

LIGO**SPECIFICATION**

Drawing No Vers.

Sheet 1 of 9

SPECIFICATION FOR ANCHOR BOLTS AND GROUTING

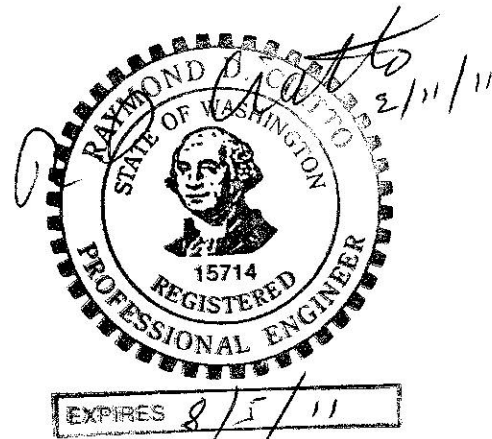
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DCC RELEASE							

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**SPECIFICATION FOR ANCHOR BOLTS AND GROUTING****1.0 PURPOSE**

1.1 This specification covers the minimum requirements of equipment anchor bolt installation for the Advanced LIGO modification of the LIGO Observatories. The initial issue of this specification applies to equipment concrete anchors and grout at the WA LHO Mid and End Stations only. The WA and LA Corner Stations were added in Version 3 (V3) of this specification. Any attachments are incorporated herein by reference and made a part of this specification.

The components to be installed are part of the Advanced LIGO upgrade of the Laser Interferometer Gravitational-Wave Observatory (LIGO). LIGO is operated by Caltech and the Massachusetts Institute of Technology (MIT) under a NSF grant and includes two observatories, one located in the Hanford Reservation (near Richland, WA) and a second in Livingston, LA.

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

1.2 It is the Seller's responsibility to follow these requirements or to propose alternate procedures and specifications to meet the requirements. All alternate approaches must be approved by the Buyer before use.

2.0 GENERAL

The Hilti HVA capsule adhesive anchoring system will be used to install LIGO vacuum equipment to concrete floor slabs. Concrete anchors have been sized and arranged to restrain the equipment against operating and seismic loads, including unbalanced vacuum loads that occur during normal operation. Proper installation of the anchors is required to ensure satisfactory performance of the vacuum equipment. Installers shall be trained in proper installation of concrete anchors. Hilti Corporation provides on-site installer training.

The seller is responsible for providing a baseplate drilling template for each vacuum component anchor baseplate. The template shall be fabricated from carbon steel plate using the anchor bolt centerline dimensions and holes sized for minimum drill clearance to promote accurate hole drilling.

Component base plates will be anchored to the floor slabs that are constructed of 4000 PSI concrete. It is the intent of this specification that the anchors be installed in accordance with the manufacturer's requirements.

**SPECIFICATION FOR ANCHOR BOLTS AND GROUTING****3.0 RESPONSIBILITY**

The installation contractor (Seller) is responsible for implementing this specification. Conflicts, if any, between this specification, manufacturer's installation requirements or other specifications of this project shall be brought to the attention of the Buyer prior to the start of installation.

The seller shall submit an anchor installation procedure for the Buyer's approval prior to installation. Provisions for QC inspection and documentation shall be included in this procedure.

The Seller shall install the anchor bolts while minimizing contamination to the LIGO buildings and in accordance with LIGO Specification LIGO_E100719 "Contamination Control".

4.0 ANCHOR BOLT REQUIREMENTS

4.1 Reference:

Hilti North American Product Technical Guide, 4.2.1 – HVA Adhesive System, Hilti, Inc., Tulsa, OK, (www.hilti.com) 2008 Edition, pp. 151-166. See the following sections of the Technical Guide for installation and ordering information, respectively:

