



**SPECIFICATION**

Drawing No Vers.


Sheet 1 of 10

**WA LIGO SITE - MID/END STATION ADV. LIGO VACUUM  
EQUIPMENT INSTALLATION**

APPROVALS	DATE	REV	DCN NO.	BY	CHECK	DCC	DATE
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## **1.0 GENERAL SCOPE**

1.1 This specification covers the minimum requirements for the moving and installation of new vacuum equipment required for the WA Advanced LIGO Modification of the LIGO Observatories. The Buyer will provide a full time representative to work with the Seller during these activities.

All equipment must be moved / installed while maintaining the strict Cleanliness of the LIGO research facility. Anytime a LIGO vessel is open to atmosphere, it must be protected by a Class 5 cleanroom (provided by LIGO) and Class 5 cleanroom procedures must be used. Some equipment (BSC vessel – Wt. = 17,000 Lb.) must be removed from one LIGO building and re-installed in another LIGO building 1.1 miles away. The BSC vessels (2) are currently anchored and grouted in place. All electrical wiring will be removed by others.

1.2 The Buyer will train the Seller personnel in site cleanliness and safety requirements (See Section 8.0 for detailed requirements) prior to the start of the work.


1.3 The California Institute of Technology (Caltech) is the Buyer for these components. The Seller is the successful bidder who is awarded this contract.

The Laser Interferometer Gravitational-Wave Observatory (LIGO) is operated by Caltech and the Massachusetts Institute of Technology (MIT) under a National Science Foundation grant and includes observatories located in the Hanford Reservation ,near Richland, WA (LHO) and in Livingston, LA (LLO). This specification only covers the Hanford, WA facility (LHO). Viewed from the Corner Station the left equipment arm is the “Y” arm and the right equipment arm is the “X” arm.

1.4 It is the Seller responsibility to follow the requirements of this specification or to propose alternate procedures and specifications to meet the requirements. All alternate approaches must be approved by the Buyer before use.

1.5 The Buyer reserves the right to refuse access to the LIGO facility to any of the Seller’s personnel for failure to adhere to LIGO Site Safety Rules or for refusing to work in a Safe and Clean manner.

1.6 All drawing and specifications referenced herein are part of this specification and are available for viewing via the link in the Statement Of Work - C1002601-v4.

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## **2.0 CODES / STANDARDS /PERMITS**

2.1 The following codes and standards, as applicable, shall be followed for the installation and testing of the equipment:


- ASTM - American Society for Testing Materials
- OSHA - Occupational Safety and Health Act Noise Standard
- Applicable - Local Codes and Standards
- ISO 14644-1 – 1999 Cleanrooms and Associated Controlled Environments

### **2.2 Permits**

Before starting work on this project, it shall be the responsibility of the Seller to make certain that all necessary permits, licenses and approvals are obtained for the work to be performed at the site.

## **3.0 SAFETY REQUIREMENTS**

- 3.1 All work executed by the Seller shall comply with Federal OSHA regulations. The Seller is responsible for the Safety of their personnel.
- 3.2 The Seller shall also comply with the Buyer's on-site Construction Safety, Health and Environmental Management program.
- 3.3 The Seller shall be fully responsible for providing first aid equipment and other safety equipment required for their personnel.
- 3.4 The Seller's foreman shall be responsible for the safe execution of the work at the site. Seller shall conduct weekly safety meetings with their crew and send a representative to all site wide safety meetings.
- 3.5 All piping shall be verified to have no internal pressure before it is cut or the connection is opened. All electrical wiring will be removed by others.
- 3.6 When directed by LIGO, areas where removal is being done shall be roped off by construction tape, to warn other site personnel.
- 3.7 The Bidders shall submit their Safety Rating as part of their bid submittal and update it quarterly during the contract.
- 3.8 All Riggers shall meet all WA State and OSHA requirements for Riggers and Crane Operators.

