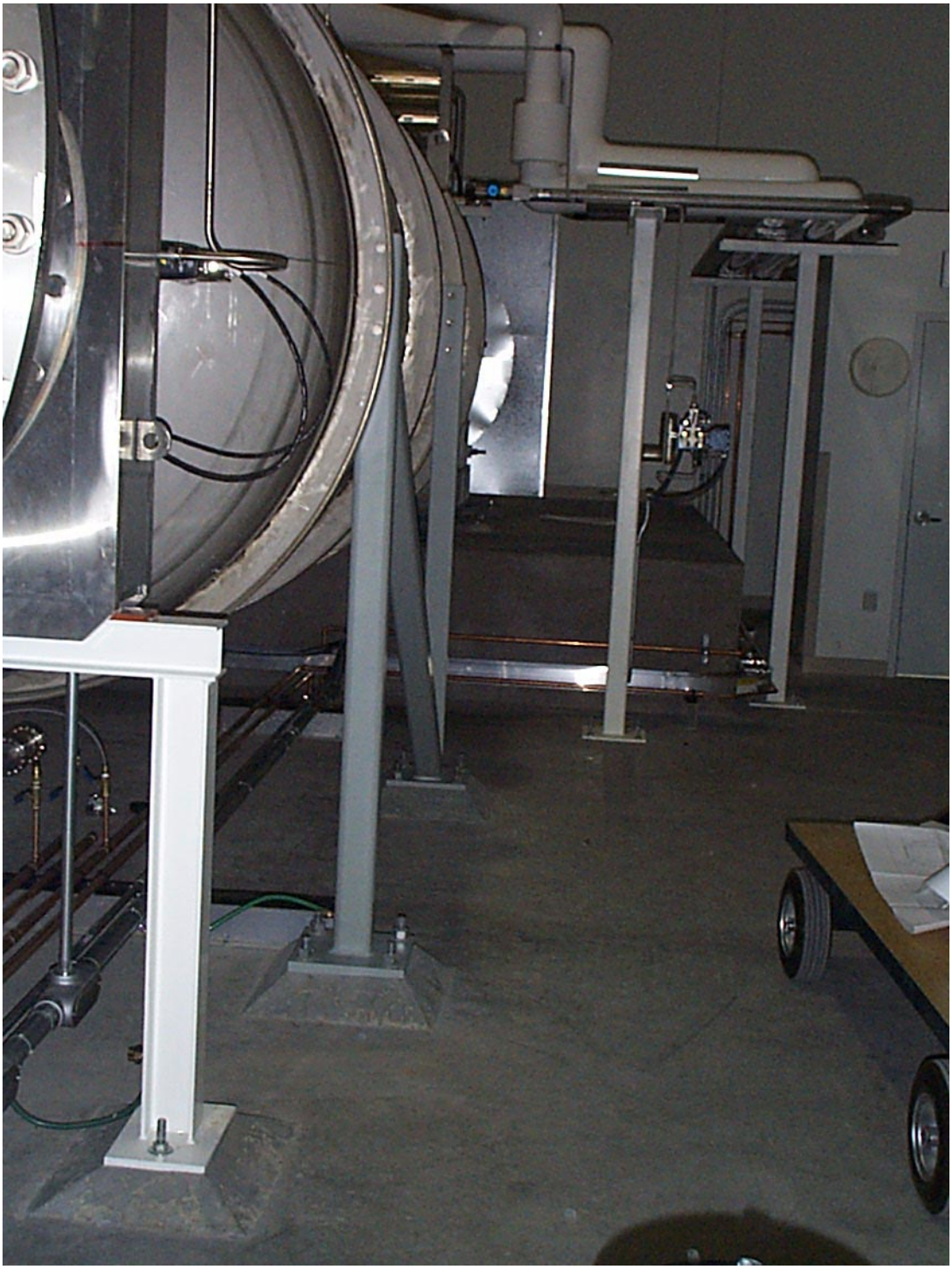
Cable Tray Installation for the LIGO Hanford Observatory

