ODH Assessment

Date: 1/29/03

Division: Accelerator - FEL

Location: FEL FACILITY

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Approval

Accelerator Division Engineering Department Head Will Jr 2/5/03

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Building Manager
EHS IH group, ms 35
EHS Documentation ms 35

ODH Risk Assessment, FEL
January 23, 2003

Introduction.

This assessment addresses the risk of oxygen deficiency hazard for the Free Electron Facility (FEL). The assessment is conducted according to the requirements of Appendix 6500-T3, "ODH Risk Assessment". This assessment addresses the helium ODH hazards associated with the facility. These are sources of helium gas which can dilute the normal oxygen content with health effects as outlined in Appendix 6500-T3.

The following sections covers the modeling scope and methodology for the cryogen dispersion release, a description of the work space, operational modes which affect the risk factors, failure rates of the components, the resultant area classification, and self-rescue-atmosphere respirators.

Model for Cryogen Dispersion Release

The building description is depicted on JLAB drawing D05309-D-001. The work areas which are covered in this analysis includes zones 1 through 7 and zone 15 on the second floor and the accelerator enclosure on the first floor. In the analysis it is assumed that administrative controls are maintained in place which eliminates penetrations or other opening between the zones of the second floor and the accelerator enclosure on the first floor. Two 12 inch ceiling vent tubes are located in the accelerator enclosure to vent small amounts of lighter than air mixtures of ODH gases to the outdoors.

Recent helium spill tests within the JLAB accelerator tunnel and the CHL vent stack test apparatus has shown that rising helium gas interacts with the surrounding air, mixing with it as it rises. Once combined with air, the helium does not readily separate out of the air/helium mixture thus is not reversible. It will retain the same helium to air percentages as long as it does not further interact with additional sources of air (dilution) or higher concentrations of helium (enrichment). Since the helium/air gas "mixture is lighter than air, the mixture rises but at a substantially smaller than pure helium gas since the mixture is heavier. When natural convection ventilation (in the form of vertical vent tubes) is provided, <u>both</u> oxygen and helium are purged from the enclosure area. The helium/air mixture will displace more of the confined space in a vertical downward direction from the ceiling if no additional sources of air are provided to mix with the escaping helium/air mixture.

The FEL Model for Cryogen Dispersion Release is based on 3-1/4 fully operational cryogenic 1600L cryomodules and cryogenic distribution system at 2K located within the FEL accelerator enclosure. The FEL ODH sources of pressurized helium gas are a cryogen distribution 3.5 atm, 35K shield supply line, a 3.0 atm shield return process line, a 3 atm 4K supply line, a 4K .031/1 atm return line, a warm (300K) 3 atmosphere helium

supply line and the component failures associated with the 3-1/2 cryomodules. The cryogen transfer line relief valves are located outdoors of the FEL facility and does not contribute as a source for ODH for the FEL accelerator enclosure.

Each of the cryogenic helium supply lines within the accelerator enclosure are identified by the JLAB Appendix 6500-T3, Table 2 as having a rupture probability of $2x10^{-8}$ hours each. The estimated spill amount of pure helium from the supply lines would be approximately 125,000 SCF with a duration of 20 minutes. This is equal to the volume of the entire accelerator enclosure and in accordance with Figure 3 of Appendix 6500-T3 would result in a fatality factor of 1 for each of the lines. The total contribution to the analysis for the transfer line supply lines in the enclosure would be $1x10^{-7}$ hrs-1.

Each cryomodule is equipped with a primary and secondary helium process relief valves. The primary reliefs are designed for a cryomodule blocked flow failure mode and is limited by the cryomodule inlet JT valve size to 15 g/s (187 scfm) ODH source availability. Please refer to attached "HELIUM SPILL" diagram. Primary cryomodule relief valve exhausts are set at 1.16 atm differential (17 PSID) and are manifolded to a guard vacuum relief header system which has its own relief valves set at 1.4 PSIG to the outdoors. Thus cryomodule blocked flow relief failure mode is not considered a source of helium gas source into the accelerator enclosure. Relief valve failure rate ($1x10^{-5}$ per day) per Table 3 of the Appendix does not contribute to the analysis for the number of system relief valves.