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#### **4.0 LIGO Site Requirements**

4.1 The LIGO Observatories are ultra-clean research facilities. The Seller shall make every effort to maintain the normal LIGO cleanliness during installation activities. During equipment de-installation, it is realized that some dusting will occur. The Seller shall minimize the area affected by this dirty work by use of plastic rooms, vacuums, etc.

4.2 All installation work must be executed while maintaining the LIGO Cleanliness Requirements. Some work will require clean room garb and practices. Seller's staff shall have new steel toed shoes dedicated to the LIGO work. These shoes should remain on site for the duration of the work so as not to bring contamination from elsewhere. The Seller's personnel must report for work in clean unscented clothing (i.e. no smoke, hydrocarbons, etc.) and be free of after-shave lotions or perfumes. The Buyer will provide all cleanroom clothing and gloves when needed.

4.3 Smoking is only allowed outside the LIGO buildings. Personnel shall be Smoke-Free for 10 minutes before re-entering the LIGO facilities.

4.4 When BSC vessels are rolled across LIGO Building floors, sheets of metal shall be placed under the rollers to prevent permanent damage to the building concrete floors.

#### **5.0 Detailed Installation Scope**


All work shall be accomplished while maintaining the Cleanliness of the LIGO Research Facility.

The Buyer will conduct training for the Seller's personnel relative to site cleanliness requirements and other special site requirements prior to the start of the work.

#### **5.1 GENERAL WORK SCOPE**

General - To complete the scope of this specification, the Seller will need to remove and re-install large vacuum doors (stainless steel dished heads with o-ring seals – Approx. Wt. 1000 Lb.) and move heavy flanged equipment (Largest, BSC vessel – 17,000 Lb.). These pieces of equipment are bolted together with 7/8 inch fasteners which must be removed and replaced with hand tools. No impact wrenches are allowed. This work requires careful handling of heavy equipment (With critical O-Ring machined sealing surfaces on both ends) using Toe-jacks, Cranes, Forklifts, Hilman roller, etc.

Much of the installation work takes place under clean room conditions, so the workers must be garbed in Class 5 cleanroom suits when working in Cleanrooms. All equipment ports when not in a cleanroom shall have clean shipping covers installed on them. When ports are open inside a cleanroom, protective cleanroom cloth (provided by the Buyer) shall be kept over the open ports until the flanges are sealed up.

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General installation instructions are given below for each item in section 5.2. The seller shall use these general instructions and their site knowledge to prepare their own detailed removal and installation procedures. All Seller procedures must be approved by the Buyer before use.

All components have delicate large flanged sealing surfaces. Sealing surface must be protected from damage during all installation operations. A minor scratch in the metal sealing surface (32 RMS finish) will ruin the sealing surface.

All installation work shall be executed to LIGO Specifications referenced herein.  
All Viton O-Rings will be provided by the Seller.  
Each Building has a Class 5 pressurized air system which the Seller may use.

Any temporary bracing required during installation shall be supplied by the Seller. Any surface that touches LIGO equipments shall be Stainless Steel. (Wood blocking shall not be used)

Any Seller personnel operating the LIGO Building Cranes or Outside Cranes shall be certified to operate that piece of equipment as required by OSHA and the state of Washington.

All LIGO building traveling cranes are rated for 10,000 Lb. Max. These cranes cannot be used to lift BSC vessels.


## **5.2 DETAILED SCOPE**

The following work shall be executed by the Seller:

### **5.2 (A) Move Y (Left) Mid-Station BSC Chamber to Y (Left) End Station**

A BSC vessel -WBSC6 (See Dwg. D060139-v1, 3 files) is currently installed in the LIGO Mid-Station (anchored to the floor and grouted). This vessel must be removed from the Mid Station and move to the End Station. See the LIGO Y Mid-Station Building Layout (Dwg. D10003175-v2).