Section 4.2.1.4 Installation Instructions

Section 4.2.1.5 Ordering Requirements

- 4.2 Equipment shall be aligned per specifications LIGO_E1000716 prior to drilling the anchor bolt hole. Equipment anchor bolt requirements are detailed in Attachment A of this specification.
- 4.3 Locate and install anchor bolts in accordance with this specification and the installation drawings. A baseplate hole template shall be used to accurately drill all anchor bolt holes. The hole location tolerance is +/- 1/16 in of position marked on concrete floor. Holes shall be plumb to within 1° of vertical. Embedment depths shown in this specification are minimum depths for the equipment listed. The anchor bolt installation hole depth tolerance is minus 0 inches / plus 1/4 inch. Drill holes using approved equipment to ensure full design bond strength and to maintain project cleanliness requirements. A Hilti DD-B or DD-C diamond core bit may be used to core drill holes for the HVA adhesive anchors. Rebar cutting is permitted. All hole depths shall be verified and noted on the QA sheet prior to anchor installation.
- 4.4 Attachment B shows the typical threaded rod installation.

**SPECIFICATION FOR ANCHOR BOLTS AND GROUTING**

Attachment “A” to this specification specifies the type of Hilti anchor to use for each anchor location. For the Standard rod, both the locking nut and the leveling nut shown on Attachment B shall conform to compatible nut material ASTM A563, Grade A. For the Super HAS rod, both the locking nut and the leveling nut shall conform to compatible nut material ASTM A563, Grade DH.

Washer material shall conform to ASTM F436.

For the LHO Mid and End stations only the Super HAS rod (ASTM A193, B7) with compatible washers and nuts shall be used.

4.5 Adhere to curing time required by Hilti before loading or disturbing anchors. The minimum cure time for this project is 2 hours.

4.6 Prior to placing grout, tighten nuts to the following torque:

3/4” – 175 ft. lbs.

1” rod - Super HAS rod – 100 ft. lbs.

Standard HAS rod – 100 ft. lbs.

A wrench on the leveling nut shall be used to hold it while the upper nut is torqued.

4.7 After grout has cured, tighten nuts for 1” rod as follows:

Super HAS rod – 400 ft. lbs.

Standard HAS rod – 250 ft. lbs.

5.0 BASEPLATE GROUTING REQUIREMENTS

5.1 Baseplate Grout shall be installed per the following:

Base plate grout shall be the flowable type and it shall meet with the requirements of ASTM C1107 for nonshrink, nonmetallic grout.

Grout testing shall be performed as required by Attachment C of this specification

The minimum grout strength shall be 7000 psi at 28 days.

**SPECIFICATION FOR ANCHOR BOLTS AND GROUTING**

Acceptable grout products are:

1. Five Star Grout - manufactured by: Five Star Products.
2. Masterflow 928 - manufactured by: BASF Chemical Co.
3. Masterflow 713 - manufactured by: BASF Chemical Co.

Application Notes:

- a. Grout must be mixed outside the vacuum equipment areas and applied in a manner to minimize contamination. (See Spec. E1000719 "Contamination Control")
- b. The undersides of all base plates shall be clean. Removal of paint is not required. The concrete surface shall be stripped of sealant, roughened and dampened prior to placing grout.
- c. At base plate locations which are required to be scarified, indentations in the concrete shall be a minimum of 1/4 inch.
- d. Grout shall be mixed, placed and cured in accordance with the manufacturer's instructions. Care shall be taken during grout installation to avoid voids in the grout pad (proper vent holes, vibration, etc.)
- e. Curing shall continue for a minimum of 7 days per the manufacturer's specifications.
- f. Grout test and QC inspection reports shall be provided to the Buyer.

- 5.2 Due to floor/beam tube center line angle/manufacturing tolerances, all beam line vessels (BSC, HAM, etc.) base plates will require between 2 to 4+ inches of grout.

6.0 QUALITY ASSURANCE

Quality Control inspection shall be documented to ensure the following:

- Materials conform to this specification.
- Holes are drilled with proper equipment thereby achieving proper diameter.
- Hole depth conforms to anchor manufacturer's requirements and this specification.
- Hole is cleaned.
- Rod is embedded to specified requirement.
- Nuts are preloaded to specified torque.
- Grout is mixed, placed, cured and tested per grout manufacturer's requirements.
- Baseplate areas have been scarified as specified herein

A QA record sheet shall be filled out for each component and delivered to the Buyer at the end of the project.



