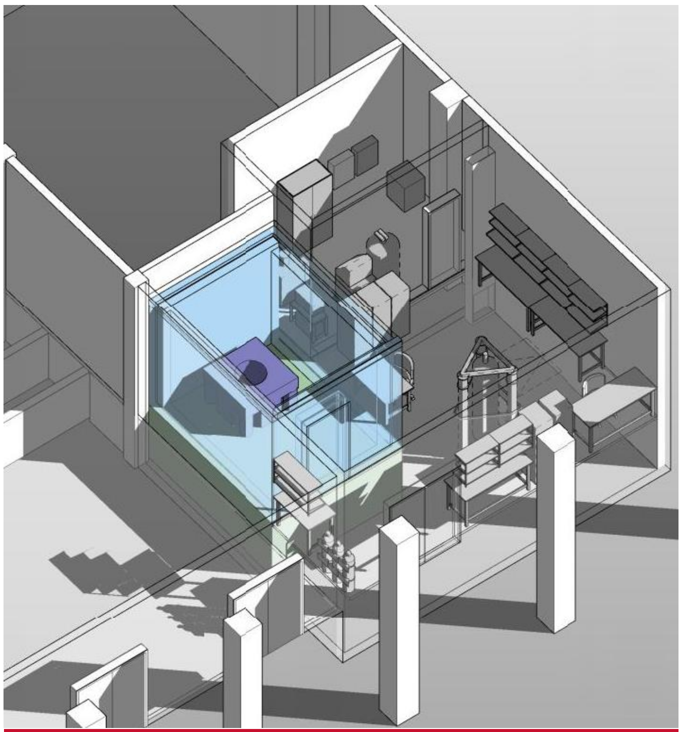

UCSB

Andrea Young laboratory

Feasibility Study

Broida Hall 1251

October 29, 2015

Final Report

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1 Executive Summary

The following document describes a feasibility study conducted on behalf of the UC Santa Barbara (UCSB) Facilities Management to determine the feasibility of laboratory modifications of Broida Hall Room 1251 to accomodate new cryo STM instruments used in research. In particular, cryo STM's (Scanning Tunneling Microscopes) require stringent vibration and acoustical isolation, relatively clean power, and are somewhat sensitive to electromagnetic interference.

In addition to these environmental constraints, cryo STM's use large quantities of cryogenic liquids, including liquid helium. Liquid helium is costly due to supply constraints, and it requires extensive energy to acquire through separation from natural gas deposits. Therefore the helium boil-off in Lab 1251 is to be recovered and liquefied for re-use and the equipment to accomplish this recovery must also be accommodated in the proposed project.

The major steps followed in development of this Study included a) review and analysis of the existing building conditions and capacities, b) concurrent meetings with Dr. Young and the UCSB team to determine laboratory requirements, c) development of design options for the lab and support systems, and d) development of the preferred option to a concept level for cost estimating. The resulting study includes sufficient detail to allow the project to proceed with confidence that the scope and cost are well-understood.

The results of the study demonstrate that the cryo-STM's can be installed in Room 1251 after significant modifications to the space. The building renovation scope is described in detail in the body of this report. Highlights include a double walled acoustic isolation room for the new high field STM, floor infill with aluminum framing, an equipment isolation room for noisy helium recovery equipment, modifications to the HVAC system, modifications to the electrical distribution, and new lighting.

The construction cost for the renovations is estimated at $1,528,000 and the details of the construction cost are included in the final section of the study.

2 Existing Conditions Broida Hall

2.1 Structure

Broida Hall is a 6 story structure with a one-story component on the east end. It has been expanded to the east with a one-story addition to house an x-ray free electron laser (XFEL) system and related research space. The building consists of a concrete structural frame of cast-in-place concrete columns and beams, with cast-in-place concrete floors and roof.

The original one-story section is where Room 1251 is located at the southeast corner. This portion of the building ground floor is recessed 5'-3". The height of the top of the roof slab above ground floor is 14'-5", with an 7" concrete roof structure resulting in 19'-1" clear to the bottom of the roof slab (14'-5" – 7" + 5'-3"). The primary beams supporting the roof extend 26" below the concrete roof slab such that the clearance below the beams is 16'-11".

The lower floor is accessed from cast-in-place concrete steps on the south side of 1251, and from concrete steps at the northwest corner of Room 1356 as well as a tall overhead coiling door to an exterior loading ramp area on the north side of 1356. There is some mechanical equipment located on the roof above 1251 as well.

2.2 Architecture

Room 1251 is 647 net square feet, bounded on the north by an interior full-height stud wall separating it from Room 1356. This wall was constructed after the original building and the original lighting and crane rails extend through the wall. This wall includes a pair of 12' +/- tall doors into 1356 that are no longer in use.

Room 1251 is also bounded on the west by a concrete block wall separating it from another laboratory, Room 1217 that was recently renovated for laser/optics/photonics research. On the east, Room 1251 is separated from the XFEL facility by the original concrete block exterior wall consisting of 8" x 12" x 12" decorative concrete block. Similar construction was used on the south wall of Room 1251 as well, although this wall is still exterior wall and includes the main entrance door to the lab at grade. The door consists of a pair of hollow metal 3' x 7' doors with removable transom.

2.3 Mechanical, Plumbing, and Fire Protection Systems

Room 1251 is currently served by the main building HVAC system and includes an exhaust fan on the roof for ventilation air. Refer to Mechanical Building System section for existing conditions and new scope. The west wall of 1251 is used extensively for utilities distributed to and through the adjacent lab 1217. In order to minimize cost and impact on 1217 operations, these utilities will be left in place with a clearance zone of 6" required in the new layout of 1251.

2.4 Electrical, Lighting and Life Safety Systems

Room 1251 is currently served by two 120/208V power panels fed from the main building system distribution board in Room 1356. Refer to Electrical Building System section for existing conditions and new scope.

3 Laboratory Requirements and Design Response

3.1 Laboratory Design Criteria

Generally Room 1251 is to be modified to meet the requirements of the instruments to be used in research, primarily consisting of an existing high magnetic field cryostat and STM (HFS) and a proposed new low field cryostat and STM (LFS). The existing HFS can be housed in a conventional laboratory space, although the high field magnet is sensitive to magnetic field interference so placement within the lab to avoid proximity to large ferromagnetic sources such as building steel is required.

The requirements for the new LFS are more stringent and include:

- Vibration: Isolation and damping to meet the limits of an Omicron NanoScience LT STM (provided by Dr. Young as a reference for the design team)
- Acoustic Isolation: The degree of attenuation required has not been specified, but the design goal is to make the isolation room "as quiet as reasonably achievable"
- Temperature and Humidity: There are no specific requirements for temperature or humidity set point. A stable temperature environment is required within the LFS space. Non-condensing humidity is desirable, but a limit on relative or absolute humidity has not been stated.
- Electromagnetic Interference (EMI): As with the HFS, no criteria for EMI fields have been provided, however the LFS is also sensitive to EMI to some degree. Therefore, all reasonable steps are to be taken to avoid ferromagnetic sources are to be incorporated.

3.2 Laboratory Operational Requirements

The two cryostat / STM systems both require substantial support to complete the set-up for scanning. Operations include initial setting of the cryostat as well as lifting and inserting the STM probe, liquid helium and nitrogen fill, vacuum pumping and extensive power and controls.

Cryostat and STM insert

Initial installation of the cryostat requires lifting the instrument into place vertically and thus requires on overhead hoist and trolley. Although this heavier load is only an intermittent use, the STM insert must be lifted and inserted on a regular basis and is a much lighter load (i.e. 50 lbs or less).

Each system will be provided with a low profile ½ ton hoist with manual chain fall for lifting and manual chain operated trolley. Combination hoist and trolley will be mounted on a steel wide flange beam section with centerline above the cryostat.

Cryogen Fill

Both systems will require routine liquid helium and liquid nitrogen for the cooling jackets in the cryostats. The helium in particular will require frequent (i.e. daily) refill to account for boil-off through the vents on the system.

The fill process requires direct access for liquid cryogen dewars or piping with transfer lines at each cryostat. The process also requires higher pressure helium for pressurization and pre-cooling.

With this in mind, it will be necessary to roll dewars and other equipment in and out of the lab frequently. The development of the current design includes floor infill at the grade level to easily allow direct movement at grade level, and avoid the recessed floor.

Vacuum Systems

Both the HFS and LFS require vacuum pumping to facilitate the instrument and as part of the cryogen fill process. Vacuum pumps are to be provided for both systems as part of the installation of the instrument. For the HFS, the roughing pump can be located remotely in the Support Equipment room, while the two smaller pumps will be located below the raised platform level adjacent to the HFS.

The vacuum pump for the LFS will also be located in the Support Equipment Room, with vacuum lines integrated through the concrete isolation slab and the inertia block. This provides separation of the pump from the STM providing vibration and acoustic damping.

All vacuum pumps require an exhaust connection to extract the vacuum effluent air, as well as power and controls.

3.3 Laboratory Design

The proposed plan for the cryo-STM Laboratory, Room 1251 is shown in Figure 3-1. The new lab will consist of 3 main spaces, and expands roughly 115 square feet into Room 1356. The total proposed area is 762 square feet, inclusive of new walls.

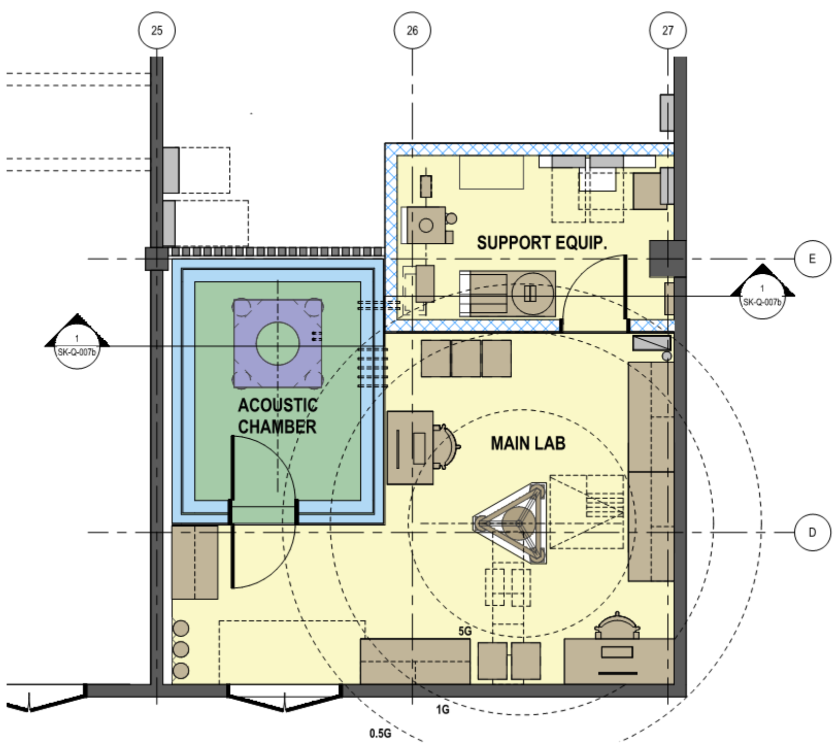


Figure 3-1. Proposed Floor Plan Room 1251

3.3.1 Acoustical Isolation Lab for LFS

The three laboratory spaces provide 3 distinct functions required by the research instruments. The first of these is an acoustic isolation room that will house the LFS. It is to be constructed of a double wythe wall of 6" and 8" nominal concrete block (CMU). A double 7" thick concrete lid completes the enclosure of the space. A cross section showing the components of the room construction is provided in Figure 3-2.

The acoustic isolation room is constructed on a concrete isolation block roughly 6' thick that will be installed on the existing compacted subgrade after sawcut and removal of the existing 8" thick concrete floor slab. This will isolate the concrete block from the structure. To reduce total concrete mass and associated cost of placement, portions of the concrete isolation block will be filled with an inert foam filler when it is poured, with appropriate reinforcing to maintain stiffness, rigidity, and load capacity.

Within the isolation block a recessed pit will be formed with the concrete pour. This pit provides space for the LFS cryostat during normal operation. Sitting atop the heavy isolation block will be a cast-in-place inertia block designed specifically for the crystat. This inertia block will be cast with a bond breaker of thin (1/4" or less) plastic that allows the block to be easily separated from the larger isolation block below. Future installation of air isolators will allow the inertia block to be "floated" roughly ¼" to provide a higher degree of vibration isolation.