Drawing D980266, Section K-K: Photograph (E41) X-Arm Manifold

TITLE

Cable Tray Installation for the LIGO Hanford Observatory

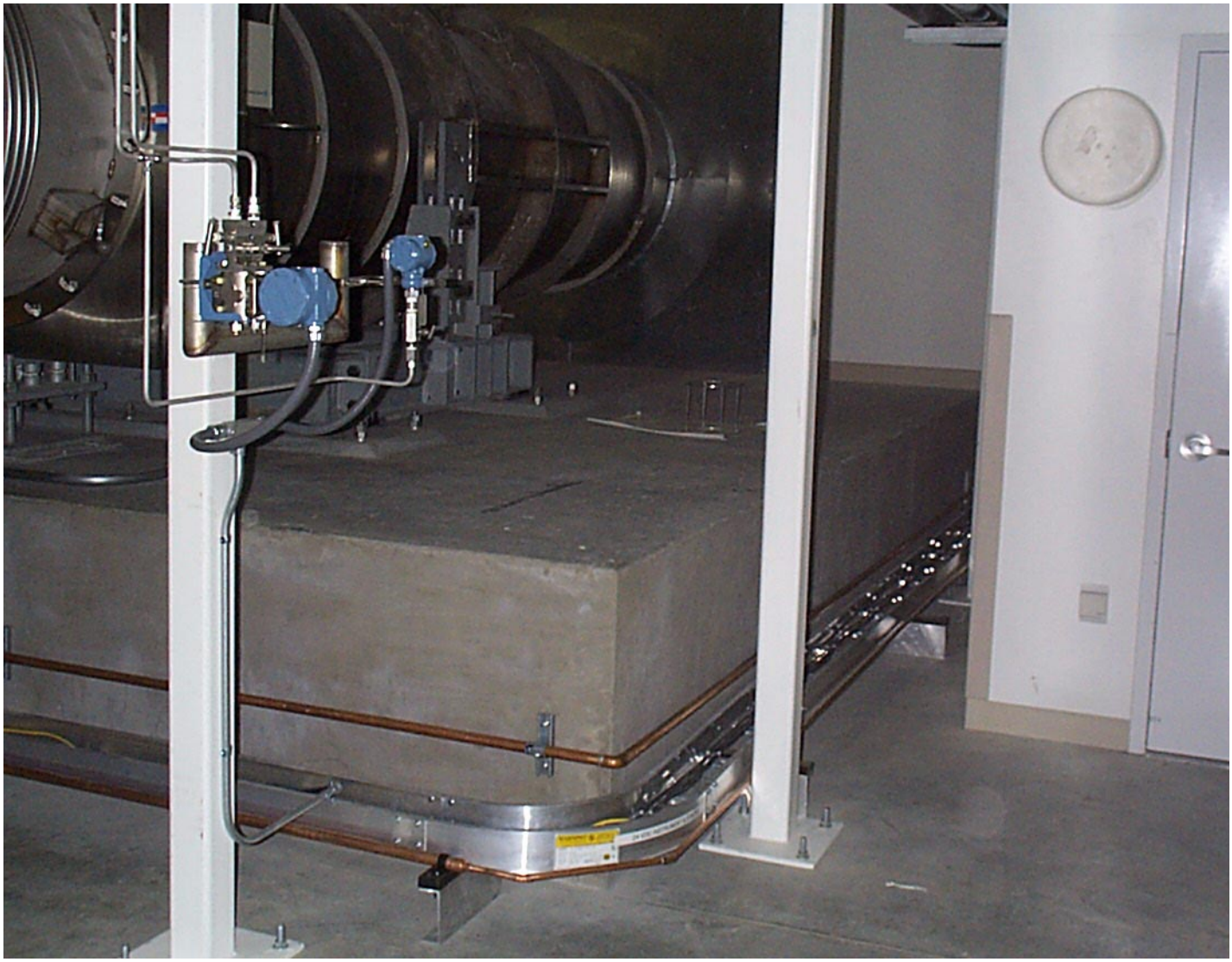
Drawing D980266, Section L-L: Photo (E42) X-Arm Termination Slab in Background