- 1) Verify with the buyer that the WBSC6 is vented to Atmosphere.
2. Before the BSC flanges can be un-bolted, the adjacent spool pieces (WA-7B1 & WA-14A) must be supported with temporary supports.. Supports can be made from Carbon Steel but shall have a SS surface where they touch the installed SS spool piece. The supports shall be designed so that the spools pieces can be slid 2 inches over the support when the bellows are compressed (Using the bellows tie-rods).
3. The BSC vessel is currently grouted in place. The grout must be chipped away under the vessel leg baseplates in order to lift the vessel. Place the rollers and Toe-jack under the BSC frame and make contact but do not try to lift the BSC. Grout removal must be done while maintaining building cleanliness. Plastic shields and vacuums shall be used as required to control the dusting and waste. Care must be exercised to not damage the anchor bolts which are holding the vessel weight. Chip away grout contacting the baseplate.
4. Once the baseplates are free from the grout and the area has been cleaned up, the Mid-Station cleanroom should be positioned over the BSC vessel (by the Seller). Once a Class 5 cleanroom environment is established by the cleanroom, the Seller (dressed in cleanroom suits) shall unbolt the two 60 inch beam-tube flanges and retract the beam-tube bellows 2 inches on each side of the BSC. This provides some room to pull the BSC out.

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Aluminum shipping covers (with Cleanroom material under them) shall be attached to the two 60 “ beam-tube flanges and the two BSC 60 “ flanges using nylon tie-raps . Once the shipping doors are installed on the beam-tube and BSC flanges, the Class 5 cleanroom can be craned to the far end of the building.

5) Once the BSC baseplates are free from the grout, the flange bolts removed and the bellows retracted, the BSC vessel can be lifted. Unbolt anchor bolts and lift the BSC off its anchor bolts using Toe-jacks mounted on a heavy duty roller system (i.e. Hilman rollers). The building floors shall be protected from damage while rolling the vessel across the flooring (metal sheets to distribute the weight).

6) The BSC must then be moved out of the Mid Station Building by winching the vessel using anchors set in the building floor. Existing LIGO equipment shall not be used for anchor points for winching. The BSC vessel shall first be moved into the building Air-lock. While in the closed Airlock, the BSC “Breather System” shall be attached to one shipping cover. With the interior door closed, the outer door may be opened. The vessel can then be winched down the sloped delivery ramp to an outside area where it can be picked up by a crane (using the appropriate spreader bar) and placed on a truck. The BSC shall be restrained at all times to prevent unplanned movement while moving it out of the building.

7) Once the BSC vessel is secured to the truck in the vertical position, it shall be slowly transported to the LIGO Y End Station.

### **5.2 (B) Install Y (Left) Mid-Station Spool**


1) Once the BSC vessel is removed from the Mid-Station, the New Mid-Station Spool (MSS) shall be immediately installed where the BSC was just removed. Move the MSS from the LIGO storage building to the Mid-Station and set it on the ground. Clean off the MSS outside prior to moving it into the Air-lock room.

2) Move the MSS into the air-lock room using temporary winches. With both doors closed, remove the final plastic shipping protection from the MSS. Clean the outside of the MSS prior to opening the interior door of the Mid-Station building. The MSS shipping covers (on the 60 inch flanges) remain in place until the MSS is protected by the Class 5 cleanroom. Replace the bolts on the shipping holes with nylon tie-raps.

3) Winch the MSS into the building far enough to get building crane access (MMS estimated shipping Wt. = 3500 Lb.) Close Air-lock inner door. Remove the MSS “Breather System” from the shipping door and cover the hole in the shipping door with cleanroom material

4) Lift the MSS (following vendor lifting instructions) with the building crane and set it carefully in between the Beam-tube 60” flanges. Align the MSS per Spec E1000716-v1 . The buyer will provide a surveyor to help locate the MSS on the beam centerline and will approve bolt hole locations prior to floor drilling. Once the MSS is aligned, the concrete anchor bolt locations can be marked on the floor. Next carefully lift the MSS with the building crane and move it aside to install the anchor bolts. Install the anchor bolts per specification E1000712-v1. Dust shall be controlled while drilling anchor holes by building plastic enclosures and vacuuming up dust as it is generated.

Once the concrete anchor bolt adhesive has cured, place the MSS over the anchor bolts and adjust the nuts to roughly align the 60 inch flange bolt holes (Per LIGO E1000716-v1).