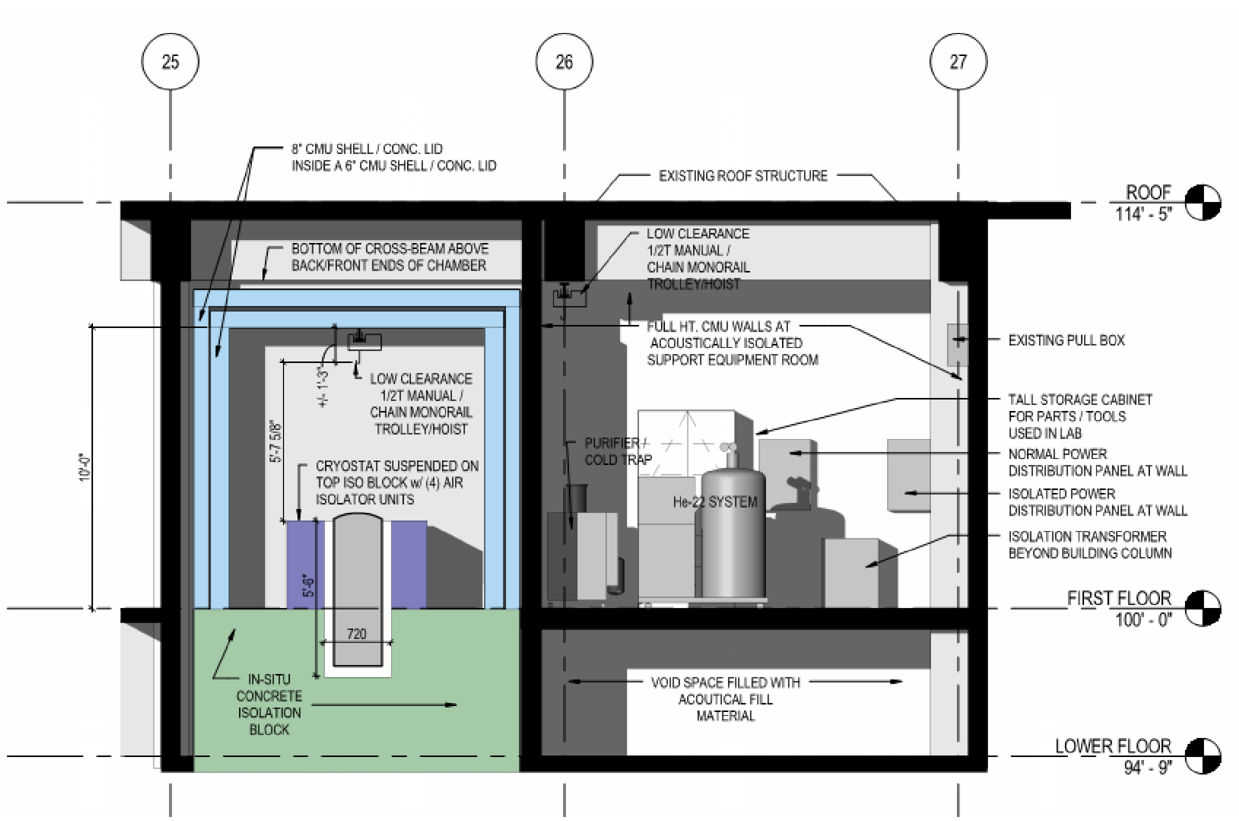


Figure 3-2. Proposed Cross Section Room 1251

A manual chain hoist with manual trolley and crane rail will be provided above the cryostat for placement of the cryostat and withdrawal / insertion of the STM insert. Vacuum piping will be provided from the vacuum pump location, through the isolation block and up into the inertia block. Power and controls conduit sleeves will be provided at selected locations for interconnects from the instrument to the controls, detectors, and other electronics located in the Main Lab in rack systems.

The design strategy for this space is to provide maximum acoustic separation from the remainder of the lab and the building. The space effectively becomes a part of the instrument and will be treated as such. Therefore no HVAC systems or sprinkler piping are to be provided within the acoustical isolation chamber. A standard operating protocol must be in place requiring that no work is done for set-up of the instrument unless the doors are propped open, and all work is to be performed in the buddy system so that no one works in the space alone. This strategy must be confirmed with the UCSB Fire Marshal and USCB Environmental Health & Safety.

3.3.2 Main Lab and HFS

The second of the three laboratory spaces is the Main Lab that houses the existing HFS with its electronics as well as the controls and electronics for the LFS. This lab space will sit upon a floor platform so that the lab floor is level with the adjacent grade. Space below the platform is to be used for liquid helium piping, power, controls, plumbing, and potentially for compressed gas lines. Vacuum pumps for the LFS will be located below the platform as well.

The platform will be constructed of aluminum planks with a solid top surface to accept resilient flooring for both comfort and safety. Planks will be anchored to aluminum tube sections spanning between aluminum posts bolted into the existing floor slab below. The entire frame will be seismically anchored horizontally to the existing structure at the west, south, and east sides and into the new Support Equipment Room structure on the north. The platform will be isolated from the new acoustic isolation room isolation block to avoid transfer of vibration. A hatch and ladder system will be provided in the lab and will use the same crane rail and hoist as the HFS for raising or lowering equipment into the subfloor.

An overhead manual hoist and manual trolley will be provided with a crane rail centered over the HFS cryostat and floor hatch. No ceiling is required in the lab and new lighting will be provided.

The Main Lab will also provide space for workstations and for bench space for instrument maintenance and repair. Limited storage will also be required for tools and small to medium sized components. Cylinder racks and valve manifolds for high pressure helium and nitrogen will be located near the entrance to the lab for ease of change-out. High pressure nitrogen is required for the air isolators to “float” both the HFS and LFS, and will be distributed to both locations. High pressure helium will also be distributed to both systems and into the Support Equipment Room.

3.3.3 Support Equipment Room

The last of the three spaces is the Support Equipment Room located in the northeast corner of the space. This room houses the helium purifier (cold trap), helium recovery compressor and dewar, vacuum pumps, and a new isolation transformer and power panels. A control manifold for low pressure helium collection and medium pressure helium supply will also be located on the wall of the Equipment Room.

It will be constructed of a single wythe of 8" CMU extending from the existing concrete floor slab to the underside of the existing concrete roof. The construction provides additional acoustic isolation for the noisy equipment located within. A concrete slab floor will be provided at the grade level to align with the platform of the Main Lab, allowing safe movement of rolling dewars into the space. To avoid the creation of a "drum" below the concrete slab, acoustical insulation will be installed in the void prior to installing the slab itself.

This room is essentially a mechanical equipment room and will not be occupied except for equipment maintenance. Additional storage for larger components will be provided as exact clearances and dimensions allow.

4 Mechanical Building System

4.1 Overview

The existing mechanical systems consist of: a once through HVAC system served by the building make up air handler, an inoperable rooftop exhaust fan and vacuum pump exhaust; lab utilities distribution includes low pressure nitrogen, compressed air, natural gas (abandoned in place), equipment cooling water; industrial water and lab waste and vent. The lab is fully protected with overhead fire sprinklers.

The existing building HVAC system will be utilized to provide ventilation of the new lab and cooling and ventilation for the new Support Equipment Room. The lab utility systems will be reconfigured and expanded to support the new lab utility requirements. The the fire sprinkler system will be reconfigured to accommodate the new raised floor and the new Support Equipment Room.

4.2 HVAC Systems

The existing HVAC system will be reused to provide ventilation for the new lab and provide cooling and ventilation for the new Support Equipment Room. The existing supply air ductwork and sidewall registers serving the south portion of the high bay lab (~ 2100 CFM) will be removed and capped at the existing 34 x 20 duct from SVAV 1-15 serving the north portion of the high bay space. The air flow to the existing high bay lab (`3100 CFM) shall be measured before modification and re- balanced to restore the current flows after duct modification. Remove the existing vacuum pump exhaust ductwork from the existing lab. Remove the existing roof mounted exhaust fan, ductwork and register. The existing roof penetration will be re-used for the new exhaust system.

Conceptual cooling load calculations were compiled to the new lab spaces. See table 4-1 below for a summary of the cooling requirements. Calculations indicate that the new laboratory will require 1400 CFM and the Support Equipment Room requires 1600 CFM of cooling.

Load Summary

Room	Area (sqft)	Area (SM)	Heat (w/sqft)	Heat (w/SM)	Load (kw)	Diversity Use (%)	Load (Mbh)	Load (ton)	Load (gpm)	Load (CFM)
Cryostat Enclosure	108	10.0	2.2	23.9	0.2	40%	0.3	0.03	0.1	15
Lab	413	38.4	23.7	255.6	9.8	60%	20.1	1.67	4.0	913
Support Equipment Room	137	12.7	72.0	775.2	9.9	100%	33.7	2.81	6.7	1,531
Raised Floor/Equipment	413	38.4	5.8	62.5	2.4	100%	8.2	0.68	1.6	372
	1,071	99.5			22.3		62.3	5.19	12.5	2,830

Table 4-1. Cooling Load Summary

To provide cooling for the new lab and support spaces install a new 2200 CFM variable volume terminal unit with hot water reheat in the Service Core. Connect the new terminal unit to the existing medium pressure supply air main duct near the connection to existing North High Bay Lab terminal unit (SVAV1-15). The new terminal unit will provide cooling and ventilation to the new Support Equipment Room and supply ventilation and exhaust replacement to the new lab space. Extend new supply air ductwork from the new terminal unit in the service core and route over the existing adjacent labs including the North High Bay Lab to the new lab and Support Equipment Room.

Supply 1600 CFM from the new terminal unit to the new Support Equipment Room through overhead diffusers. This air shall be fully exhausted through high and low exhaust registers at 800 CFM each and a tracking exhaust terminal unit connected to a new exhaust fan mounted above the platform above the Support Equipment Room. The room supply/exhaust flow offset shall be manually set to maintain the equipment room at a pressure negative to the lab. A temperature sensor in the equipment room will control the supply new terminal unit air flow and temperature to provide occupant comfort +/- 2 Deg. F.

Install a new 2000 CFM in-line mixed flow variable speed exhaust fan above the equipment room. Route the new acoustically lined exhaust discharge duct up through the existing roof opening to a new spun aluminum vent hood to match the original exhaust fan appearance. In addition to exhausting the equipment room, the fan shall also draw 400 CFM through a variable flow exhaust terminal unit from the space below the raised floor. 200 CFM shall be exhausted within 6” of the floor and 200 CFM shall be exhausted within 6” of the raised floor. Exhaust openings shall be covered with ¼” x ¼” welded wire fabric. Underfloor exhaust flow shall be reset to maintain the lab pressure set point.

Install a new 1400 CFM semi custom fan coil to recirculate air and to provide cooling, heating and ventilation in the new lab. The new fan coil will consist of an OSA/RA mixing plenum section, MERV 13 filter, chilled water cooling coil, hot water heating coil, direct drive variable speed plenum fan and supply plenum. Unit will include sound adsorbing panels and plenums and configured for low sound performance to deliver a lab sound level of NC 35. Air shall be supplied by the fan coil unit through a sound attenuator to sidewall registers located low in the south wall above the Support Equipment Room. Return air shall be drawn through acoustically lined ductwork from a sidewall filter return grille (MERV 8) located higher on the south wall above the Support Equipment Room. Route condensate drain from the fan coil to the relocated cup drain on the west wall.

> **There is no direct ventilation within the Acoustic Chamber. All ventilation will be provided during occupied periods through open doors. Oxygen levels will be monitored and alarmed. At no time will the chamber be occupied without open doors.**

Connect a new 4” vacuum pump exhaust to the existing 4” vacuum pump exhaust header located near Colum Line F/25. Extend the 4” Vacuum Pump Exhaust line to the new laboratory. Extend 1- ½’ Vacuum Pump Exhaust from the high field vacuum pumps below the raised floor and an 1- ½’ Vacuum Pump Exhaust from the low field vacuum pumps in the Support Equipment Room to the new 4” Vacuum Pump Exhaust line.