SPECIFICATION

SPECIFICATION FOR ANCHOR BOLTS AND GROUTING

ATTACHMENT "A" TO E1000712

ANCHOR REQUIREMENTS

REQUIRED CONCRETE ANCHORS FOR VACUUM EQUIPMENT (New HAM Tag Numbers Used-See note 8)

Component Tag No.	Anchor Diameter	Quantity	Rod Length	Minimum Embedment Depth	Notes
LHO Y END STATION					
WBSC-6	1	8	15 1/8"	8 1/4"	1
"	1	8	19 1/4"	12 3/8"	1, 2
A-18	1	8	15 1/8"	8 1/4"	1
LHO Y MID STATION					
MSS	1	16	19 1/4"	12 3/8"	1
LHO X END STATION					
WBSC-5	1	8	15 1/8"	8 1/4"	1
"	1	8	19 1/4"	12 3/8"	1, 2
A-18	1	8	15 1/8"	8 1/4"	1
LHO MID STATION					
MSS	1	16	19 1/4"	12 3/8"	1
LHO CORNER STATION					
WHAM-1	1	24	20 ea -15 5/8"/4 ea -19 3/4"	8 1/4"/12 3/8"	5, 6
WHAM-6	1	24	20 ea -15 5/8"/4 ea -19 3/4"	8 1/4"/12 3/8"	5, 6
WHAM-12	1	24	20 ea -15 5/8"/4 ea -19 3/4"	8 1/4"/12 3/8"	5, 6
WHAM-7	1	24	20 ea -15 5/8"/4 ea -19 3/4"	8 1/4"/12 3/8"	5, 6
MCA (Qty-4)	1	16	15 5/8"	8 1/4"	7
MCB (Qty-4)	1	16	15 5/8"	8 1/4"	7
LLO CORNER STATION					
LHAM-1	1	24	20 ea -14 1/8"/4 ea -18 1/4"	8 1/4"/12 3/8"	5, 6
LHAM-6	1	24	20 ea -14 1/8"/4 ea -18 1/4"	8 1/4"/12 3/8"	5, 6
MCA (Qty-2)	1	16	14 1/8"	8 1/4"	7
MCB (Qty-2)	1	16	14 1/8"	8 1/4"	7

**SPECIFICATION FOR ANCHOR BOLTS AND GROUTING****Notes:**

1. Install Hilti HVA anchors with HVU capsules and HAS 'Super' rods, unless otherwise noted, in accordance with this specification. Rod shall be provided with 45° chisel or cut point to provide proper mixing of adhesive components.
2. For BSCs use 12 3/8" minimum embedment for base plates at end of beam arm (8 anchors ea BSC).
3. The minimum anchor cure time shall be 2 hours.
4. Temporary anchors used to winch heavy components for alignment or installation shall be 1 inch Hilti "Kwik Bolt 3" carbon steel anchors with 6 inch minimum embedment. Temporary anchors shall be cut off and sealed after use.
5. Use HAS 'Standard' rods for these anchors. Rod shall be provided with 45° chisel or cut point to provide proper mixing of adhesive components. Scarify floor.
6. For each of these components, the 4 long anchor bolts with 12 3/8" embedment shall be installed at the end of the beam arm.
7. Use HAS 'Standard' rods except anchors connected to diagonal members shall use 'Super' rods.
8. The Advanced LIGO modification has renumbered HAM Vessel Tag Numbers as follows:

LA (LLO): Old LHAM1 now LHAM2,
Old LHAM2 (Moved HAM) now LHAM1,
Old LHAM5 (Moved HAM) now LHAM6,
Old LHAM6 now LHAM5