TITLE

Cable Tray Installation for the LIGO Hanford Observatory

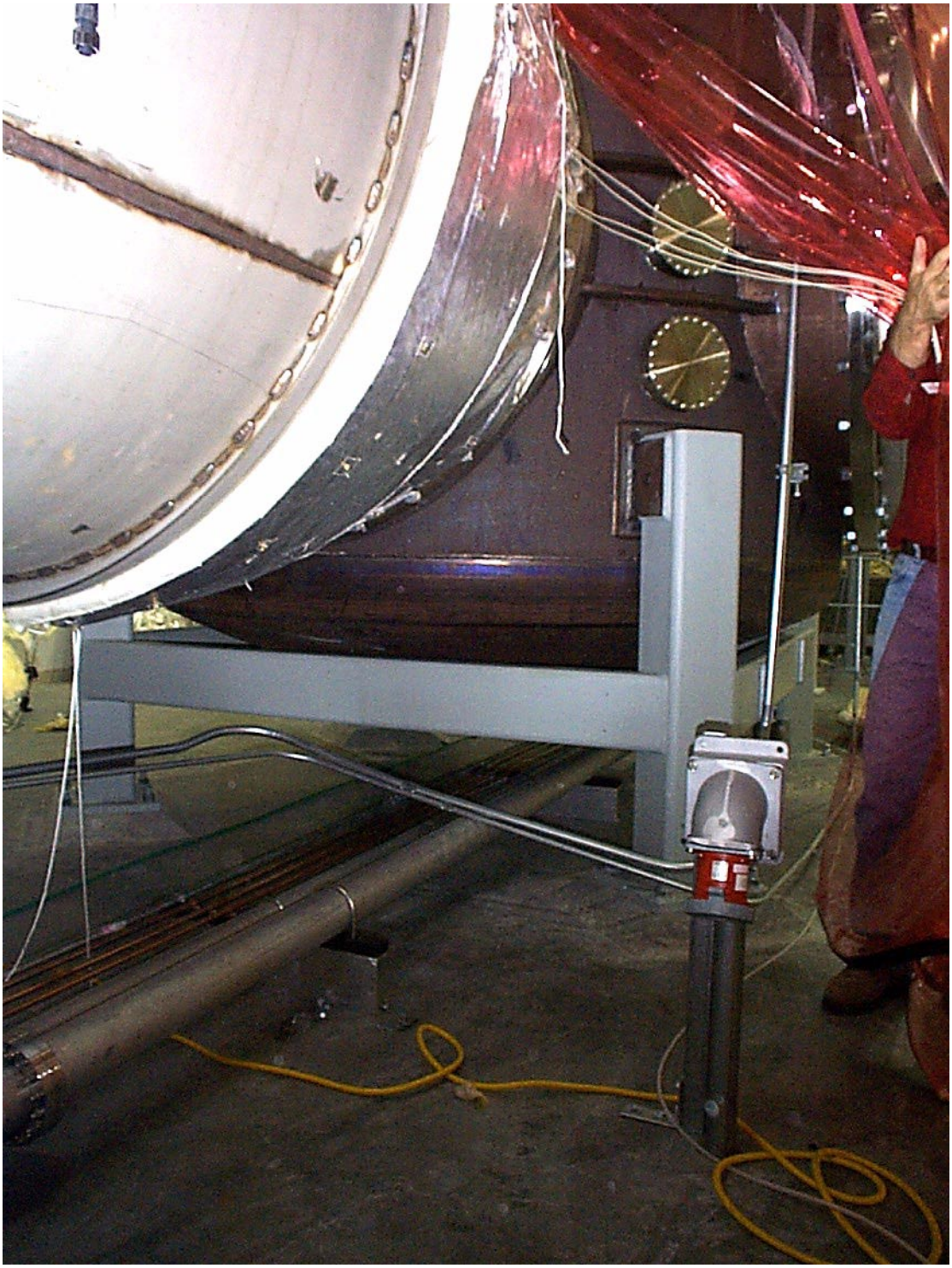
Photograph (E43) Close-Up of X-Arm Termination Slab