HVAC Controls shall be an extension of the existing campus DDC control system. Lab temperature shall be controlled for occupant comfort +/- 2 Deg. F. The fan coil and exhaust fan shall operate continuously. Both fan motors shall be monitored for failure. The fan coil shall operate normally at a fan speed of 50%. Upon a temperature increase in the space temperature he HVAC control system shall increase the supply fan speed shall and modulate the two way chilled water cooling coil control valve simultaneously to maintain a 55 Deg. F. supply air temperature. Upon a drop in temperature the fan speed shall decrease while maintaining the supply air temperature until the fan speed reaches 50%. Upon a further decrease the HVAC Control System shall maintain the fan speed at 50% and close the cooling coil control valve first then modulate the heating coil hot water control valve open to maintain space temperature. The exhaust fan shall be variable speed to maintain duct static pressure. Provide oxygen depletion sensors and alarms in the Lab above and below the raised floor, the Support Equipment Room and in the chamber.

Extend new chilled water supply and return to the new fan coil unit and equipment cooling water heat exchanger from new hot tapped connections to the existing chilled water mains in the basement level of the Service Core. Extend new heating hot water supply and return to the new terminal unit and fan coil unit from new hot tapped connections to the existing heating hot water mains in the service core. The exact location of the tie in points will be determined in schematic design phase of the project.

4.3 Lab Utility Systems

The existing lab utility systems serving the room are; low pressure nitrogen, compressed air, natural gas (abandoned in place), equipment cooling water; industrial water and lab waste and vent. The existing utilities, except those that serve the lab to the west shall be removed and capped at their origin. The existing utilities that serve the lab to the west shall be reconfigured to allow the installation of the new chamber, including the relocation of the cup drain that serves the humidifier. The drain lines, cup drain lab waste and waste vent shall be relocated to the south to allow access to the cup drain after the installation of the new chamber.

Extend new low pressure nitrogen, compressed air and industrial water to lab cocks at each workbench and as required for the helium recovery system. Provide cylinder gas racks as shown on the lab layout in Figure 3-1. Provide auto change over and pressure regulating manifold for He gas cylinders and cylinder connection and pressure regulation for HPN2 cylinder. Route He and HPN2 cylinder gas to use points in the lab via ¼" 316 L electro polished (10 RA max) stainless steel tubing with Swagelok connectors. Bends can be substituted for elbows if the bend radius is greater than 10 x the diameter of the tube.

Provide a new 10 GPM equipment cooling water system for the helium recovery system. The equipment cooling water system includes: automated RO water makeup control valve, automated industrial water makeup control valve, pressure regulators, resistivity controller, bleed valve, a brazed plate heat exchanger, redundant in-line corrosion resistant pumps, UV light for bacteria control, pressure relief valve, replaceable 10 uM filter, piping valves fittings and connections to supply cooling water to the helium recovery equipment. The Building Management System (BMS) will monitor pump status and start the backup pump upon a failure of the lead pump. The BMS will modulate the chilled water control valve to maintain the supply water temperature set point of 60 Deg. F. The BMS will monitor the resistivity of the equipment cooling water supply to the equipment. If the resistivity falls below the set point the BMCS shall open the bleed valve and the RO makeup valve until the resistivity rises above the set point. If the resistivity rises above the set point (plus a dead band) the BMCS shall open the bleed valve and the Industrial Water makeup valve until the resistivity falls below the set point (plus a dead band)

4.4 Fire Protection Systems

The existing overhead fire sprinkler system shall be modified to permit the installation of the new Acoustic Chamber and Support Equipment Room. Replace all heads with ESFR heads with the same coverage and discharge temperature as the existing heads. Install new branch piping and heads to provide coverage for the new Support Equipment Room and to provide new coverage for the area under the raised floor.

5 Electrical Building System

5.1 Overview

The following descriptions are based upon a site visit by made HDR personnel in Sept. 2014 and a review of record drawings, dated April 2000, furnished by the University.

The proposed area RM. 1251 is currently served by multiply electrical panelboards. Panel “11X” an 800A rated, 400MCB, 120/208V, 3PH. 4W. distribution panel is located in the area immediately adjacent to the lab. This distribution panel is fed from an overhead busduct “”1GK” located in the Service Corridor Level 1. This busduct provides service primarily to laboratory loads within the building. Panel “11X” serves five (5) 100A, 120/208V, 3PH. 4W. panelboards. Panels “11XF” and “11XD” are located in the proposed lab space. Panels “11XA”, “11XB” and “11XC” are located in the adjacent area. The two (2) panels in the proposed lab serve only loads within that space and will need to be removed to accommodate the new layout. The three (3) remaining panels serve loads outside of the lab area and are not intended to be utilized for this project. Panel “1PB”, a 225A, 480V, 3PH. 3W. distribution panel is located adjacent to the aforementioned panel “11X”. This panelboard is lightly loaded, showing only two (2) 3HP service crane’s as loads. This panelboard is fed from a main distribution board located in the buildings’ main electrical room. Refer to electrical one-line sketches and the proposed lab plan for electrical equipment locations.

5.2 Electrical Power (Lab Level)

In order to facilitate the lab layout, new electrical distribution equipment, dedicated to the lab, will need to be provided. A new isolation transformer and a new 125A, 120/208V, 3PH. 4W. panelboard “11XD.2”, will need to be provided to serve lab sensitive equipment loads. A new 225A, 120/208V, 3PH, 4W panelboard “11XD.1”, will also need to be provided to serve miscellaneous and non-sensitive equipment loads.

An existing 225A, 480V 3PH. 3W. panelboard “1PB” will be utilized to provide service to any new mechanical equipment within the vicinity of the lab requiring this voltage.

Electrical Power Standby (lab Level)

The new lab will require a small quantity of standby power 120V convenience receptacles. As there does not appear to be any standby power within the proposed project area, a source will need to be identified in order to accommodate this requirement.

5.3 Lighting (Lab Level)

Existing lighting consists of industrial type fluorescent fixtures mounted near ceiling height and controlled thru local wall switches.

The existing lighting does not meet the requirements of the new lab layout and will need to be replaced with high bay LED fixtures. The lighting design shall result in a 60 foot-candle light level at the lab workbench surface.

5.4 Electrical Power (Service Corridor Level 1)

There are two (2) 120/208V 3PH. 4W panelboards “1EA” and “1EB” and one (1) 277/480V 3PH. 4W. existing panelboard “1EH” adjacent to the proposed helium recovery equipment in the Service Corridor Level 1. Upon initial investigation, it appears that one of these panels contain sufficient spare capacity to accommodate the new equipment loads.

Due to the age of the facility and electrical documentation, it is recommended that a 24HR/30Day load monitor study be done on all the existing panelboards proposed for use in this project in order to verify that sufficient capacity exists’ to support the new lab equipment loads.

5.5 Grounding

There does not appear to be an equipment ground bus within the proposed lab area. A copper ground bus bar will need to be provided within the lab for the connection of lab equipment ground wires. All metal flooring, handrails etc. will need to be bonded back to the ground bus bar.

An insulated ground wire will need to be installed from the ground bus bar to the building ground system. If a building ground system does not exist, the ground wire shall be taken to the nearest building steel.

6 Helium Recovery System

A stand-alone helium recovery system will be included in the renovation project. A manufacturer's schematic of this system is shown in Figure 6-1. This system begins with a low pressure collection bladder connected to the vent outlets of the cryostats though a * 2" brazed copper tube with a low cracking pressure check valve. As helium boils off in each system it will be under low pressure (i.e. 0.5 psi) and slowly inflate the bladder as it fills. The bladder will be a custom size of roughly 4' x 12' x 7' tall and is planned to be located in the Service Core at the second floor level between grids between grids 20 and 21. A new grating platform between the existing catwalks will be required to support and anchor the bladder.

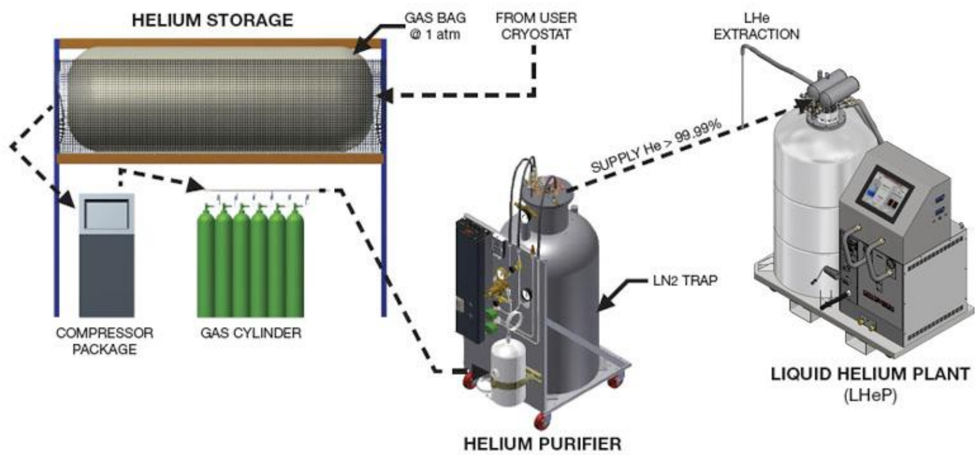


Figure 6-1. Helium Recovery Concept Diagram Showing Components
(diagram courtesy of Cryomech, Inc.)

From the bladder the helium is pumped by a compressor into medium pressure tanks (i.e. 400 psi) through a * ¼" stainless steel tube for storage of larger gas quantities and to provide the pressure throughput required by the purifier and cold trap. The compressor and medium pressure tanks will be located in the Service Core at the second floor level between grids 18 and 19. This area has existing grating that will need to be replaced with a heavier structure to support the load of the new compressor. Refer to Figure 6-2 for a diagrammatic layout of the bladder and medium pressure equipment in the Service Core.

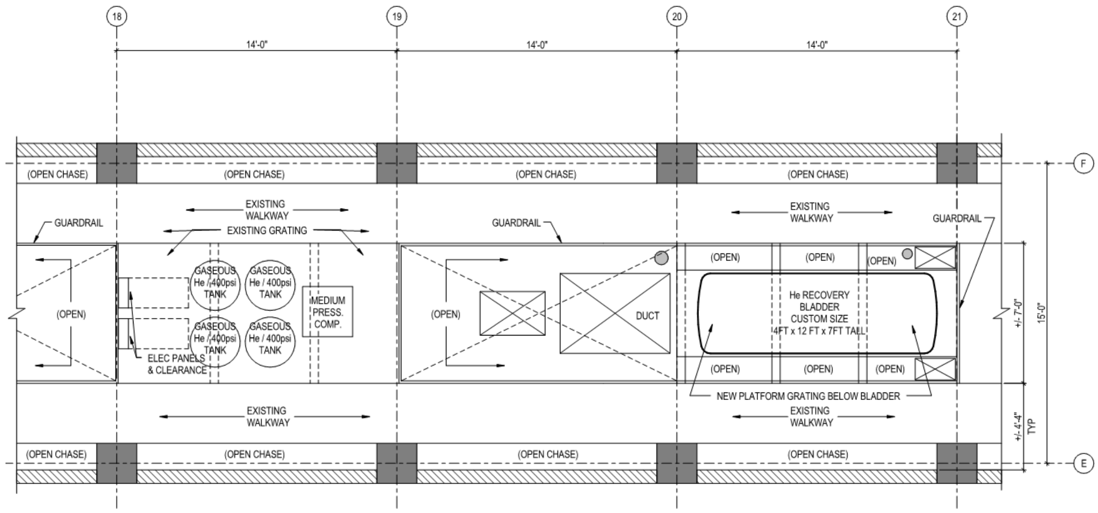


Figure 6-2. Collection Bladder & Medium Pressure Helium Recovery

The medium pressure helium is released from the storage tanks via * 1/4” stainless steel tubing back through the Service Core into the Support Equipment Room, where it is routed into the purifier. From the purifier, helium will be hard piped via * 1/4” stainless steel tubing into the liquefier plant which consists of a compressor and storage dewar.

Vacuum jacketed liquid helium piping* will be provided from the recovery dewar location in the Support Equipment Room to each of the two cryostats. Piping will include bayonet * fittings at both ends to allow transfer hoses to be installed when needed in order to refill each cryostat.

* All system piping and tubing sizes and routing shall be confirmed by the helium recovery system manufacturer.

