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LAWRENCE LIVERMORE NATIONAL LABORATORY

Engineering Specification Document (ESD) of X-ray Vacuum Transport System (XVTS) for LCLS XTOD

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Disclaimer

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LCLS Engineering Specifications Document # 1.5-100	XTOD Vacuum Tunnel System	Revision 0

XTOD - XVTS

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Brief Summary:

This design specification covers the minimum engineering requirements for XVTS, the tunnel segment of the XTOD section of the LCLS. It reviews physics requirements and specifies the system configuration, selection of the vacuum components, and structural design. Also included are the requirements of plans for procurement, mechanical integration, project schedule and the cost estimates.

Change History Log

Rev Number	Revision Date	Sections Affected	Description of Change
000		All	Initial Version

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1 Introduction

The vacuum system of the X-Ray Vacuum Transport System (XVTS) for the Linac Coherent Light Source (LCLS) X-ray Transport, Optics and Diagnostics (XTOD) system has been analyzed and configured by the Lawrence Livermore National Laboratory's New Technologies Engineering Division (NTED) as requested by the SLAC/LCLS program. The preliminary system layout, detailed analyses and suggested selection of the vacuum components for the XTOD tunnel section are presented in the preliminary design report [1]. This document briefly reviews the preliminary design and provides engineering specifications for the system, which can be used as "design to" specifications for the final design. Also included are the requirements of plans for procurement, mechanical integration, schedule and the cost estimates.

1.1 General Description

The XVTS, the tunnel segment of the XTOD section of the LCLS, is 190 meters long as measured between gate valves (Fig. 1.1 , 1.2 and 1.3). There are 3 x-ray beam transport lines with an outer diameter of 4" that serve to transport the beam from the end of the Near Experimental Hall (NEH) to the Far Experimental Hall (FEH).There are no other components aside from the vacuum equipment that reside in this area The vacuum requirements are to design a system that can be continuously operated for 10 years with minimal maintenance. In addition, the pressure within the line should have reasonable minimal impact on the x-ray beam loss (Fig. 1.4).