TITLE

Cable Tray Installation for the LIGO Hanford Observatory

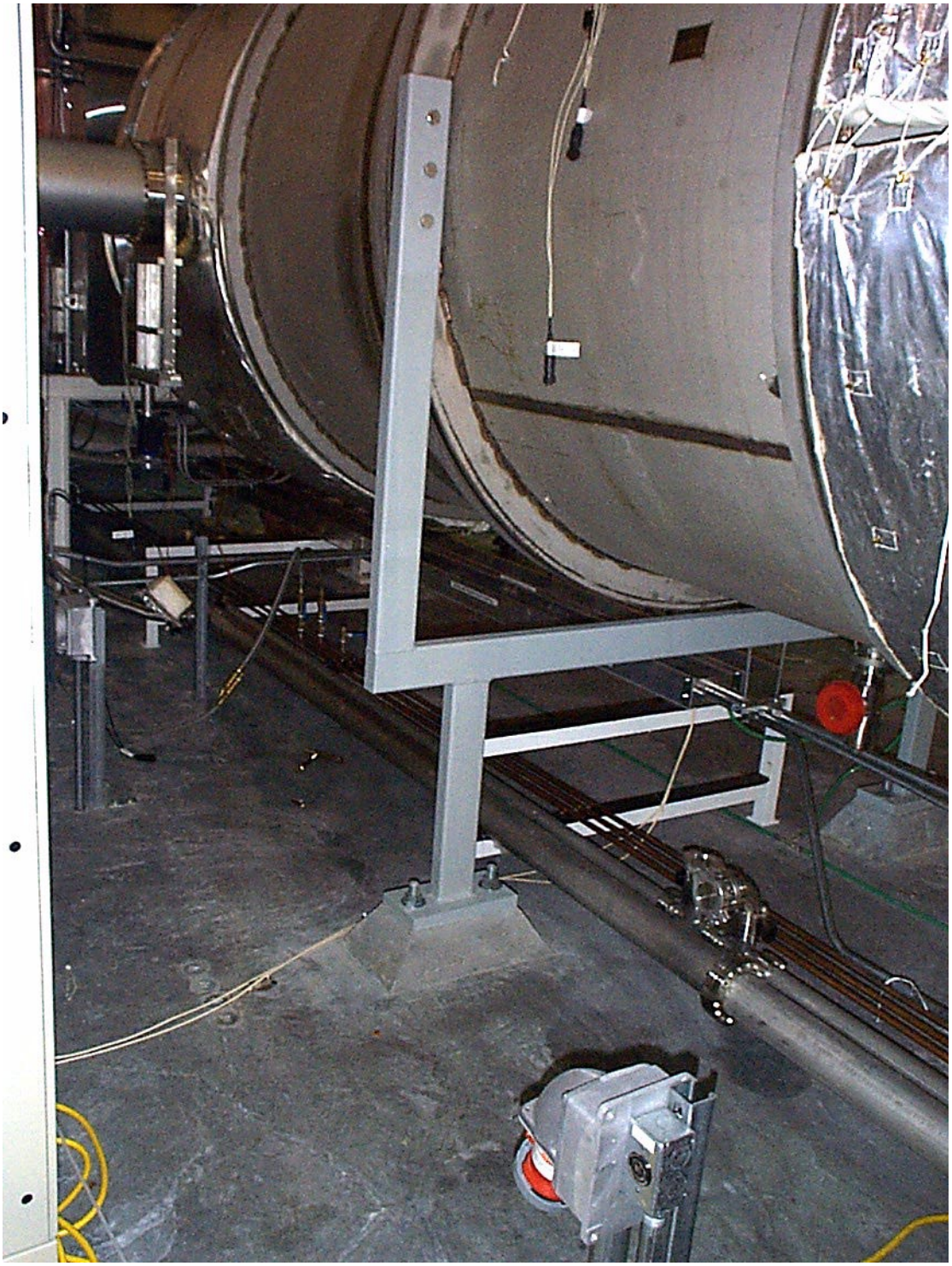
Drawing D980270, Section A-A: Photograph (E8) Typical View under BSC in Mid-Station