7 Acoustics and Vibration

7.1 Vibration Design

The Omicron NanoScience LT STM has been identified as the basis of design instrument for this project. The vibration limits for this instrument as published by Omicron are indicated below:[1]

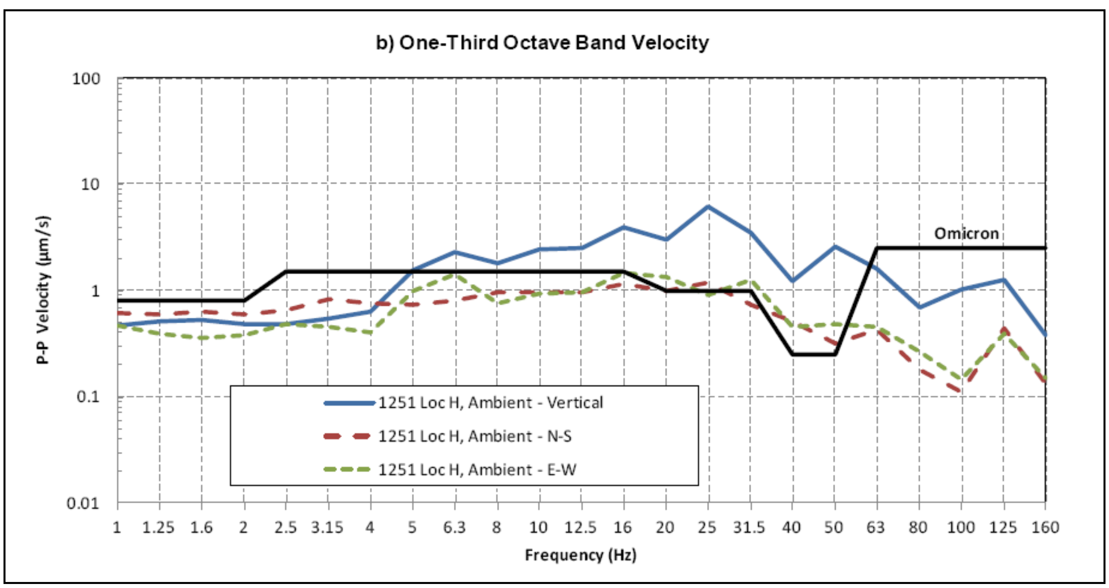
Omicron NanoScience LT STM

Vibration limits to ensure 5 pm stability of the STM without additional external damping:

Frequency range (Hz)	Peak to Peak vibration (µm/s)
1 - 2	0.8
2 - 20	1.5
20 - 39	1
39 - 50	0.25
> 50	2.5

These limits do not indicate the frequency bandwidth so there is some ambiguity in how to interpret the vibration limits. For lack of better information, we can conservatively assume that these limits apply to 1/3 octave bands corresponding to the frequency ranges indicated. With that in mind, it should be noted that these limits, when converted to “rms”, are well below the very stringent VC-E (3.125 µm/s) criterion. However, these limits seem to apply to the STM “without additional external damping”. Thus, it would appear that the quality and performance of the “external damping” system would be the controlling factor in whether the STM is able to perform or not.

Colin Gordon Associates (CGA) carried out a vibration survey of this lab space in September 2014.[2] The findings showed that the ambient vibrations exceeded the STM specification in the vertical axis. The data from one of these measurement locations compared to the STM specification is shown in the following figure:



[1] LT STM Vibration Limits.pdf

[2] Instrument Installation Survey – Vibration Broida Hall UCSB Report, CGA Project 14047, dated Sept 2, 2015

Note however that if these results were converted to “rms”, they would easily meet the VC-E (3.125 µm/s) criterion. Thus, we would consider the ambient vibrations on the existing floor to be very low already.

The new STM will be located in an acoustical enclosure that is constructed on top of a large concrete block. The block elevates the chamber floor to the same elevation as the corridor since the current floor is about 5’-3” below grade. The mass of the concrete block is expected to provide some additional attenuation of the ambient vibrations, and there should also be an improvement in floor stiffness as well. As long as the concrete block is structurally tied into the existing slab, there should not be any degradation in horizontal vibration performance.

To reduce the amount of concreted needed for the block, rigid foam fillers can be used in the forming stages of the concrete block. These foam blocks however should not be placed any closer than 12” from the top surface of the concrete block so as not to degrade the point stiffness as they essentially create a void. Furthermore, the blocks should be distributed randomly (in size and position) so that the voids are non-uniform. This will reduce any resonance response that may be created by the voids.

Beyond the large concrete block, there is little more that can be done structurally to further reduce the ambient vibrations short of implementing an isolation system for the block itself. This is unnecessary however as the STM will include its own isolation system. In fact, in this case, it is undesirable to have two separate isolation systems acting in series since it creates a two-degree-of-freedom situation. This results in two distinct frequencies where vibrations will be amplified; and in the worst case, the two frequencies line up resulting in a very large amplification.

7.2 Mechanical Equipment Vibration Isolation

In addition to a good structural design, it will be important that major pieces of mechanical, electrical, and plumbing (MEP) equipment are also vibration isolated. These will be reviewed during detailed design and vibration isolation recommendations can be provided as necessary. Of course, a good layout where MEP equipment can be kept reasonably far away will minimize the impact risks as well.

7.3 Acoustics Design

As noted in the prior section, the STM will be located inside an acoustical enclosure to minimize the exterior noise impact onto the instrument. The enclosure will consist of a double wall system and two types of constructions were evaluated:

Option 1: Double Wall Concrete Block
Pros:

- Better low frequency performance due to mass.

Cons:

- May take up a larger footprint.
- Construction may be tricky to ensure that inner and outer walls/lids do not touch and that there are no gaps/leaks.
- Interior sound absorption would have to be added separately if needed.
- Acoustical Doors (may need 2 of them) and Pass-throughs need to be carefully designed.

Option 2: Acoustical Chamber (IAC)
Pros:

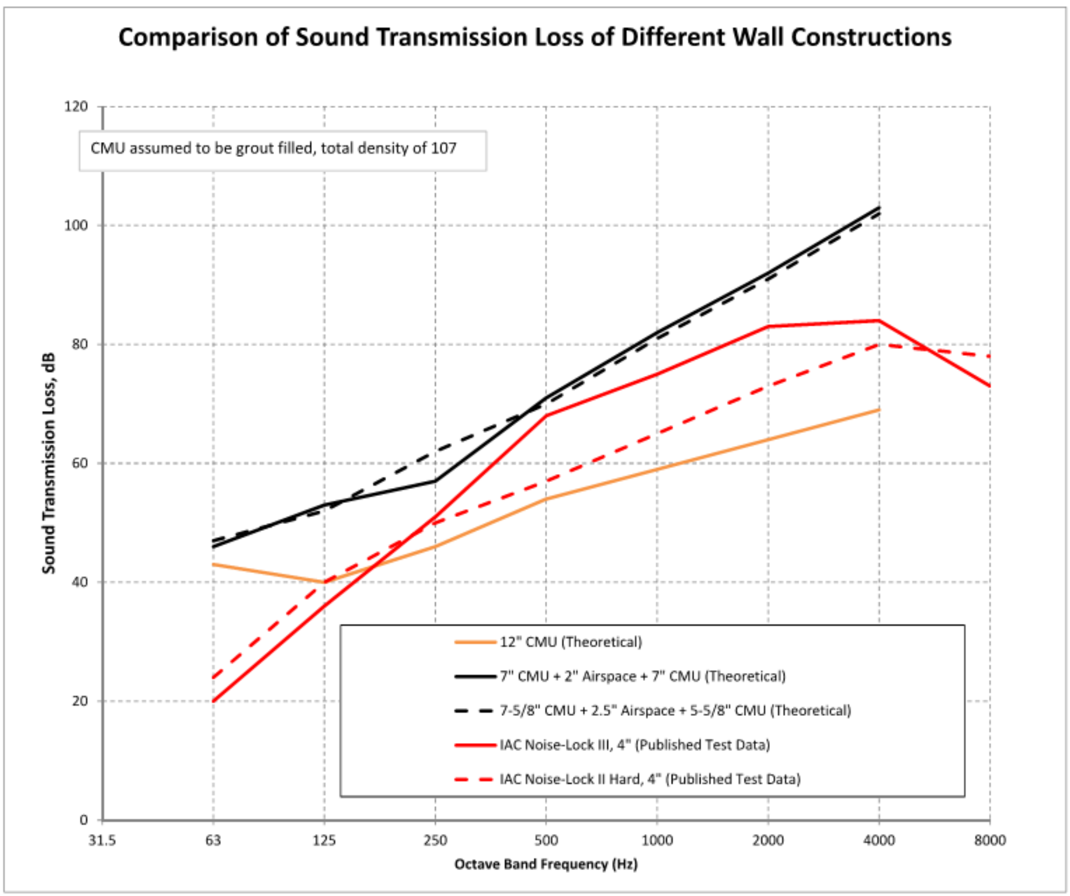
- Smaller footprint.
- Interior absorption can be incorporated into the panels.
- IAC can take design responsibility of the entire chamber so doors and pass-throughs are integrated into the assembly.
- IAC usually supervises installation and carry out their own in-field validation measurements

Cons:

- Would not perform as well at low frequencies because lack of mass.

Figure 7.1 compares the octave band sound transmission loss (STL) data for potential double wall constructions based on the two options noted. Note that the data for the concrete constructions are theoretical while the data for the composite IAC constructions are lab test data. At around 500 Hz, both the concrete constructions and the composite IAC constructions can achieve similar levels of STL. However, the overwhelming mass of the concrete constructions will outperform the composite panels over a broader frequency range, and especially at low frequencies.

	Octave Band Data									
Frequency (Hz)	31.5	63	125	250	500	1000	2000	4000	8000	STC
12" CMU (Theoretical)		43	40	46	54	59	64	69		57
7" CMU + 2" Airspace + 7" CMU (Theoretical)		46	53	57	71	82	92	103		71
7-5/8" CMU + 2.5" Airspace + 5-5/8" CMU (Theoretical)		47	52	62	70	81	91	102		73
IAC Noise-Lock III, 4" (Published Test Data)		20	36	51	68	75	83	84	73	59
IAC Noise-Lock II Hard, 4" (Published Test Data)		24	40	50	57	65	73	80	78	61



* Theoretical assumes no edge damping, no insultion in airspace between CMU

Figure 7-1. Comparison of sound Transmission Loss of Different Wall Constructions

Figure 7.2 presents a further refinement of the STL data for the two concrete double wall constructions (1/3 octave band STL instead of octave band STL). Also shown is the STL for a single 12" concrete wall. An important aspect worth noting is the small dip in the STL for all of these constructions. This dip is the often referred to as the "coincidence dip" where sound waves at that frequency coincide with the resonance frequency of the wall, and thus are more easily transmitted through the wall. By having two walls of the same thickness, the coincident dip is cumulative. By differing the two wall thickness, the coincidence dips do not align and the overall dip is not as severe. Hence, this data demonstrates that having two walls of different thicknesses is the preferred construction.

1/3 Octave Band Data																				
50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000
44	44	43	40	39	41	44	47	49	52	54	56	58	60	61	63	65	66	68	70	71
44	47	50	53	54	52	53	62	65	69	72	76	79	83	86	90	93	97	100	104	107
44	48	50	52	53	52	61	61	64	68	71	75	78	81	85	89	92	96	99	103	106

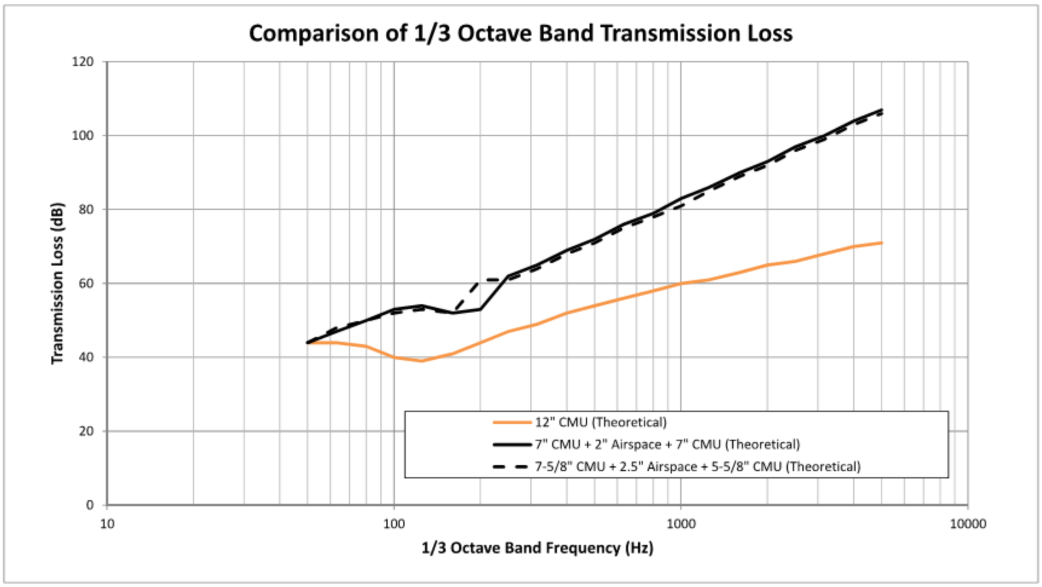


Figure 7-2. Comparison of 1/3 Octave Band Transmission Loss

As the STM chamber will be unoccupied during experiments, there is no need to circulate air within the chamber. Thus, there are no HVAC systems supplying and extracting air from the chamber eliminating a potential noise path into the chamber. Penetrations and pass-throughs for utilities into the chamber will need to be well sealed with a resilient material.