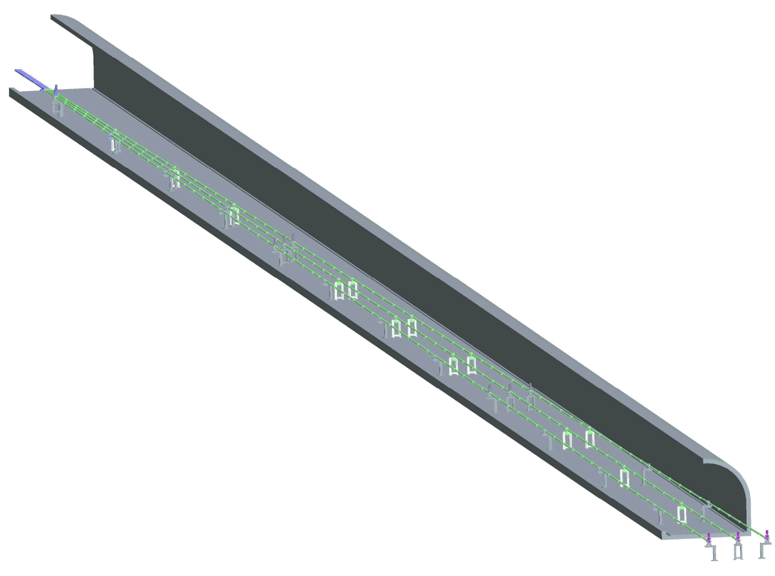

Figure 1.1. XVTS System View-1

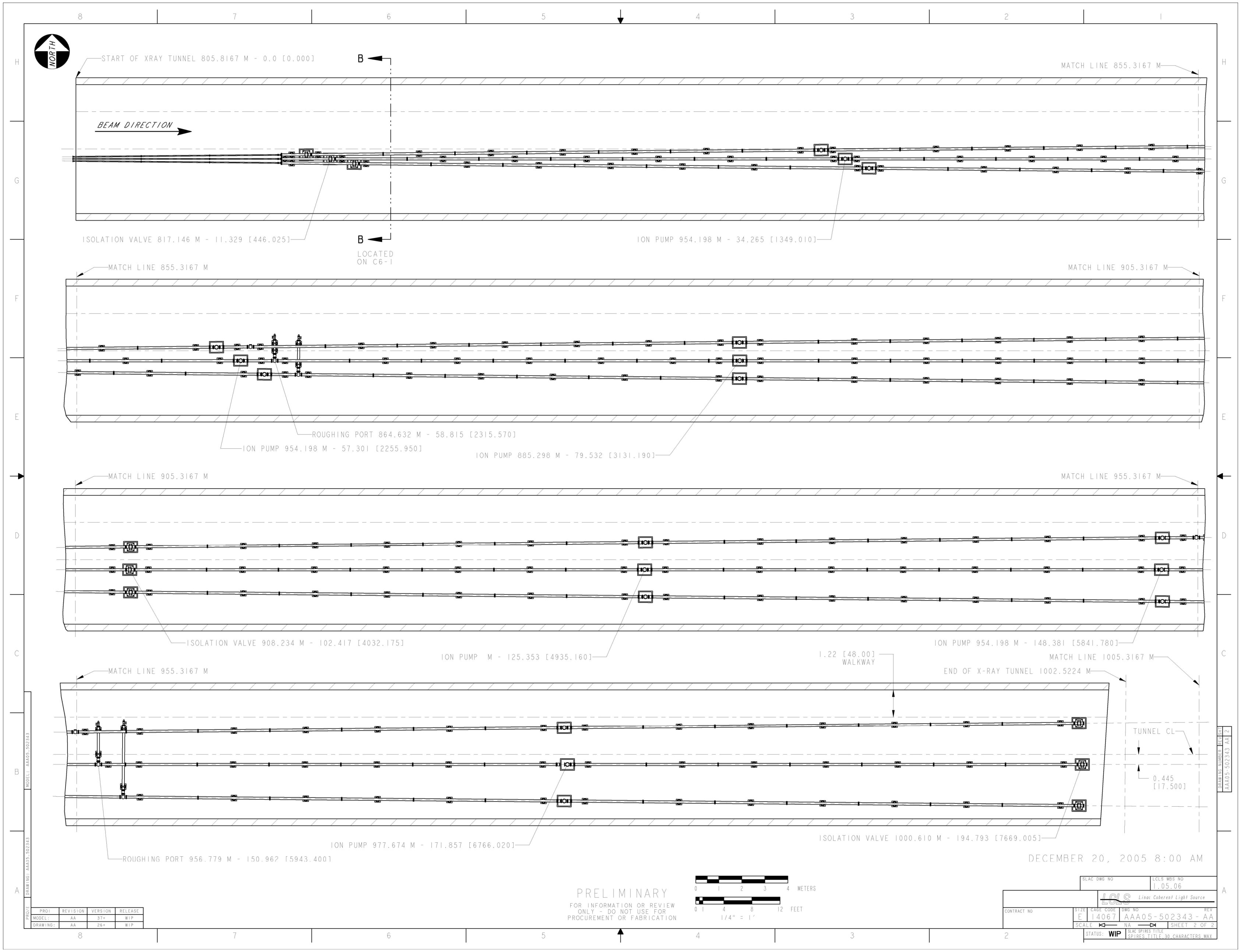

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Fig. 1.2 XVTS System Configuration

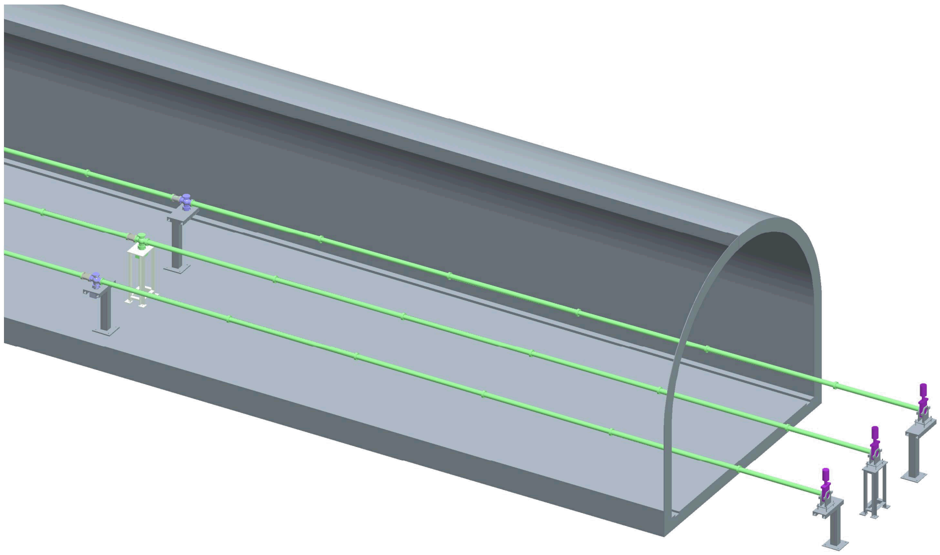

Figure 1.3. XVTS System View 2

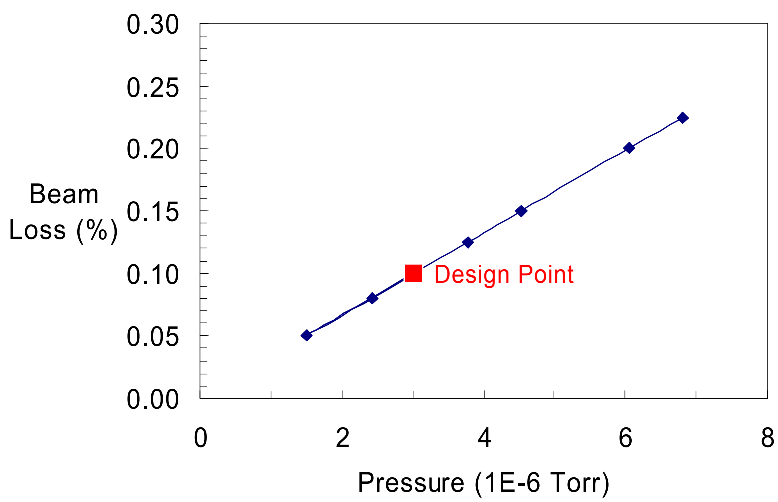

Figure 1.4. Per-cent Beam Loss of an 818-eV X-ray Beam over 370 meters

1.2 Deliverables

The engineering design effort includes designing a vacuum system that meets the pumping requirements and integrates with the XTOD tunnel structure. The design tasks include the following:

1. Specification of the configuration of vacuum system components, including the layout of vacuum lines and interfaces.
2. Engineering calculations for vacuum pump-down rates, system outgas rate and base pressures, pumping speeds, etc.
3. Selection and specification of valves, bellows, seals, and other general vacuum hardware.
4. Selection and specification of high vacuum pumps.
5. Design of system instrumentation and controls, with P&ID drawings.
6. Design of system operation and safety features.
7. Specifications and procedures for material preparation and cleaning.
8. Installation Plan.
9. Cost estimates for procurement.
10. Project schedule.
11. Formal presentation of the design, including a written report covering all of the above mentioned aspects.

1.3 System Requirements References

All documents relevant to the Physics Requirements for XVTS system are listed in the following table (Table 1.1).

Reference No.	Document No.	Issued Date	Description
[2]	LCLS PRD # 1.5-001	5/14/04	Requirements for the LCLS X-Ray Transport and Diagnostics
[3]	LCLS ESD # 1.1-302	7/26/05	LCLS Mechanical Vacuum Specifications
[4]	LCLS PRD # 1.5-002	1/20/06	Physics Requirements for the XTOD Mechanical-Vacuum Systems
[5]		11/16/05	LCLS Conventional Facility Title II – 60% Submitted Drawings
[6]	SLAC-I007-12004 -001 RI	4/17/03	SLAC Vacuum Department Guidelines for Vacuum Systems

Table 1.1. List of Reference Documents

2 Performance Specifications

2.1 Physics Requirements – PRD for XTOD

"Physics Requirements for the LCLS X-Ray Transport and Diagnostics" – Beam Transport Requirements [1] states that:

"The vacuum flight path must be sized to exclude the possibility of being struck by the x-ray beam. The average pressure throughout the system should be less than 10^{-5} Torr. In addition, the pressure at the ion pumps must be low enough to ensure long pump life (> 10 years). Vacuum components that are highly susceptible to radiation damage, such as elastomer o-rings, are discouraged. In general, SLAC standard procedures for cleaning and handling of UHV components must be followed."

2.2 Physics Requirements – PRD for XTOD Mechanical-Vacuum System [3]

Relevant requirements for XVTS are summarized below:

1. **Vacuum Systems: General**
    - 1.1. Follow LCLS ESD 1.1-302 and SLAC-I-007-12004-001.
    - 1.2. Hydrocarbon-free, all-metal systems.
    - 1.3. Design pressure in particular sub-system must consider requirements of adjacent systems.
    - 1.4. The design pressure of XVTS must consider the pressure requirements of all adjacent sub-systems.
    - 1.5. According to PRD 1.5-001:
        - 1.5.1. Average pressure less than 10^{-5} Torr
        - 1.5.2. Pressure at ion pumps low enough to ensure pump life > 10 years
        - 1.5.3. Components highly susceptible to radiation damage discouraged

2. **Vacuum-Mechanical Systems**

    Minimize outgassing and improve reliability by placing precision mechanics OUTSIDE vacuum (whenever possible), and use metal bellows to transfer motions to simple shapes in-vacuum.

3. **Mechanical Rigidity**
    - 3.1. For precision mechanical systems, avoid amplification of floor vibrations by using designs with sufficient rigidity. In most locations, the amplitudes of floor vibrations fall rapidly with increasing frequency. At the Stanford Synchrotron Radiation Laboratory, mechanical designs whose fundamental modes of vibration generally lie above 120 Hz have proven successful.
    - 3.2 Use damping foils in support structure joints to attenuate transmission from floor to system.

4. Standard Alignment Provisions

4.1. Provide standard tooling-ball sockets and alignment degrees-of-freedom to enable fiducialization, alignment and installation by the SLAC Alignment Group.

4.2. Provide "traveler" document to detail fiducialization, alignment and installation sequence and tolerances.

5. Beam Clearance Specifications

5.1. According to PRD 1.5-001, the vacuum flight path must be sized to exclude the possibility of being struck by the x-ray beam." The motivation for this statement is interpreted as follows: Components which may be damaged if struck by the beam must not be struck. Also, irrespective of a damage issue, components which, if struck, would result in the generation of significant radiation background in occupied areas, must not be struck. Therefore, the FEL beam, the spontaneous beam or both may have to be considered, depending on the specific situation.

5.2. Require FEL beam clearance of 3 mm minimum to components which may be damaged by beam strike. 5 mm desired. 2 mm only with special considerations and means to assure clearance.

5.3. Calculate full mis-steer envelope for any component which may be damaged by beam strike. These calculations must be based on verifiable specifications for beam source location and direction worst-case variation, or fixed apertures and their alignment tolerances.

6. Controls Specifications

6.1. According to PRD 1.5-001, all control systems must be EPICS compatible. EPICS-based systems are preferred.

7. Documentation

7.1. Drawings of all LCLS collaboration hardware shall be generated, exchanged and delivered as agreed to in ESD 1.1-320, "LCLS Collaboration Drawing Control".