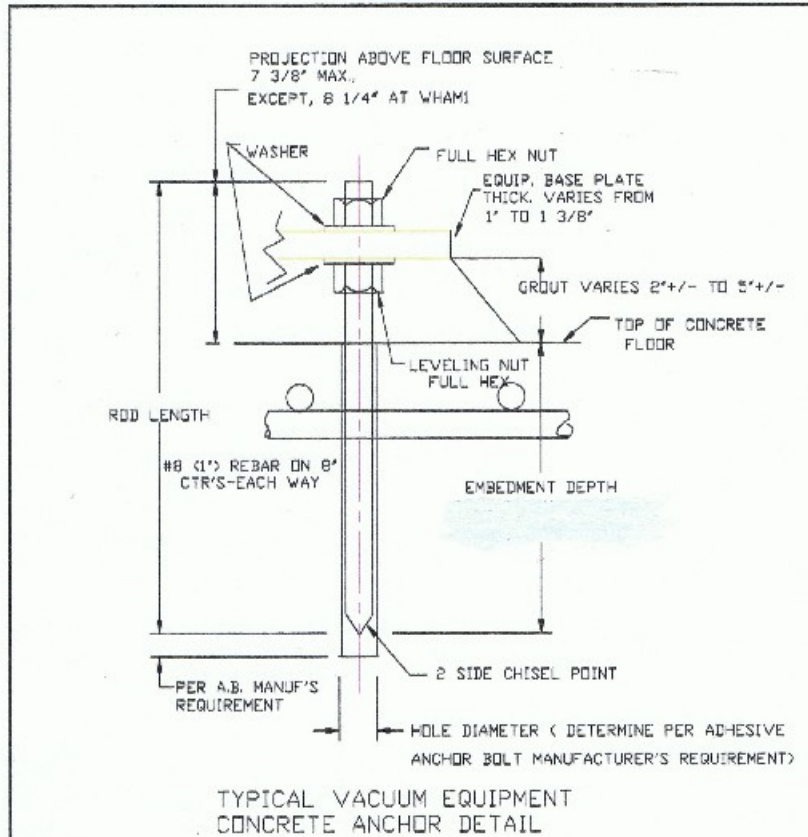
WA (LHO): Old WHAM1 now WHAM2,
Old WHAM2 (moved HAM) now WHAM1,
Old WHAM5 (Moved HAM) now WHAM6,
Old WHAM6 now WHAM5,
Old WHAM8 (Moved HAM) now WHAM7,
Old WHAM7 now WHAM8,
Old WHAM11 (Moved HAM) now WHAM12,
Old WHAM12 now WHAM11

This specification references the New Tag Numbers.



SPECIFICATION FOR ANCHOR BOLTS AND GROUTING

Attachment B - Anchor Detail



REF INSTALLATION SPEC

1	ISSUED FOR CONSTRUCTION			REC	09/30/97	0581	
3	ISSUED FOR CONSTRUCTION			REC	09/08/97	0548	
REV.	ISSUE DESCRIPTION	ENG.	CHKD	DRWN	DATE	DESB	
DO NOT SCALE THIS DWG.							
				PROCESS SYSTEMS INTERNATIONAL INC. 30 VALLEY DR. WESTBOROUGH, MASSACH. 01581 USA			
				CONCRETE ANCHOR DETAIL LARGE EQUIP. ADHESIVE TYPE LIGO VACUUM EQUIPMENT			
CIS FILE		SIZE		PAGE NO.		REV.	
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**SPECIFICATION FOR ANCHOR BOLTS AND GROUTING****ATTACHMENT "C"
(Attachment to E1000712)****GROUT TESTING**

1. Purpose

Grout will be placed below vacuum equipment support base plates. Compression tests will be performed to ensure that the quality of the grout is acceptable. Anchor Bolts will be installed per this specification.

2. Reference Documents

- a. ASTM C1107, Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink).
- b. ASTM C109, Standard Test Method for compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens).

3. Test Method

The test method of ASTM C109 shall apply.

4. Frequency of Tests & Number of Specimens

One set of tests shall be performed for each day that grout is placed. Each set shall consist of three specimens that are cast in accordance with ASTM C109. Compression tests shall be performed at 7, 14, and 28 days.

5. Reports

Test reports shall be provided to the Buyer within 3 days of completion of each compression test.