Support equipment for the STM system such as compressors, vacuum pumps, etc will be housed in a separate closet from the main lab area. This reduces the noise impact to the main lab, which is beneficial to the lab users and lab equipment themselves.

8 Cost

C. P. O'HALLORAN ASSOCIATES INC.
CONSTRUCTION COST MANAGEMENT

FEASIBILITY STUDY COST MODEL
CONSTRUCTION ESTIMATE

for

Broida Hall Room 1251 Renovation - Andrea Young Laboratory
University of California Santa Barbara

Prepared for :

HDR
251 South Lake, Suite 1000
Pasadena, CA 91011

November 12, 2015

 # 15-2386

30423 CANWOOD STREET, SUITE 133 ·AGOURA HILLS, CA 91301-4315 ·T 805-494-3703 ·F 805-497-7721 ·WWW.CPOHALLORAN.COM

Feasibility Study Cost Model Construction Estimate

Basis of Estimate

The estimate is based on feasibility study design narrative and drawings dated October 29, 2015. Estimated unit costs include average prevailing wage labor rates with competitive bid conditions. Competitive bid conditions generally occur when bids are received from a minimum of three subcontractors for each trade. The estimate includes allowances and assumptions for materials, building systems, specifications and construction schedule, these assumptions should be confirmed at the next design stage and prior to completion of bid documents. The estimate includes general contractor general conditions, general requirements, bonds, insurances, profit, estimate contingency and cost escalation to mid-point of construction. Project soft costs are not included. Unit costs include premiums for limited access and less than industry standard productivity.

The estimated construction cost represents our best judgment as a professional consultant familiar with the construction industry. We have no control over the cost or supply of labor, materials and equipment, a contractor's methods of determining bid prices and market conditions. We cannot and do not warranty or represent that bids or negotiated prices will not vary from the estimated construction cost.

Estimate Exclusions

Professional design, testing, inspection and management fees.
Fire and all risk insurance.
Legal and financing costs.
Building permits and fees.
Construction, project or staging contingencies.
Owner furnished equipment.
Furnishings and moveable equipment.
Laboratory equipment.
Hazardous material abatement.

Feasibility Study Cost Model Construction Estimate

			762 SF	
COMPONENT SUMMARY				
1.	Foundations		11.52	8,775
2.	Vertical Structure		97.80	74,526
3.	Floor and Roof Structure		279.66	213,099
4.	Exterior Cladding		-	-
5.	Roofing and Waterproofing		7.35	5,600
	Shell (1 - 5)		396.33	302,001
6.	Interior Partitions and Doors		28.45	21,681
7.	Interior Finishes - Floors, Walls, Ceilings		23.31	17,760
	Interiors (6 - 7)		51.76	39,440
8.	Casework, Specialties and Fixed Equipment		100.02	76,215
9.	Stairs and Elevators		-	-
	Equipment, Stairs and Elevators (8 - 9)		100.02	76,215
10.	Plumbing		312.35	238,009
11.	Heating, Ventilation, Air Conditioning		184.27	140,412
12.	Electrical		164.85	125,619
13.	Fire Protection		14.11	10,750
	Mechanical and Electrical (10 - 13)		675.58	514,789
14.	Site Preparation and Selective Demolition		26.77	20,402
15.	Site Development		-	-
16.	Site Utilities		-	-
	Sitework (14 - 16)		26.77	20,402
	TOTAL BUILDING and SITE		1,250.46	952,847
	General Conditions and General Requirements	20.0%	250.09	190,569
	Bonds and Insurances	2.5%	37.51	28,585
	Overhead and Profit	8.0%	123.04	93,760
	TOTAL CONSTRUCTION, 11/2015		1,661.10	1,265,762
	Estimate Contingency	15.0%	249.17	189,864
	Cost Escalation to Mid Point of Construction 09/2016	5.0%	95.51	72,781
	TOTAL CONSTRUCTION ESCALATED		2,005.78	$1,528,408

Component Description	Quantity		Unit Cost	$
1. Foundations				
Reinforced concrete foundation below CMU walls, allow	10	CY	877.50	8,775
			$	8,775
2. Vertical Structure				
Reinforced concrete blockwork interior wall, 8"	811	SF	41.60	33,738
Acoustic chamber wall				
Reinforced concrete blockwork, 8"	480	SF	41.60	19,968
Reinforced concrete blockwork, 6"	572	SF	36.40	20,821
			$	74,526
3. Floor and Roof Structure				
Acoustic chamber reinforced concrete lid				
Reinforced concrete lid, 7" - 8" thick	167	SF	68.25	11,398
Reinforced concrete lid, 6" thick	142	SF	61.43	8,722
Extra for prepared pipe penetrations	10	EA	474.50	4,745
Void between slabs	142	SF	32.50	4,615
In-situ concrete isolation block with inert foam filler, 12' x 14' 6" x 6' deep	1	EA	37,700.00	37,700
Extra for cryostat pit, 28" dia x 30" deep	1	EA	2,860.00	2,860
Cast-in place inertia block, 60" x 60" x 36" high	1	EA	10,833.33	10,833
Air isolation springs - OFOI				-
Main laboratory - platform framing / access hatch and ladder				
Aluminum posts bolted to slab with top and bottom anchor plates, 5' 3" high	19	EA	744.25	14,141
New solid aluminum decking plank	428	SF	89.07	38,122
TS-shaped aluminum extrusion primary beam support	101	LF	84.50	8,535
C-shaped aluminum extrusion secondary beam support	103	LF	84.50	8,704
Aluminum ladder / handrail assembly, 24" wide x 5 risers - fixed in place	1	EA	8,937.50	8,938
Removable guardrail assembly, 3' 6" high	14	LF	299.00	4,186
Removable hatch, 3' x 4'	1	EA	975.00	975

Component Description	Quantity		Unit Cost	$
3. Floor and Roof Structure				
Support equipment room				
Suspended reinforced concrete slab	160	SF	68.25	10,920
Acoustical fill material at void space below platform, 5' 3" high	160	SF	64.84	10,374
Helium recovery bladder platform				
Platform grating including framing and support	63	SF	227.50	14,333
Guardrail - existing				-
Miscellaneous metals and concrete	1	LS	13,000.00	13,000
			$	213,099
4. Exterior Cladding				
			$	-
5. Roofing and Waterproofing				
Patch roofing	1	LS	3,000.00	3,000
Caulking and sealants	1	LS	2,600.00	2,600
			$	5,600
6. Interior Partitions and Doors				
New partition, 16' 11" high	12	LF	621.83	7,462
Core and repair existing partition for new piping penetration	4	EA	279.50	1,118
Interior doors, frames and hardware				
Door, 3' 6" wide	2	EA	3,705.00	7,410
Door, 3' 6" wide - STC 52	1	EA	5,001.75	5,002
Removable acoustic seal threshold, 3' 6" wide	1	EA	689.00	689
			$	21,681

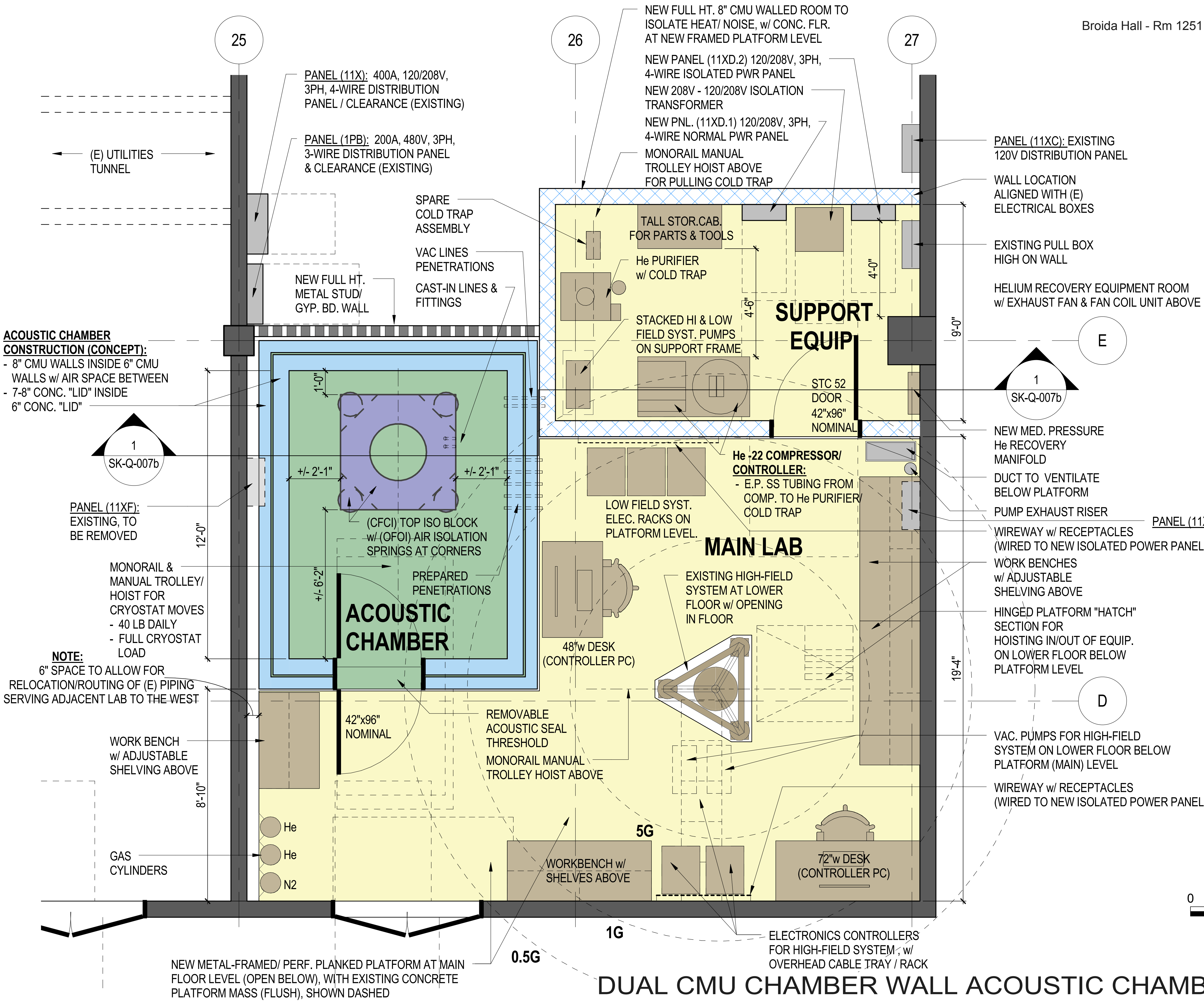
Component Description	Quantity		Unit Cost	$
7. Interior Finishes - Floors, Walls, Ceilings				
Flooring and base				
Resilient flooring	588	SF	9.75	5,733
Rubber base	148	LF	4.65	688
Wall - patch, repair and paint	2,072	SF	4.55	9,428
Ceiling - patch, repair and paint exposed concrete slab	588	SF	3.25	1,911
			$	17,760
8. Casework, Specialties and Fixed Equipment				
Code signage	1	LS	650.00	650
Casework, laboratory grade				
Tall storage cabinets	4	LF	942.50	3,770
Work benches with adjustable shelving above	22	LF	1,118.00	24,596
Countertop desk				
72" long	1	EA	2,145.00	2,145
48" long	1	EA	1,560.00	1,560
Laboratory equipment				
Monorail and manual trolley / hoist - 1/2 ton capacity				
Acoustic chamber	1	EA	9,703.31	9,703
Main laboratory	1	EA	9,703.31	9,703
Support equipment room	1	EA	9,703.31	9,703
Cylinder stand / rack for 3 cylinders	1	EA	1,254.04	1,254
Equipment racks	5	EA	546.00	2,730
Medical gas cylinders - NIC				-
Equipment anchorage - allowance	1	LS	10,400.00	10,400
			$	76,215
9. Stairs and Elevators				
			$	-