7.2. Copies of vendor-provided instruction and operation manuals shall be supplied for all purchased components.

7.3. System operation documentation shall be developed and provided.

2.3 Physics Requirements Summary

Taking all consideration into account, the Tunnel "Physics" Requirements can be summarized as:

1) The vacuum flight path must be sized to exclude the possibility of being struck by the x-ray FEL beam.
2) The attenuation of the X-Ray beam through the residual gas must be less than 0.1%, implying a maximum average pressure of $< 10^{-5}$ Torr.

3) In addition, the pressure at the ion pumps must be low enough to ensure long pump life (> 10 years).
4) Vacuum components that are highly susceptible to radiation damage, such as elastomer o-rings, are discouraged.
5) In general, SLAC standard procedures for cleaning and handling of UHV components must be followed.
6) The tunnel XVTS transports FEL and spontaneous radiation from the NEH to the FEH having photon energies < 25 keV. (The FEL offset mirror system upstream of the XVTS provides the high-energy cutoff of 25 keV.)
7) The design of the XVTS should not preclude any future upgrades that would allow the central beam line to transport the full spectrum of spontaneous radiation should the project decide to do so at some time beyond the initial commissioning of the LCLS.
8) The two side beams will only transport FEL and spontaneous radiation deflected into them by the Flipper Mirror System, which is presently envisioned to have a high-energy cutoff of 25 keV.
9) Vacuum System
    a. Design pressure of 3×10^{-6} Torr
    b. System remains within design pressure after a loss of one Ion pump or one Ion Pump controller.
    c. Pump carts provided by SLAC will be used for initial evacuation and for maintenance work on the XVTS.
    d. LN dewars will be used for up-to-atmosphere service in the x-ray Transport Tunnel. SLAC will provide the dewars, equipped with good, wheeled frames, and standard gas fittings. The pump carts will provide the interface between the system and the LN dewars.
    e. Any exhaust from mechanical pumps will be vented into the tunnel.
    f. Local control of the ion pumps and valves will be through an Alan Bradly PLC which will read pressures and enforce the interlocks to prevent improper sequencing of events such as opening a valve to atmosphere when an ion pump is in operation.
    g. The EPICS control system will be able to
        i. Read and archive all gauges, all valve positions, and all ion pump currents in the XVTS.
        ii. Control/turn on/off the ion pumps and the sensitive gauges.
        iii. Provide an alarm chain through LCLS global controls for any faults that may occur.
10) Must meet or exceed SLAC/LCLS safety requirements
11) Must be ready for installation 2 weeks after beneficial occupancy of the tunnel, July 2007

3 Derived Engineering Specifications Summary

All requirements relevant to the engineering design of the XVTS system are summarized in the following table (Table 3.1.). Each listed issue will be discussed in detail in Chapter 4.

Number	Category	Issue	Description
1	System	System Configuration	From NEH to FEH (190 m) within tunnel envelope. Operation consistent with conventional facility design
2		Interface	Consider requirements of adjacent systems Provide appropriate isolation
3		Beam Clearance	Avoid or minimize damage by beam strike
4		System Upgrade Capability	Central beamline to transport full spectrum of spontaneous radiation
5	Mechanical	Structure Clearance	Consistent with the design of conventional facility
6		Rigidity	Seismic and vibration studies
7	Vacuum	Vacuum Performance	Operating/ design pressure below $3x10^{-6}$ Torr Ion pump life time > 10 years Contingency for pump or controller failure
8		Component/Material Selection	Ion pump operation only. Roughing pump carts will be provided All metallic materials
9		Handling and Cleaning	UHV standard
10		Facility Supply	LN purge gas supply
11	I&C	System Compatibility	EPICS based and Allen Bradley PLC system
12		Instrumentation	RGA/Cold cathode/ Convection-enhanced Pirani
13	Project	Safety-ES&H	LLNL IMS Standard
14		Cost Estimate & procurement	Bill Materials & procurement plan
15		Project Schedule	ready for installation 2 weeks after beneficial occupancy of the tunnel, July 2007
16		Fabrication, Testing and Installation Plan	Sub-assembly delivery to LCLS
17		Review	PRD and FDR
18		Documentation	Engineering drawings – LLNL standard Manufacturer technical materials Design reports, and operational manual

Table 3.1. XTOD-XVTS Engineering Requirements

4 Description of Engineering Specifications

4.1 System - Configuration

A drawing of the system layout is shown in Figure 1.2. This baseline design shows the selection of 6 ion pumps for each of the three beam lines. The XVTS system is isolated from the rest of the XTOD vacuum with gate valves. The distance between the outer gate valves is about 190 meters. The outer diameter of each line is 4 inches. For maintenance convenience, one interior gate valve divides the lines into halves. The pump locations are constrained by uniform distribution and use of standardized 10-ft sections of beam tube. Longer sections of beam tube cannot be used because of space restrictions of the conventional facility and geometry constraints for installation.

4.2 System - Interface

The XVTS system is isolated from the rest of the XTOD vacuum with gate valves. The vacuum level at the end regions should be designed to be below 3x 10^{-6} Torr. The pressure requirements of systems adjacent to the XVTS should recognize that XVTS vacuum levels will likely be in the low 10^{-6} Torr range at the interfaces."