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5) Using the building crane, position the cleanroom over the MSS and establish Class 5 Air Quality conditions. Once Class 5 air conditions are established, removed the 4 shipping doors and adjust flange bolt hole alignment (using baseplate nuts). Install Viton O-rings and torque flanges per LIGO Spec. E0900431-v1.

Next slowly releasing the tension on the bellows tie-rods, allowing the flanges to touch. Install Flange bolts and torque to specification.

6) After the alignment is approved by the Buyer, Grout the MSS leg anchors per Spec. E1000712-v1.

### **5.2 (C) Install Y (Left) End-Station New Components (BSC, A-16, A-17 & A-18 Spools)**

1) The BSC vessel WBSC-6 (Moved from the Mid Station) is installed 1<sup>st</sup> in the End station. After the BSC vessel is anchored to the floor, the remaining spools can be installed using the End Station cleanroom. Do not grout any supports until all components are installed and aligned. Install Flanges and o-rings per LIGO Spec E0900431-v1.

2) Lift the BSC from the truck and roll it into the End Station Building air-lock using winches from temporary anchors installed in the building and a roller system. With both Air-lock doors closed, wash off the BSC in the airlock before moving it into the End Station. When clean, move the BSC vessel into the End Station using the temporary winch system. Rough locate the BSC per LIGO Dwg. D1003177-v1 "End Station Adv. LIGO Equipment Layout".

3) The BSC vessel should be aligned per LIGO Spec. E1000716-v1. Align the BSC vessel and mark the floor where anchor bolts holes should be drilled. A baseplate hole template is required to accurately drill the anchor bolt holes. Anchor bolts shall be installed per LIGO Spec. E1000712 and E1000719-v1. Care shall be used to minimize contamination during anchor bolt hole drilling. The shipping doors should remain on the BSC during this installation work. After the concrete anchor bolt adhesive has cured, the BSC can be lifted onto the anchor bolts using the Toe-jack system (Using the nuts and washers to hold each BSC baseplate). Adjust the BSC Flanges to their final aligned position using the anchor bolt nuts. Tighten the anchor bolt nuts in stages per E1000712-v1. Grout all baseplates after spools (A-16,A-17 & A-18) have been installed in step 7.2 (C) 4.

4) Spools A-16, A-17 & A-18 have to be installed one at a time, due to access space limitations. All installation must be done under Class 5 cleanroom conditions.


4.1 Spool A-18 is installed first. Position the A-18 spool between BSC10 and BSC6 (near BSC10) using temporary supports. Move the cleanroom over A-18 and the 60 inch flange on WBSC10 and establish Class 5 air quality.

Once class 5 air quality is established, remove the 60 inch cover on WBSC10 and the shipping cover on the 60 inch end of A-18. Lift A-18 with the building crane and bolt-up to WBSC-10 while still supporting A-18 with the crane. Install Flanges and O-rings per LIGO Spec E0900431-v1.

Mark A-18 Anchor bolt locations on the floor. Un-bolt the 60 inch flange and set A-18 back on its temporary supports. Place 60 inch shipping covers on WBSC10 and A-18.

Move the cleanroom aside and install the A-18 concrete anchor bolts per LIGO E1000712-v1.

Once the concrete anchor bolt adhesive has cured, place the cleanroom back over A-18 and the WBSC10 60 inch flange and establish Class 5 air quality.

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Once class 5 air quality is established, remove 60 inch shipping covers. Clean and re-install all Viton O-rings. Use nuts and washers on the anchor bolts to help align the 60 inch flanges. Bolt A-18 to WBSC10. Wrap the 60 inch Vacuum cover to keep it clean and move it out of the cleanroom. It will be installed on the end of WBSC6 in a later step.

4.2 Spool A-16 is installed next. Move the cleanroom to cover the 60 inch flange on WBSC6 and A-16 and establish class 5 air quality.

Once class 5 air quality is established, remove the 60 inch shipping covers on A-16 and WBSC6 and install A-16 on WBSC6. Install Flange and o-ring per LIGO Spec E0900431-v1.