Component Description	Quantity		Unit Cost	$
<u>10. Plumbing</u>				
Equipment rough-in and connections, allowance	5	EA	2,860.00	14,300
Condensate drain	50	LF	49.40	2,470
Relocate cup drain	1	EA	3,575.00	3,575
Equipment cooling water system, 10 GPM				
Equipment includes	1	LS	46,800.00	46,800
Reverse osmosis water make-up control valve				
Automated industrial water make-up control valve				
Pressure regulators and relief valve				
Resistivity controller and bleed valve				
Brazed plate heat exchanger				
Redundant in-line corrosion resistant pumps				
UV light for bacteria control				
Replaceable filter				
Cooling supply and return piping	200	LF	60.13	12,025
Valves and connections	1	LS	3,126.50	3,127
Laboratory gas piping and equipment				
Helium recovery equipment, new support equipment room - OFCI	1	EA	26,000.00	26,000
Helium purifier with cold trap				
Spare cold trap assembly				
Helium recovery compressor and dewar				
Vacuum pumps on support frame				
Medium and low pressure helium recovery control manifold				
Medium pressure helium collection equipment, 2nd floor - OFCI	1	EA	26,000.00	26,000
Helium recovery bladder, custom size 4' x 12' x 7' tall				
Tanks, 400 PSI (4 EA)				
Medium pressure compressor				
Low field cryostat - OFOI				-
Laboratory gas piping, allowance				
Low pressure nitrogen gas piping, copper	100	LF	80.60	8,060
Compressed air piping, copper	100	LF	80.60	8,060
Low pressure helium gas piping - copper	300	LF	80.60	24,180
Medium pressure helium gas tubing, 1/4" dia - electro polished 316L stainless steel	250	LF	106.60	26,650
Vacuum jacketed liquid helium piping	50	LF	149.50	7,475

Component Description	Quantity		Unit Cost	$
10. Plumbing				
Laboratory gas piping and equipment				
Gas manifolds	5	EA	1,155.70	5,779
Valves and connections	1	LS	14,512.88	14,513
Test, purge and sterilize	24	HRS	175.50	4,212
Trade demolition	32	HRS	149.50	4,784
			$	238,009
11. Heating, Ventilating and Air Conditioning				
Piping and insulation				
Chilled water piping	100	LF	75.40	7,540
Heating hot water	150	LF	75.40	11,310
Insulation	250	LF	19.18	4,794
Hot tapped connections	2	EA	975.00	1,950
Valves and connections	1	LS	4,901.00	4,901
Semi-custom fan coil unit, 1400 CFM	1	EA	21,840.00	21,840
VAV terminal unit with reheat coil, 2200 CFM	1	EA	3,048.50	3,049
In-line mixed flow variable speed exhaust fan	2,000	CFM	3.71	7,410
Air distribution and return				
Galvanized sheet metal ductwork	950	LBS	16.58	15,738
Plenum, allow	1	LS	8,450.00	8,450
Vacuum pump exhaust, <=4" dia	120	LF	88.17	10,581
Flexible connections	15	EA	122.67	1,840
Dampers, manual volume	6	EA	108.40	650
Acoustical duct liner, allow	150	SF	9.75	1,463
Sound attenuators	1	LS	4,550.00	4,550
Diffusers and grilles	6	EA	370.50	2,223
Oxygen depletion sensors and alarms	1	LS	7,800.00	7,800
DDC control	1	LS	12,000.00	12,000

Component Description	Quantity		Unit Cost	$
11. Heating, Ventilating and Air Conditioning				
Testing and balancing	24	HRS	201.50	4,836
Trade demolition	48	HRS	156.00	7,488
				$ 140,412
12. Electrical				
Main power service and distribution				
Isolation transformer	1	EA	29,250.00	29,250
Feeder conduit and wire	50	LF	49.40	2,470
Emergency power - allowance	1	LS	8,450.00	8,450
Equipment connections and switches				
Laboratory equipment, disconnect switches - allow	6	EA	895.25	5,371
HVAC equipment, junction boxes	3	EA	416.00	1,248
Miscellaneous equipment connections and switches	1	LS	7,150.00	7,150
Power				
Panel boards	2	EA	7,150.00	14,300
Feeder, conduit and wire	100	LF	49.40	4,940
Receptacles, conduit and wire	10	EA	553.80	5,538
Receptacles and wire to wall mounted raceway	6	EA	430.30	2,582
Raceway	12	LF	97.50	1,170
Cable tray, 24" wide	10	LF	75.40	754
Grounding, modification	1	LS	1,950.00	1,950
Lighting				
Fixtures, conduit and wire	762	SF	28.60	21,793
Switches, conduit and wire	6	EA	487.50	2,925
Occupancy sensor, conduit and wire	2	EA	598.00	1,196
Lighting controls - none				-
Telephone and data conduit				
Telephone and data conduit and outlets	4	EA	403.00	1,612
Telephone and data cabling	4	EA	975.00	3,900

Component Description	Quantity		Unit Cost	$
12. Electrical				
Fire alarm system				
Fire alarm devices	6	EA	812.50	4,875
Tie to existing system	1	LS	650.00	650
Trade demolition	24	HRS	145.60	3,494
			$	125,619
13. Fire Protection				
Automatic wet pipe fire sprinkler system				
New branch piping and heads				
Support equipment room	160	SF	11.70	1,872
Main laboratory, below platform	428	SF	11.70	5,008
Replace all heads with EFSR heads, Main Laboratory	458	SF	8.45	3,870
			$	10,750
14. Selective Demolition				
Protective construction, dust and sound barriers	762	SF	13.00	9,906
Selective interior demolition and debris removal				
Saw cut concrete floor slab	53	LF	14.56	772
Concrete floor slab	174	SF	26.00	4,524
Partition wall	1	LS	1,950.00	1,950
Debris removal	1	LS	3,250.00	3,250
Hazardous material abatement - excluded				-
			$	20,402



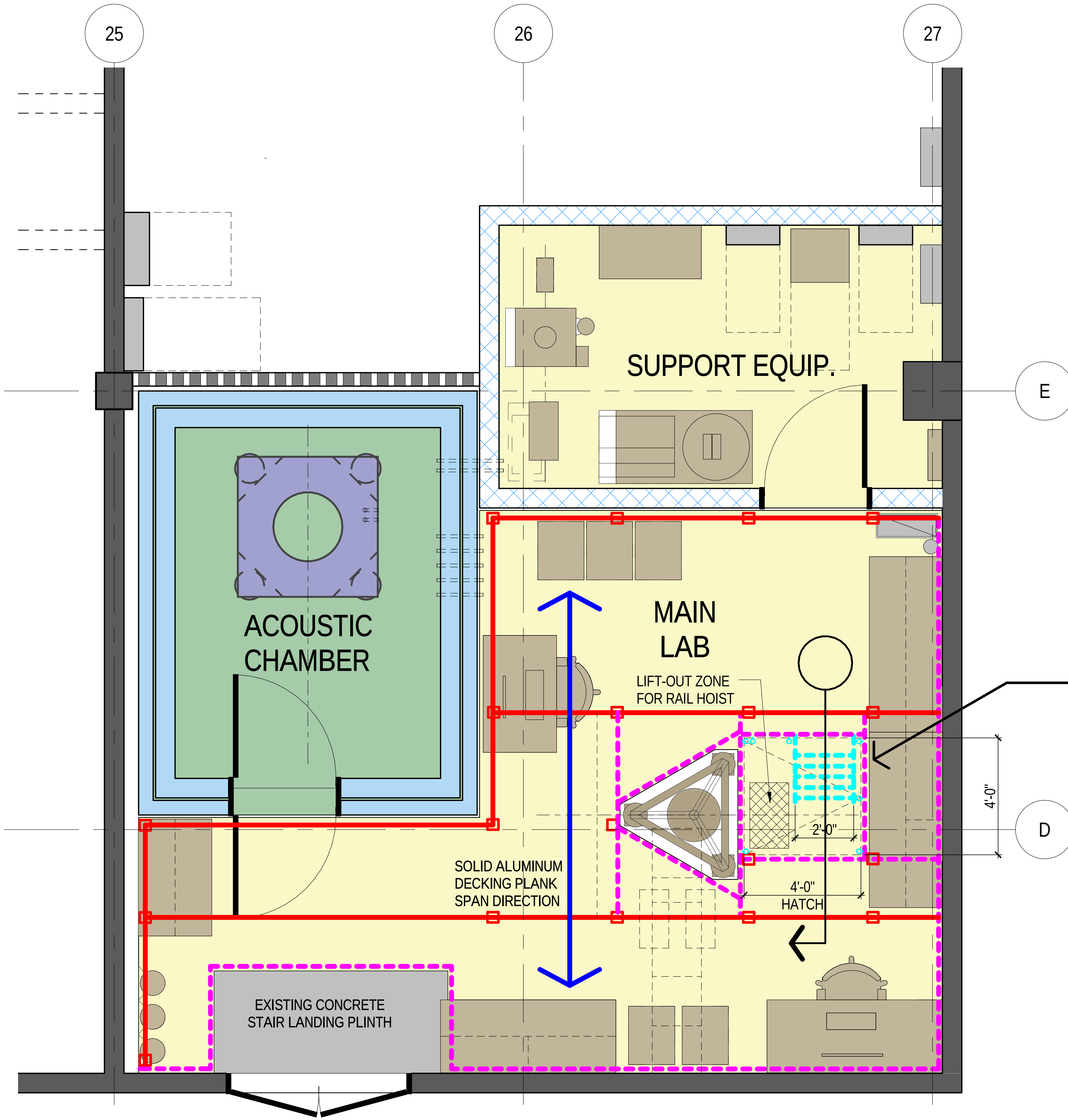
NOTE:
THIS OPTION, MEDIUM PRESSURE He COLLECTION EQUIPMENT:
- COLLECTION BLADDER
- (4) 400 PSI TANKS
- MED. PRESSURE COMPRESSOR TO LOCATE IN EXISTING SERVICE CORE / SECOND LEVEL

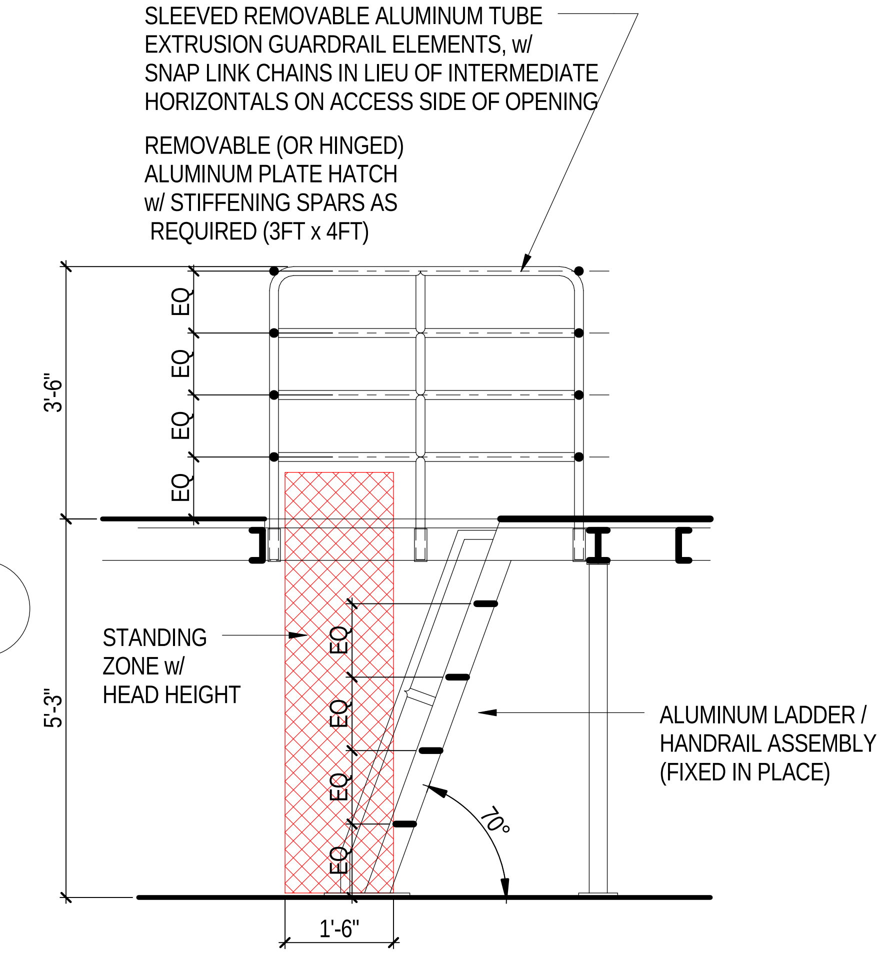
SK-Q-007r1

DUAL CMU CHAMBER WALL ACOUSTIC CHAMBER_OPTION 7

UCSB
HDR

SK-Q-007-frm1





<u>REMOVABLE HATCH:</u>
1. NOMINAL 3 FT x 4FT

<u>FIXED ACCESS LADDER:</u>
1. (ALUMINUM FRAMED) TO SUB-FLOOR AREA BELOW.
2. INCLUDES TUBULAR CONTINUOUS HANDRAILS AT EACH SIDE OF LADDER.