4.3 System - Beam Clearance

The XVTS transports FEL and spontaneous radiation from the NEH to the FEH having photon energies < 25 keV. Mis-steer calculations must be made to assure that the FEL beam cannot hit components of the XVTS, or estimates should be made for the effect of multiple strikes at 120 Hz with a saturated FEL beam on the vacuum chambers, seals, and valves.

4.4 System Upgrade

Should LCLS ever want to transport the full spontaneous spectrum through the central pipe then there could be potential radiation problems with the > 100 keV component of the unfiltered spontaneous radiation and other high-energy contamination in the direct beam striking the vacuum vessel in the center pipeline. The > 100 keV component of the unfiltered radiation spreads out to ~ 4 inches diameter (FWHM) at the entrance to the far hall so portions of it *will* strike the walls of the vessel. The maximum total power in the > 100 keV spontaneous is 1.4 W, which may certainly require that the tunnel be unmanned.

4.5 Mechanical – Structure Design

The beam lines can be structurally broken into sections that are mechanically isolated by bellows. The design of the conventional facility limits the beam tube length to 10 feet. Tube with 4-in diameter is selected because it provides better conductance, beam clearance and less deflection, as compared to 2-in beam tube. Each pump stand is capable of supporting an ion pump and a UHV gate valve as well as the seismic loading in the beam line direction of 4" vacuum tube.

4.6 Mechanical – Rigidity

The mechanical structure should be designed for the whole length of 190 meter. Evaluation of the mechanical strength and deflection under seismic loading should be performed.

The seismic loads are prescribed in SLAC document, "Specification for Seismic Design of Buildings, Structures, Equipment, and Systems at the Stanford Linear Accelerator Center" dated December 4, 2000. The SLAC document dictates a load of 1.5g's in the horizontal plane and 1.15g's vertically for a structure with 2% damping with a natural frequency of 20 Hz. Structures with 2% damping are typically welded, while structures with 5% damping are usually bolted. The seismic response curve is about 25% higher for 2% damping. The use of 2% damping is therefore conservative in this case, but not overly so. The first natural frequency being around 20 Hz was confirmed by SAP 2000.

The structure should be modeled with various beam elements to closely approximate the real life structure of a 60 foot section of beam line. The beam line can be broken in sections at each bellows, which mechanically isolates the sections from each other.

All steel components exceeded the requirements of the AISC LRFD. All aluminum components, which are the flex plates, passed the AA ASD code.

4.7 Vacuum – Performance

a. General Operation

The XVTS system consists of 3 lines that are 4 inches in outer diameter and 190 meters long. The vacuum pumps and instrumentation are connected on the underside of the 3 beam lines. The vacuum pump spacing along each line should be determined by detailed vacuum calculations. The type and size of the pumps are chosen to provide a) a beam line pressure below the specification, with redundancy in case of one ion pump failure or one controller failure that does not require immediate shut down of the system; b) reliable pumping during system conditioning; and c) minimal cost for the lowest reasonable pressure.

The gas load in the XVTS system must be characterized during all phases of operation (i.e., start-up, conditioning, and steady-state). This is necessary to correctly choose the size, type, and number of high vacuum pumps. All vacuum system components (pumps, bellows, instrumentation, etc) must fit within the support structure. The pumps must be accessible for repair or replacement without disturbing the beam alignment. The modes of LCLS operation considered in this report are:

1. Commissioning & Preliminary Checkout (Initial Pumpdown)
2. Normal Continuous operation (10 yrs)
3. Maintenance Mode (Vacuum recovery within 1-2 shifts)

b. Ion Pump Life Time

Ion pumps are the choice to maintain the base pressure during the 10 year operation, mainly because of their high pumping speed and reliability for long-term operation. For example, Varian StarCell ion pump has a lifetime of > 80,000 hrs (~ 9 yrs) at 7.5×10^{-7} T. Lower inlet pressures will further increase the lifetime that is dependent on the sputtering/erosion rate of the electrodes. Another alternative is the Gamma ion pump that has a comparable lifetime, cost, and slightly improved performance.

c. Vacuum Requirements

The requirements of vacuum levels for all conditions are listed in table 4.1.

PARAMETER		REQUIREMENTS / VALUE
Pumping to overcome system outgas rate and seal leaks		1×10^{-10} T-L/sec/cm^2 at 100 hrs for stainless steel surfaces and 1×10^{-7} T-L/sec for each 6" seal
Beam line pressure Normal : all ion pumps on	Design Required	1.1×10^{-6} T $< 3 \times 10^{-6}$ T
Ion Pump Port Pressure	Design Required	1×10^{-7} T $< 6 \times 10^{-7}$ T
Beam line pressure Failure : one ion pump or controller fail s	Design Required	4.4×10^{-6} T $< 6 \times 10^{-6}$ T

Table 4.1. XVTS Vacuum System Requirements

4.8 Vacuum – Component and Material Selection

Only metallic or ceramic materials components may be used, that includes all seals. Elastomers or organic materials are not permitted unless they are specifically authorized by the Systems Manager of LCLS Photon Beam Systems, or designee [3, 6].

