

This document covers the technical content for acceptance review of a subset of the Advanced LIGO (aLIGO) installation. See document [M1300468](#) for an overview of the aLIGO acceptance process. Acceptance by Systems Engineering is to be indicated in the metadata for this document in the LIGO Document Control Center (DCC).

1 Installation Instance/Subset Definition

Modifications to the LHO Vacuum Equipment consisted of the following:

- Relocation of HAM2 and HAM5.
- Installation of large diameter mode cleaner tubes between the relocated HAM chambers on both the input and output arms.
- Installation of septum vacuum plates between HAM1/HAM2 and HAM5/HAM6.
- Installation of new pumps and instrumentation at HAM1 and HAM6.
- Although not part of the H1 installation, similar changes were made to the diagonal vacuum section.(H2)
- In addition the H2 BSC end chambers were relocated to the END stations.

Interferometer [<i>L1 or H1</i>]:	H1
Building(s)/Room(s): [<i>e.g. corner/LVEA</i>]	Vacuum Equipment
Vacuum Chamber(s):	All Vacuum Equipment
Electronics Rack Designation(s):	N/A
Optics Table(s)/Enclosure(s) Designation(s), and other equipment/assemblies related to this installation:	N/A

2 Procedures and Modifications

If there are any caveats or explanatory notes regarding the procedure documentation or modifications cited in the table below, then add these notes to the table entries.

Vacuum Modifications (LLO and LHO)	Refer to section 1 of FMP Acceptance Review at the following link LIGO-E1300450-v6 .
LHO Vacuum Modifications	Refer to LHO alog https://alog.ligo-wa.caltech.edu/aLOG/index.php <i>Search criteria</i> <i>Author(s):</i> kyle.ryan@LIGO.ORG john.worden@LIGO.ORG (Any) <i>Keyword(s):</i> vacuum (Exact string) Some specific alogs: #840 #877 #869 #788 #596 #589 #1780 , BSC5 move underway
Baseline or initial Installation Procedure(s):	E1000708-aLIGO WA Corner Station VE Installation Specification

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<p><i>[enter linked DCC document #(s); found under E1200023]</i></p>	<p>and E1000712-Anchor Bolt Installation Extract from FMP Acceptance Review section 1 refer to LIGO-E1300450-v6.</p>
<p>As-Built/Installed Procedure(s), either:</p> <p>a) Enter hyperlinked DCC number for revised or red-lined baseline install procedure, and/or</p> <p>b) Enter hyperlinked DCC number for separate document with installation notes on deviations, changes in procedure, changes in tooling, etc., and/or</p> <p>c) Enter a list of hyperlinked electronic log entries detailing the experience in applying the baseline installation procedure</p>	<p>Refer to LHO alog https://alog.ligo-wa.caltech.edu/aLOG/index.php</p> <p><i>Search criteria</i> <i>Author(s): kyle.ryan@LIGO.ORG</i> <i>john.worden@LIGO.ORG (Any)</i> <i>Keyword(s): vacuum (Exact string)</i></p>
<p>Baseline or initial Alignment Procedure(s):</p> <p><i>[enter linked DCC document #(s); found under E1100734]</i></p>	<p>E1000716-Component Alignment Procedure. Extract from FMP Acceptance Review section 1 refer to LIGO-E1300450-v6.</p>
<p>As-Built/Aligned Procedure(s), either:</p> <p>a) Enter hyperlinked DCC number for revised or red-lined baseline alignment procedure, and/or</p> <p>b) Enter hyperlinked DCC number for separate document with alignment notes on deviations, changes in procedure, changes in tooling, etc., and/or</p> <p>c) Enter a list of hyperlinked electronic log entries detailing the experience in applying the baseline alignment procedure</p>	<p>Refer to LHO alog https://alog.ligo-wa.caltech.edu/aLOG/index.php</p> <p><i>Search criteria</i> <i>Author(s): kyle.ryan@LIGO.ORG</i> <i>john.worden@LIGO.ORG (Any)</i> <i>Keyword(s): vacuum (Exact string)</i></p>

3 Drawings

Enter hyperlinked DCC document number(s) for each drawing in the table below. If elements of the table are not applicable, enter "not applicable". All chamber-level, assembly drawings can be found listed at [E1200562](#) and found linked under [D0901491](#).