<u>REMOVABLE GUARDRAIL ASSEMBLY:</u>
1.. ALUMINUM TUBE RAILING SECTIONS ON NORTH & SOUTH SIDES THAT SLIDE INTO TUBE SECTION ANCHOR SLEEVES AT C-CSECTION FRAMING BELOW PLANE OF REMOVABLE HATCH ASSEMBLY.
2. CHAIN LENGTHS w/ SNAP HOOKS TO FASTEN TO EYE HOOKS FOR ACCESS TO FIXED LADDER
3. INCLUDE REMOVABLE RAIL SECTION AT HEAD-END OF LADDER TO ASSIST IN CLIMBING UP/DN.

W-FLANGE SHAPED ALUMINUM EXTRUSION PRIMARY BEAM SUPPORT

C-SECTION SHAPED ALUMINUM EXTRUSION PERIMETER / SECONDARY SUPPORT FRAMING

ALUMINUM EXTRUSION VERTICAL POSTS w/ TOP & BOTTOM ANCHOR PLATES

0 2'-0" 4'-0" 8'-0"

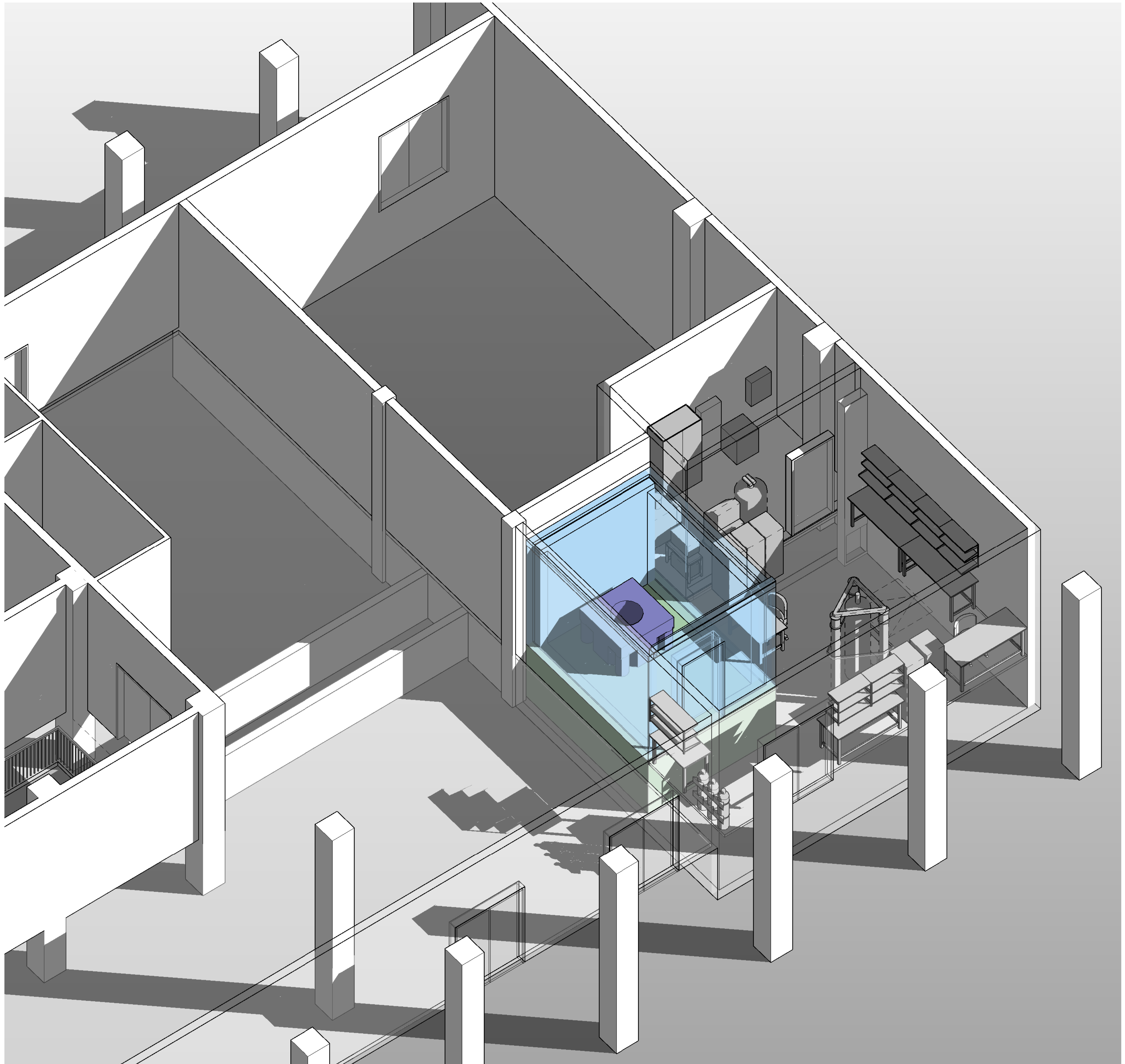
As indicated

UCSB

HDR

PLATFORM FRAMING / ACCESS HATCH-LADDER

SK-Q-007a



DUAL CMU WALL ACOUSTIC CHAMBER_COMPACT OPTION 7_ rev 1_3D VIEW

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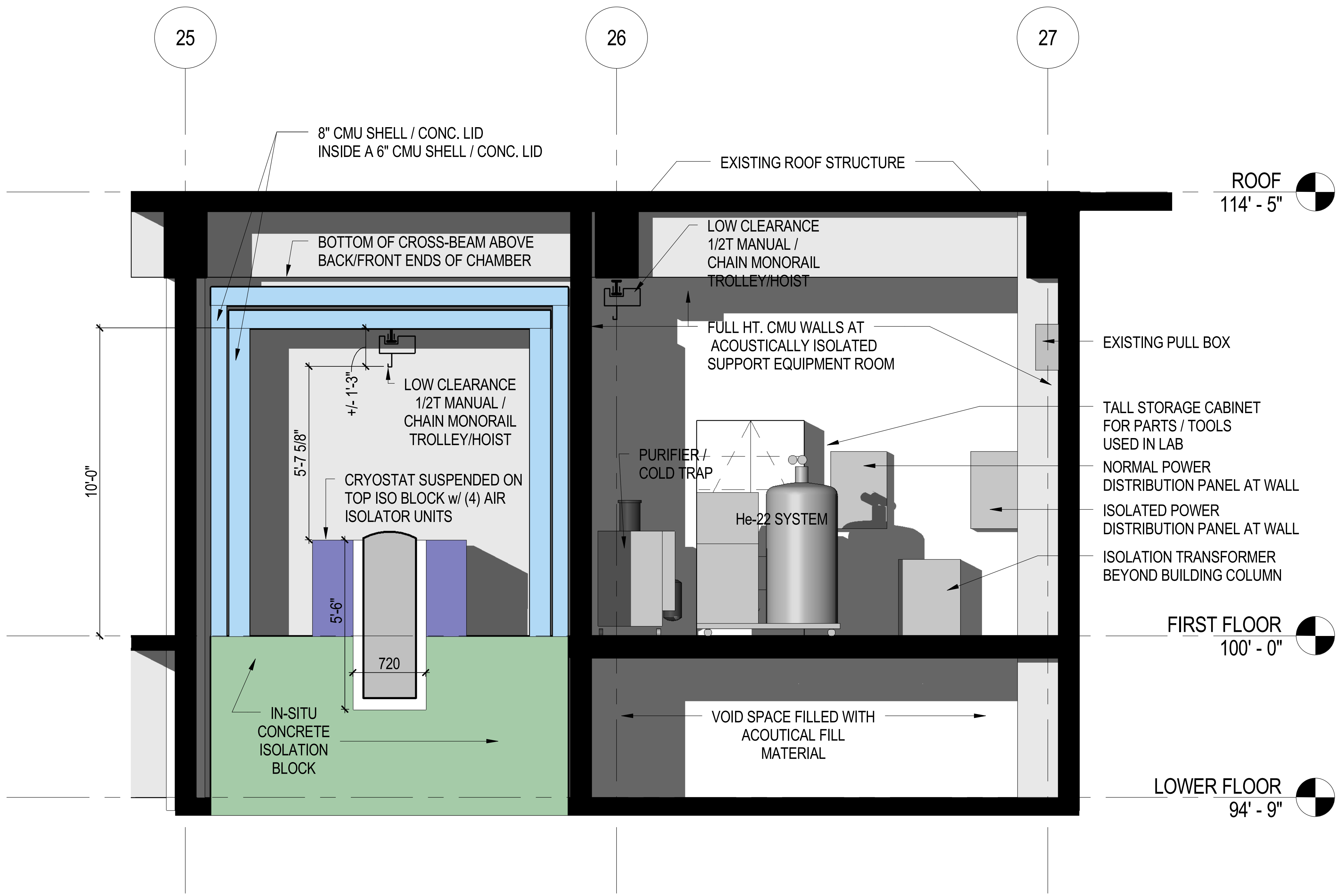
HDR

SK-Q-007b



1/4" = 1'-0"