For roughing the system, pump carts provided by SLAC will be used for initial evacuation and for maintenance work on the XVTS. The interface to the pump cart will be an all-metal, right-angle valve with 4.5 inch Conflat flange.

4.9 Vacuum – Handling and Cleaning

Consistent with the requirements listed in SLAC-I-007-12004-001, the XTVS vacuum system must be designed and constructed with a major emphasis on eliminating contamination sources, i.e. built essentially as an all-metal, UHV-capable, clean-vacuum system.

Fabrication of all vacuum components must comply with the specifications listed below and their front pages are attached in Appendix A.

1. MEL95-001818-00, "Fabrication and Handling of Components for Ultra-High Vacuum Environment", Mechanical Engineering Department, LLNL, University of California.
2. ENC-93-910-REV 01, "Cleaning Stainless Steel Alloy Components", Mechanical Engineering Department, LLNL, University of California.
3. ENC-93-912-REV 01, "Cleaning Copper and Copper Alloy Components", Mechanical Engineering Department, LLNL, University of California.
4. MEL95-001817-00, "Welding of Stainless Steel components of Ultra-High Vacuum Environment", Mechanical Engineering Department, LLNL, University of California.

4.10 Facility Supply

During certain maintenance operations, some or all of the sections of the XVTS vacuum system may be purged with a positive pressure of dry N_2 gas to prevent contamination from the atmosphere from reaching the interior surfaces of the vacuum system. Over-pressure safety should be designed into the XVTS system. LN dewars will be used for up-to-atmosphere service in the XVTS. LCLS conventional facility will provide the dewars, equipped with good, wheeled frames, and standard gas fittings. The pump carts will provide the interface between the system and the LN dewars.

4.11 Instrumentation & Control – Compatibility

The design of the instrumentation and control system for the LCLS XTOD Tunnel Vacuum System (XVTS) should be based on the design of EPICS. The control system's basic design is to have a Programmable Logic Controller (PLC) controlling the vacuum pumps and gate valves. The PLC will be connected to a network which will have EPICS I/O Controllers (IOCs) that will provide the data to a user interface in a client server model. The PLC will monitor the status of the vacuum pumps and vacuum setpoints from the vacuum gauge controllers and use interlocks generated from the PLC's logic to ensure proper operation of the vacuum system. In the event of a vacuum system malfunction, interlocks will be available to the Machine Protection System to safely shutdown the system. The XVTS vacuum system should be in full compliance with LCLS standards for hardware, software and safety.

The design of the XVTS uses ion pumps connected to a pump cross, which in turn is connected directly in the beam line. A scroll and turbomolecular pump cart will be used to pump down the system from atmosphere to a pressure where the ion pumps can be started safely, without overheating the pumps or causing internal electrical discharges.

LCLS has decided to standardize on the Allen-Bradley ControlLogix family of PLCs and associated hardware and software.

The control system for the XVTS will consist of a PLC that will be connected via a network to the global control system, EPICS. The PLC will execute its ladder logic software in a continuous loop, evaluating the status of the vacuum system. Based on the ladder logic and the status of the vacuum system, the PLC can automatically close a valve or shutdown a pump. The PLC can not automatically open a valve or start a pump; such an operation must be done by an operator using EPICS. Interlock logic within the PLC will prevent the operator from selecting an improper valve or pump operation.

4.12 Instrumentation & Control – Instrumentation

Although vacuum pressure can be derived from ion pump current, there is a need to measure vacuum pressure before the ion pumps are started. An ion pump requires a moderately high vacuum condition to be established by other pumps before it can be started. The better the starting vacuum, the longer the life of the ion pump. Another reason for using a separate pressure gauge rather than relying solely on an ion pump's current to determine the vacuum pressure is that any leakage current in the pump, cable or connector will cause the ion pump controller to give a false, high pressure reading.

To provide the most robust control system, an independent pressure gauge is required to determine if the pump cart has pumped out the XVTS to a sufficient vacuum condition for the ion pumps to be started. The independent gauge will also provide pressure readings and might be able to help diagnose problems if the ion pump controller is giving false readings. Cold cathode gauges are recommended for HV/UHV use in the LCLS.

At least one convection-enhanced pirani gauge will be used on each section of the beamline. A convection-enhanced pirani is used to measure pressure from atmosphere down to the milliTorr range. The convection-enhanced pirani gauge was selected because it is more accurate at the higher pressures than a thermocouple gauge or a basic pirani gauge since it has a temperature-compensated heat sensor and can measure convection current.

A residual gas analyzer (RGA) will be available to measure the partial pressure of gas species in the vacuum system. This is an important diagnostic tool for high vacuum systems and the preliminary design calls for one RGA in each of the beamlines.