4.3 A-17 spool is installed next. With the shipping doors still attached, compress the A-17 bellows 2.0 inches using the bellows tie-rods.

Move the A-17 spool into the cleanroom and establish class 5 air quality.

Once class 5 air quality is established, remove the shipping covers and install cleanroom material on the flanges to protect the sealing surfaces during A-17 insertion. Move A-17 into position using the building crane.

Remove cleanroom material protecting flanged surfaces. Release the tension on the bellows tie-rods and bolt-up the flanges. Install Flanges and O-rings per LIGO Spec E0900431-v1.

5) Move the cleanroom to the far end of WBSC6 and establish class 5 air quality.

Once class 5 air quality is established, install the 60 inch vacuum door in place of the shipping cover on the end 60 flange of WBSC6. Install Flanges and O-rings per LIGO Spec E0900431-v1.

6) Once all spools are installed, aligned and Approved by the Buyer, install the baseplate grout per LIGO Spec. E1000712-v1.

### **5.2 (D) Move X (Right) Mid-Station BSC Chamber to Right End Station**

See Dwg. D1003176-v2. See Par 5.2(A) for the required procedure.


### **5.2 (E) Install Y (Right) Mid-Station Spool**

See Dwg. D1003176-v2. See Par 5.2(B) for the required procedure.

### **5.2 (F) Install Right End-Station New Components (A-16, A-17 & A-18) Spools**

See Dwg. D1003177-v1. See Par 5.2(C) for the required procedure.



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## **6.0 Equipment and Materials**

### **6.1 Equipment and Materials Supplied By the Buyer for use by the Seller:**

- A) 5 Ton Building Cranes in each building and associated new lifting straps (for use inside the LIGO Buildings only).
- B) “Baked” Viton O-Rings for each sealing flange
- C) Clean small tools for removing nuts and bolts on equipment flanges (For use inside LIGO buildings only)
- D) Cleanroom clothes and Cleanroom material for protecting flange sealing surfaces
- E) All new vacuum equipment spools including nuts and bolts.

### **6.2 Equipment and Materials Supplied By the Seller:**

The Seller must provide all additional materials needed to accomplish the scope of this specification that are not provided by the Buyer. These items include (but are not limited to) site outdoor crane, trucks, adhesive anchor bolts, grout, nuts, washers, etc. (All installation materials shall be purchased per specifications contained herein).

## **7.0 DOCUMENTATION**

The Seller shall provide all documentation listed below:

- A) Detailed equipment installation procedures
- B) “As Installed Drawings” showing the exact location of all installed equipment. The equipment shall be referenced to building walls and Survey Monuments.
- C) Grout testing reports
- D) Completed Alignment Data Sheets

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EQUIPMENT INSTALLATION****9.0 ATTACHMENTS SUMMARY**

The following attachments referenced herein are part of this specification and are available via the links in the Statement of work (SOW) - C1002601-v4:

**LIGO Building Equipment Layout Drawings:**

- A) ALIGO Installation, LHO Y Mid Station Equipment Layout - D1003175-v2
- B) ALIGO Installation, LHO X Mid Station Equipment Layout - D1003176-v2
- C) ALIGO Installation, LHO Y End Station Equipment Layout - D1003177-v2
- D) ALIGO Installation, LHO X End Station Equipment Layout - D1003178-v2

**Equipment Outline Drawings:**

- E) BSC Vessel Outline Drawing - D060139-v1
- F) LHO End Station Spools:
  - 1. WA-16 - D1100110-V1-v2
  - 2. WA-17 - D1100111-V1-v2
  - 3. WA-18 - D1100112-V1-v2
- G) LHO Mid Station Spool - D1100113-V1-v2

**Specifications**

- H) Spec. for Anchor Bolt / Grout Installation - E1000712-v1
- I) Spec. for Contamination Control - E1000719-v1
- J) Spec. for Component Alignment - E1000716-v1
- K) Spec. for O-Ring and Flange Installation - E0900431-v1