SECTION - DUAL CMU WALL ACOUSTIC CHAMBER_COMPACT OPTION 7_rev 1

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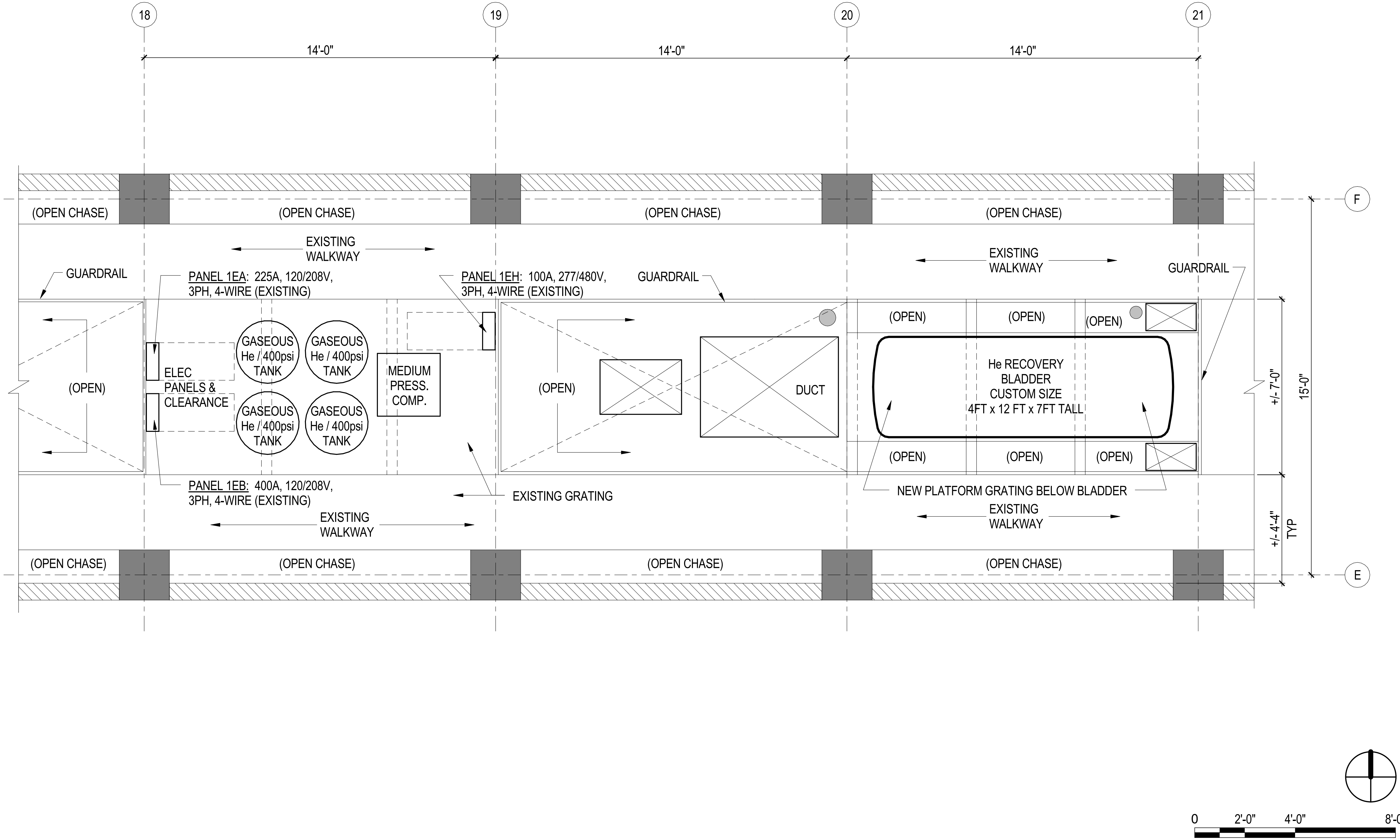
HDR

SK-Q-008



1/4" = 1'-0"

He RECOVERY SYSTEM AT 2nd FLOOR SERVICE CORE

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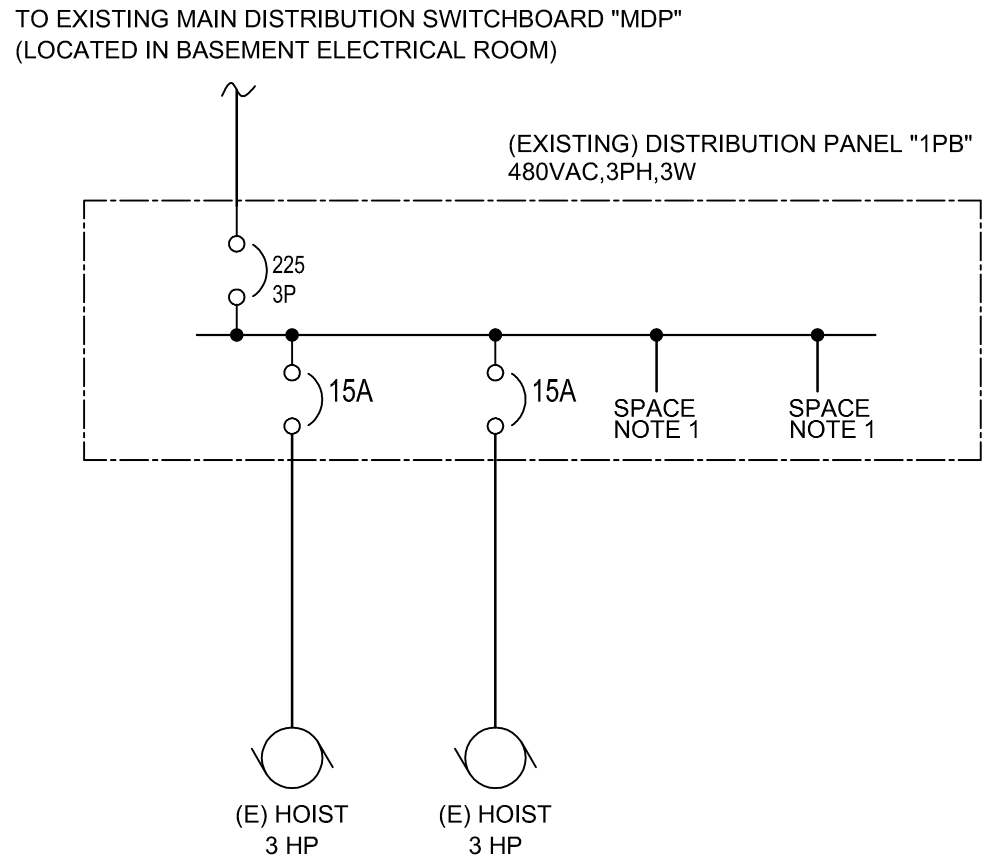
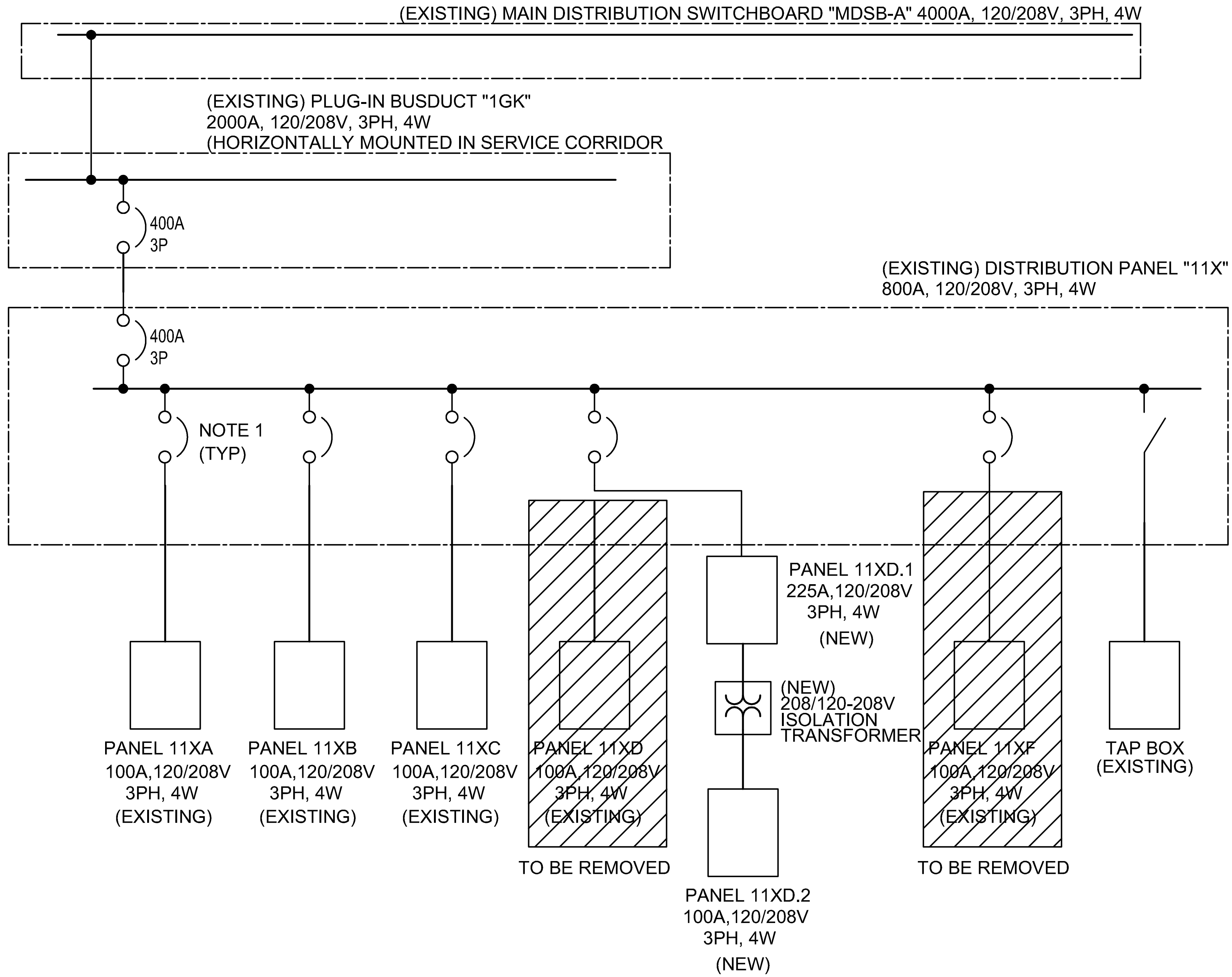


BROIDA HALL-ROOM 1251 ELECTRICAL 480VAC ONE-LINE DIAGRAM (SHT. 1 OF 2)

NOTE 1 : AVAILABLE FOR FUTURE LAB OR MECHANICAL LOADS

APPENDIX 2



BROIDA HALL-ROOM 1251 ELECTRICAL 120/208V ONE-LINE DIAGRAM (SHT. 2 OF 2)

NOTE 1: CONTRACTOR TO VERIFY ALL EXISTING OVERCURRENT PROTECTION WITHIN PANEL

Equipment Scope Responsibility Matrix
Draft List

Equipment Scope	Scope Responsibility	
Work Scope	**Assignment**	
	Base Build	***Hook-up***
Structural Systems		
Concrete Work	*CFCI*	
Platform Construction	*CFCI*	
Roof Construction (scope TBD - penthouse, repairs, etc)	*CFCI*	
Architectural Systems		
Walls, doors, finishes, roofing, flashing, and louvers at roof	*CFCI*	
HVAC Systems		
Fan coil units, exhaust fans, modifications to air handlers (if needed)	*CFCI*	
Ductwork to point of connection, all air devices (vents, grilles, etc)	*CFCI*	
Controls (valves, control points & panels, devices)	*CFCI*	
Process Systems (Laboratory Services)		
Equipment cooling water heat exchanger and pump	*CFCI*	
Equipment cooling water piping to point of connection (valves)	*CFCI*	
Equipment cooling water hoses and final connections to research equipment		*OFOI*
N2 distribution piping (house system 15 psi) to points of connection	*CFCI*	
N2 distribution piping (local system high pressure) to points of connection	*CFCI*	
He distribution pipint (local system from cylinders) to points of connection	*CFCI*	
Liquid Nitrogen Piping (from liquifier dewar to inside chamber)	*CFCI*	
Liquid Nitrogen Hoses / Interconnects - liquifier compressor to liquifier dewar, required if the Liquifier system is non-integrated		*OFOI*
Helium recovery medium pressure compressor, 400 psi tanks, collection bladder (refer toCryomech Medium Pressure Helium Recovery Spec Sheet)		*OFCI*
Helium recovery purifier (cold trap), (refer toCryomech Medium Pressure Helium Recovery Spec Sheet)		*OFCI*
Helium liquifier compressor, liquifier dewar with cold head (refer to Cryomech Liquid Helium Plant Spec Sheet Integrated LHeP22)		*OFCI*
Electrical Systems		
Normal power distribution (demo, renovation, additions)	*CFCI*	
New isolation transformer	*CFCI*	
New isolated power distribution panel, and distribution to points of connection (typically outlets or equipment disconnects)	*CFCI*	
Lighting and lighting controls	*CFCI*	
Grounding system	*CFCI*	
Grounding connections from tools to bus bars		*OFOI*
Special Systems		
Fire Alarm System	*CFCI*	
Oxygen Depletion Monitoring and Alarms	*CFCI*	
Interconnecting controls on helium recovery equipment		*OFCI*
Miscellaneous Equipment and Systems		
He & N2 Gas Cylinder Restraints (wall mounted)	*CFCI*	
He & N2 Gas Cylinder Manifolds (wall mounted)	*CFCI*	
Storage cabinets	*CFCI*	
Electronics racks		*OFOI*
Cryostats		*OFOI*
Vibration isolators for cryostats		*OFOI*
Vacuum pumps for cryostats		*OFOI*
Work desks and computers		*OFOI*