4.13 Safety- ES&H

a. LLNL-ISM

During the design process, the system will be continually evaluated for safety in every phase of LCLS work, including design, transportation, installation, testing, operation, and maintenance. The following is a brief description of design safety considerations in the LLNL Integration Worksheet LCLS X-Ray Tunnel Vacuum Transport System (LLNL IWS #12920 [7]):

1. Seismic stability of the vacuum system will be documented in a formal, peer-reviewed engineering document, and designed based on Specification for Seismic Design of Buildings, Structures, Equipment and Systems at the Stanford Linear Accelerator Center. SLAC-1-720-0A24E-002.
2. Electrical system components will be NRTL listed or equivalent, as determined by the LLNL AHJ testing and certification program, and will meet the requirements of the SLAC EEIP program. Procedures will be written to establish safe methods for de-energizing, installing, testing, and maintaining (including effective lock-out tag-out capability) ion pumps and their power supplies and cabling.
3. Construction, Lifting and Industrial Hazards: As a part of the design process, LLNL will consider how components can be delivered and installed into LCLS.

4. The potential for creating oxygen deficient atmospheres will be considered.
5. Fire Hazard: Equipment will be designed to limit the amount of combustibles in the underground areas, and to avoid interference with the tunnel fire suppression system. Cables and other potentially combustible materials will meet LCLS fire prevention requirements.
6. As a backup to proper design and operating procedures, gas and vacuum system components will be protected from overpressure by relief valves
7. The planned arrangement of equipment will take into consideration the need for emergency egress, and the need to access critical equipment or operating stations (crash buttons etc.).
8. The effects of radiation on personnel and equipment will be evaluated for normal, emergency, and maintenance operations.
9. LLNL will anticipate quantities of hazardous materials and pollutants that will be part of, or used by, LCLS components. This will allow implementation of industrial hygiene controls and proper documentation of environmental regulatory compliance.

b. ES&H

All work will be done in accordance with LLNL ES&H policies. These policies are addressed in the LLNL "Health and Safety Manual" and the "Environmental Protection Handbook". Furthermore, LLNL ES&H policies implement U.S. Department of Energy orders to comply with all local, state, and federal regulations. These policies are carried out in accordance with LLNL's Integrated Safety Management program using an Integrated Worksheet. Furthermore, all work performed by LLNL employees at SLAC will be in accordance with SLAC safety rules, and all LLNL safety documentation for LCLS will be written with the goal of meeting SLAC documentation requirements.

4.14 Cost Estimate & Procurement

All components recommended in the design should be standard catalog items wherever possible, i.e. items that do not require any development. Cost estimates should be made for purchasing all hardware required for the complete vacuum system. Spare parts should be included.

In the Engineering Design phase, procurement documents including the detailed performance specification for all components will be prepared. These items will be sent out for bid to DOE/LLNL specified vendors and purchased by the LLNL procurement department. They will be subject to Final/Approved Detail Drawings and LLNL Mechanical Engineering Department Specifications. Established LLNL ISM and Quality Assurance Procedures will be followed. All selected materials will meet ASTM specifications and/or LLNL approval.

4.15 Project Schedule

XVTS system must be ready for installation 2 weeks after beneficial occupancy of the tunnel, July 2007. Major project milestones are:

1. Final Design Review and Package (6/06)
2. Complete Procurement (2/07)
3. Available for Site Installation (8/07)
4. System Commissioning (2/08)

4.16 Fabrication, Testing and Installation Plan

Fabrication, preliminary assembly and testing of the vacuum pumping components are planned to take place at the LLNL Vacuum Sciences and Engineering Lab. The facility provides ample room for complete module system assembly and testing. There is a wide variety of hardware and software in the LLNL Vacuum Sciences and Engineering Lab that will be available for recording experimental data. All technical staff will receive required training.

4.17 Review

Conduct formal presentation of the design including a written report covering all of the requirements.

4.18 Documentation

Prepare all drawings of fabricated parts, sub-assemblies and assemblies.

Provide copies of vendor-provided instruction and operation manuals.

Submit the Final Design Report and system operation documentation.

References

1. "Preliminary Design Report";
   LCLS PDR # 1.5-001; 11/14/05
2. "Physics Requirements for the LCLS X-Ray Transport and Diagnostics";
   LCLS PRD # 1.5-001; 5/25/04
3. "Physics Requirements for the XTOD Mechanical-Vacuum Systems";
   LCLS PRD # 1.5-002; In preparation.
4. "LCLS Mechanical Vacuum Specifications";
   LCLS ESD # 1.1-302; 7/19/05
5. "LCLS Conventional Facility Title II – 60% Submitted Drawings"; 11/16/2005
6. "SLAC Vacuum Department Guidelines for Vacuum Systems"
   SLAC-I-007-12004-001 R1; 4/17/03
7. LLNL IWS #12920; 6/2005

Appendix A - UHV Component Handling Procedures

AAN95-106130-00

MEL95-001817-00

SPECIFICATIONS

UNIVERSITY OF CALIFORNIA
LAWRENCE LIVERMORE NATIONAL LABORATORY

MECHANICAL ENGINEERING DEPARTMENT, LIVERMORE

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TITLE	WRITTEN BY	DATE
Welding of Stainless Steel Components for Ultra-High Vacuum Environment	Michael R. McDaniel	9/1/95
	APPROVED-SPEC. & STDS.	
	N/A	12/95
	APPROVED-DIVISION HEAD	
	Den P Atheran	9/1/95

1. SCOPE

1.1 Purpose This specification defines the procedures for controlling the quality of material to be used and the welds to be made on stainless steel components subject to Ultra-High Vacuum (UHV) environment for Lawrence Livermore National Laboratory (LLNL). Extreme care is required in the design fabrication and assembly of said components. This specification is applicable to the welding of austenitic, chromium-nickel steels (ASTM 300 series) using gas metal arc welding (GMAW) and/or gas tungsten arc welding (GTAW) processes. This is a general specification and not all sections necessarily apply to all drawings which refer to this specification. Refer to section 5.0 for required documentation for LLNL information and approval.