<p>Applicable Building/Room Top-Level Drawing(s):</p>	<p>As-built vacuum equipment drawings (D990684-v1, also can be viewed here with LVC pwd). The above links are the best links / pointers to the detailed drawings supplied by the contractor.</p>
<p>Top-Level Corner & End Station Vacuum Drawing(s):</p>	<p>LIGO-D0901865: AdvLIGO, Vacuum Equip Layout, LHO Corner Station LIGO-D0901867: AdvLIGO, Vacuum Equip Layout, LHO Y-End Station LIGO-D0901468: AdvLIGO, Vacuum Equip Layout, LHO X-End Station</p>
<p>Chamber Level Vacuum Drawings (HAM)</p>	<p>LIGO-D0901820: AdvLIGO VE HAM1-H1 Vacuum Equip Assembly LIGO-D0901084: aLIGO VE HAM2-H1 Vacuum Equipment Assembly LIGO-D0901095: AdvLIGO VE HAM3-H1, Vacuum Equip Assembly LIGO-D0901126: AdvLIGO VE HAM4-H1, Vacuum Equip Assembly LIGO-D0901130: AdvLIGO VE HAM5-H1, Vacuum Equip Assembly</p>

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	LIGO-D0901823: AdvLIGO VE HAM6-H1, Vacuum Equip Assembly
Chamber Level Vacuum Drawings (BSC)	LIGO-D0901138: AdvLIGO VE BSC1-H1, Vacuum Equip Assembly LIGO-D0901143: AdvLIGO VE BSC2-H1 Vacuum Equipment Assembly LIGO-D0901147: AdvLIGO VE BSC3-H1 Vacuum Equipment Assembly LIGO-D0901151: AdvLIGO VE BSC9-H1, Vacuum Equip Assembly LIGO-D0901155: AdvLIGO VE BSC10-H1, Vacuum Equip Assembly

4 Serial Number Records

Serial numbers are used to track a subset of the parts, particularly active elements (see [M1000051](#)) and electronics (with S-numbered documents; see [T0900520](#)). Enter the hyperlinked DCC document number(s), and name(s) for the highest level assembly(ies) covered by this installation acceptance document in the table below. Also enter the hyperlink to the ICS entry for the instance of this assembly in the Inventory Control System (ICS). If elements of the table are not applicable, enter "not applicable". If elements of the table are not available/missing, then enter "not available".

Assembly DCC D- Number	Assembly Name	ICS entry
	All Vacuum Equipment	N/A (assembly and install done before ICS)

5 Testing

All post-installation, stand-alone, in situ, checkout/testing (phases 2 and 3 per [M1000211](#)) must be completed, be successful and be documented:

- phase 2: pre-installed, post-storage, test results for the assembly (testable item)

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- phase 3: stand-alone, in situ test results for the assembly (testable item)

Note that integrated testing (phase 4 testing per [M1000211](#)) is covered under the system acceptance review, not this installation acceptance review. In the table below, enter hyperlinked DCC document number(s) for all of the relevant testing for the major subassemblies/subsystems covered within this installation instance/subset. If elements of the table are not applicable, enter "not applicable". If elements of the table are not available/missing, then enter "not available".

Subsystem	Testable Item	DCC document numbers	
		Phase 2	Phase 3
FMP	Vacuum Equipment (Analysis)	C1001600-GNB FDR Submittal Topsfield Analysis Extract from FMP Acceptance Review section 1 refer to LIGO-E1300450-v6 .	
FMP	Vacuum Equipment (Inspection and install)	Q1300009-aLIGO Spool Component Inspection Reports from GNB Corp. Extract from FMP Acceptance Review section 1 refer to LIGO-E1300450-v6 .	Refer to LHO alog https://alog.ligo-wa.caltech.edu/aLOG/index.php Search criteria Author(s): kyle.ryan@LIGO.ORG john.worden@LIGO.ORG (Any) Keyword(s): vacuum (Exact string)

6 Installation Completeness

If/as applicable, provide a hyperlink reference to a list of remaining tasks to be completed before the installation is finished (i.e. a 'punch' list).

Installation tasks remaining to be completed:	All items are installed.
Leak testing (Beam Tube)	In light of the Beam Tube leak at LLO, RGA accumulations were performed on the 4 Beam Tube modules at LHO. No significant leaks were identified. Refer to LHO alog https://alog.ligo-wa.caltech.edu/aLOG/index.php Specific alogs: #14167 #14173 #12358 #5666

7 Installation/Integration Issues and ECRs

If/as applicable, provide a hyperlinked list of integration issues and Engineering Change Requests (ECRs) encountered during installation and which are relevant to the installation subset/instance covered by this acceptance document. See [M1300323](#) for a description of the Integration Issue and ECR Tracker.

On review it appears elog is used more than bug tracker for vacuum related work refer to Refer to LHO alog <https://alog.ligo-wa.caltech.edu/aLOG/index.php>

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Tracker # <i>[hyperlinked]</i>	Title/description
Bug 81 (accepted whenvent)	add vacuum hardware to TM chambers for future instruments without venting
Bug 846 (accepted whenvent)	WHAM1 ALS viewport scratched and must be replaced
Bug 761 (accepted onhold)	In Situ, Visual Inspections of All Viewport Windows
Bug 941 (accepted whenvent))	Installation of ESD pressure switches into LVEA chambers
Bug 949 (accepted pending)	Inadequate Current Limitation to In-Vacuum Wiring?
Bug 493 (Closed)	Vacuum safety concern & leak -- inadequate o-ring compression on TCS viewports
Bug 80 (Closed)	Possibility of damage to ESD pattern on ERMs and CPs due to arcing