TITLE

Cable Tray Installation for the LIGO Hanford Observatory

Drawing D980270, Section B-B: Photo (E9) Typical View of Plumbing under Cryopump



TITLE

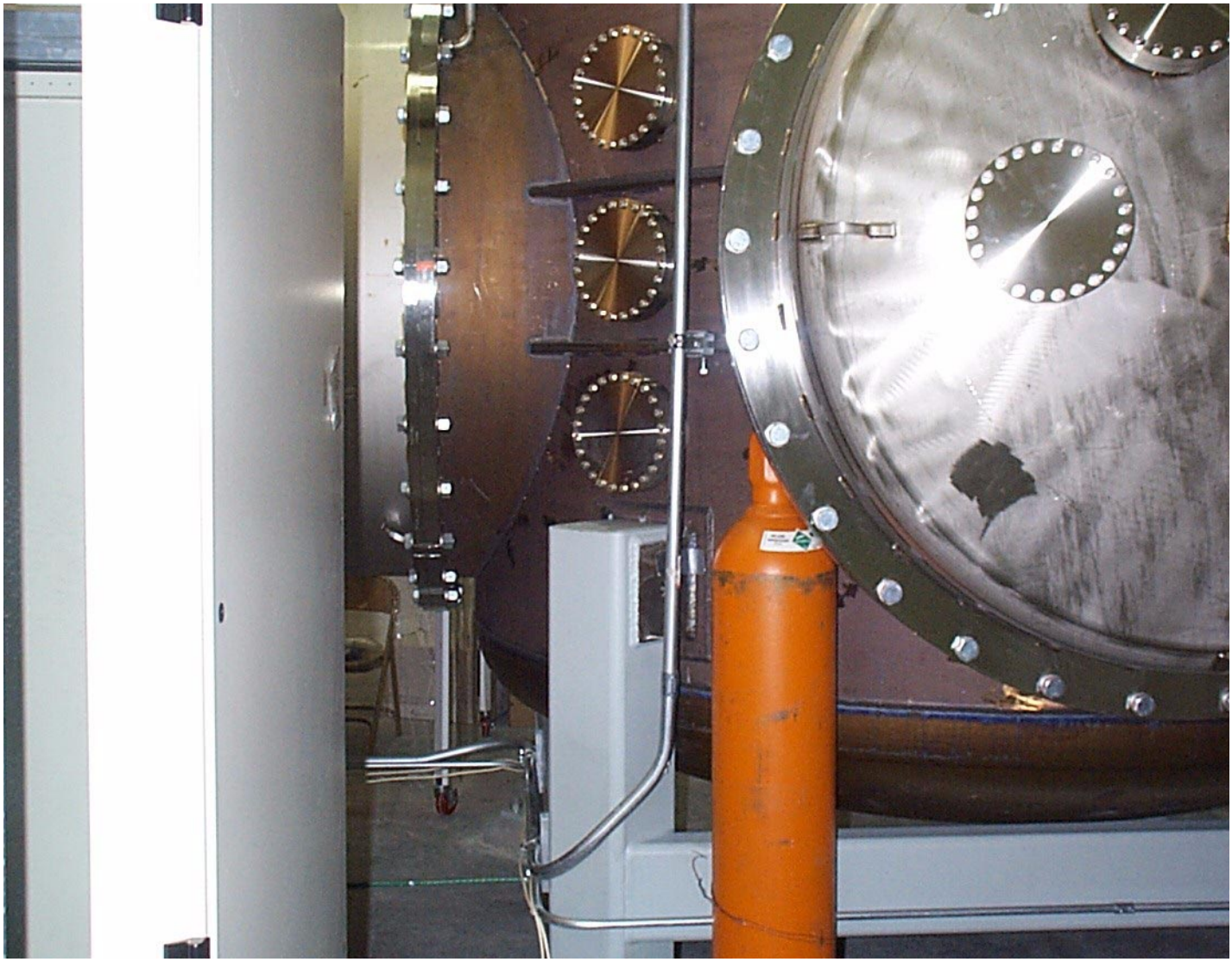
Cable Tray Installation for the LIGO Hanford Observatory

Drawing D980271, Section A-A: Photograph (E2) View behind Electronics Rack under Cryopump

TITLE

Cable Tray Installation for the LIGO Hanford Observatory

Drawing D980271, Section B-B: Photograph (E3) View between Electronics Rack and BSC



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TITLE

Cable Tray Installation for the LIGO Hanford Observatory

Drawing D980271, Section C-C: Photo (E5)Cable Tray Templates (6”x 6”) Shown beside BSC Support

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APPENDIX A
SITE LAYOUT AND MAP (not to scale)