2. REFERENCE DOCUMENTS

The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue used shall be the one in effect on the date of request for quotation. Any conflicts between this specification and the referenced documents shall be brought to the attention of LLNL in writing for resolution before any action is taken by the seller.

			CLASSIFICATION
REV. A	BY	DATE	

AAN 93-104962-0A

SPECIFICATION **ENC-93-912-REV 01**

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LAWRENCE LIVERMORE NATIONAL LABORATORY

MECHANICAL ENGINEERING DEPARTMENT, LIVERMORE

TITLE	WRITTEN BY	DATE
Cleaning Copper and Copper alloys	C.P. Steffani	9-1-1993
	CHECKED BY	
	J. W. Dini	9-1-1993
	APPROVED BY	
	J.C. Whitehead	9-1-1993

SEQUENCE

1. Remove all tape, inks, and other residue using Acetone and a clean cotton rag or paper wiper. Other solvents may be used as long as they are permitted for use in the shop and the requester is aware of the change.

2. Pressure wash using RELEASE D'GREASE @ 10 vol. % and 3-5 KSI setting.
*** FOR FRAGILE PARTS IMMERSE IN ACETONE OR BRULIN 815GD. For components having tubes, blind holes, and passageways cleaning/rinsing agents will be fed into these areas at low pressure.**

3. Spray water rinse.

4. Immerse in ENTHONE NS-35 non-silicated cleaner (30 gm/L @ 65 C) for a minimum of 10 minutes.

5. Spray water rinse until all traces of cleaner are removed. If water breaks are present repeat step 4.

6. Descale in 50 % vol. HCL.

7. Spray water rinse.

8. Acid dip in ENTHONE ACTANE 97 (10 gm/L "A", 12 gm/L "B" @ 25 C) until surface is clean and bright.

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SPECIFICATION · **ENC-93-910-REV 01**

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LAWRENCE LIVERMORE NATIONAL LABORATORY

MECHANICAL ENGINEERING DEPARTMENT, LIVERMORE

TITLE	WRITTEN BY	DATE
Cleaning Stainless Steel Alloy Components	C.P. Steffani	9-1-1993
	CHECKED BY J. W. Dini	9-1-1993
	APPROVED BY J.C. Whitehead	9-1-1993

SEQUENCE

1. Remove all tape, inks, and other residue using Acetone and a clean cotton rag or paper wiper. Other solvents may be used as long as they are permitted for use in the shop and the requester is aware of the change.

2. Pressure wash* using RELEASE D'GREASE @ 10 vol. % and 3-5 KSI setting.
*** FOR FRAGILE PARTS IMMERSE IN ACETONE OR BRULIN 815GD. For components having tubes, blind holes, and passageways cleaning/rinsing agents will be fed into these areas at low pressure.**

3. Immerse in ENTHONE NS-35 non-silicated cleaner (30 gm/L @ 65 C) for a minimum of 10 minutes.

4. Spray water rinse until all traces of cleaner are removed. If water breaks are present repeat step 2.

5. Acid pickle (50 % vol. HNO_3 = 5 % vol. HF @ 25C) for:
   A. 10 minutes or until all mill scale is removed.
   B. 30 seconds to remove all traces of alkaline film.

6. Spray water rinse. All but welds and blind holes should be given special attention to remove all traces of trapped chemicals. The air water aspirator can be used to help rinse these hard places. Ultrasonic rinsing in DI water can also remove trapped material.

7. Cold water rinse. ($2x10^6$ ohm resistivity). Resistivity is monitored and maintained by automatic additions of fresh DI water.

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SPECIFICATIONS

UNIVERSITY OF CALIFORNIA
LAWRENCE LIVERMORE NATIONAL LABORATORY

MECHANICAL ENGINEERING DEPARTMENT, LIVERMORE

TITLE	WRITTEN BY	DATE
Fabrication and Handling of Components for Ultra-High Vacuum Environment	Michael R. McDaniel	9/1/95
	APPROVED-SPEC. & STDS.	
	N/A	12/95
	APPROVED-DIVISION HEAD	
	[signature]	9/1/95

1. SCOPE

1.1 Purpose This specification defines the procedures for controlling the cleaning and handling of material and components subject to Ultra-High Vacuum (UHV) environment for Lawrence Livermore National Laboratory (LLNL). Extreme care is required in obtaining clean components that will not produce contamination at the end use machine. This specification will cover machining and cleaning techniques required before, during and after fabrication of said components. This is a general specification and not all sections necessarily apply to all drawings which refer to this specification. Refer to section 5.0 for required documentation for LLNL information and approval.

2. REFERENCE DOCUMENTS

The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue used shall be the one in effect on the date of request for quotation. Any conflicts between this specification and the referenced documents shall be brought to the attention of LLNL in writing for resolution before any action is taken by the seller.

		CLASSIFICATION
REV. A BY	DATE	