Two 12 inch diameter enclosure ceiling vent tubes to the outdoors provide up to 37.5 g/s helium (470 SCFM) natural vent capacity for minor cryomodule or cryogen transfer line leaks at 17% oxygen level with a helium/air mixture. The resultant sum fatality factor for leaks (JT valve failure), etc. of a single component is 0 (19.5% O2) with an individual probability of $1.1x10^{-4}$ hours. Clearly the product/sum (10^{-10}) of all individual devices under a small leak failure mode is $<10^{-7}$ under Table 6 of ODH Classification Appendix and does not substantially contribute to the ODH analysis for leaks.

Each cryomodule secondary relief valve is a parallel plate relief with a setting of 3.4-4 atm (35-45 PSIG) that can relieve into the accelerator enclosure. However this is unlikely since an instantaneous vaporization of the liquid inventory of a single cryomodule (1600 liquid liters, 49,000 SCF from 2K liquid) would expand directly into the sub atmospheric return header. The return header is amply sized to limit the pressure to 15 PSIG for beam line or insulating vacuum failure within the cryomodule under 2K or 4K operation. Again, consideration of a faulty relief valve as the mode of failure does not contribute to the analysis for the number of relief valves within the enclosure.

To ensure the 2K return header is never isolated from a cryomodule, the cryomodule RT (return valve) **must** be administratively locked open by a JLAB Standard Operations Procedure (TSOP or SOP using the JLAB administrative "Danger" lock system) any time a cryomodule is connected to the 2K return header and is assumed in effect for this analysis. Other operational, maintenance, or repair process connection configurations must be considered separately under additional JLAB TSOPs or SOPs whenever the

cryomodule is disconnected from the 2K return header and is cold with liquid inventory. Such special procedures should be considered separately and is not part of this assessment.

The model for a helium release rate is based on the worst release cases listed under the Operational Modes below. Failure rate estimates (P_i) are based on JLAB listed equipment rates under EH+S Section 6500. Fatality Factors (Fi) are derived from Figure 3, of the EH+S Appendix 6500-T3. The sum of the failure product of the F_i and P_i for each of the operational modes determined the area classification in accordance with table 6 of Section 6500 of the EH+S manual.

Description of Work Space:

The accelerator enclosure space has a large main area measuring 50 feet wide, 220 feet long and 9 feet in height with a small alcove triangle area for a total of 110,000 ft^3. The second floor has the same projected space but with slightly higher ceiling (12 feet).

ODH RISK ASSESSMENT

The following are the set of events and the associated probability and fatality factors.

Cryomodule and TL (Accelerator Enclosure) (normal ops, small natural vent)

EVENT	SPILL RATE, cfm	SPILL, scfm	%O2	P_i	Fi
Small Leak	12.5	22500	19.5[1]	1.1×10^{-4}	0
4K Line Rupture,2	6250	125,000	<9[2]	4×10^{-8}	1
Shield Line Rupture,2	6250	125,000	<9[2]	4×10^{-8}	1
Power Outage	0	0	21	$2x10^{-4}$	0
Relief Failure	42500	48000	<9	$12x10^{-10}$	1
Blocked Shield Rtn	188	3760	17[2]	$1x10^{-7}$	0
Blocked 2K return	188	125000	21[2]	$1x10^{-6}$	0
Insul Vac Loss	10625	48000	<9[3]	$4x10^{-6}$	0
Beam Line Vac Loss	42500	48000	<9[3]	$4x10^{-6}$	0
Waveguide Vac Loss	10625	48000	<9[3]	$4x10^{-6}$	0

Super Scrip Notes:

Note 1: Not detectable by upper ceiling ODH sensors
Note 2: Relief Valve to Guard Vacuum Header System, out-of-doors
Note 3: Absorbed by 2K return line header, limited to 2 atm pressure

FEL Second Floor (sealed from Accelerator Enclosure but assumed to have some leak, via 40 sq. inches, 20 minutes (enclosure cryogen supply line break)

EVENT	SPILL RATE, cfm	SPILL, scfm	%O2	P_j	Fi
Spill Leak	375	7500	16[1]	9×10^{-6}	5×10^{-6}

Super Scrip Notes:

Note 1: Upper 3 feet of ceiling space

FEL Accelerator Enclosure U-Tube Operation (per demand):

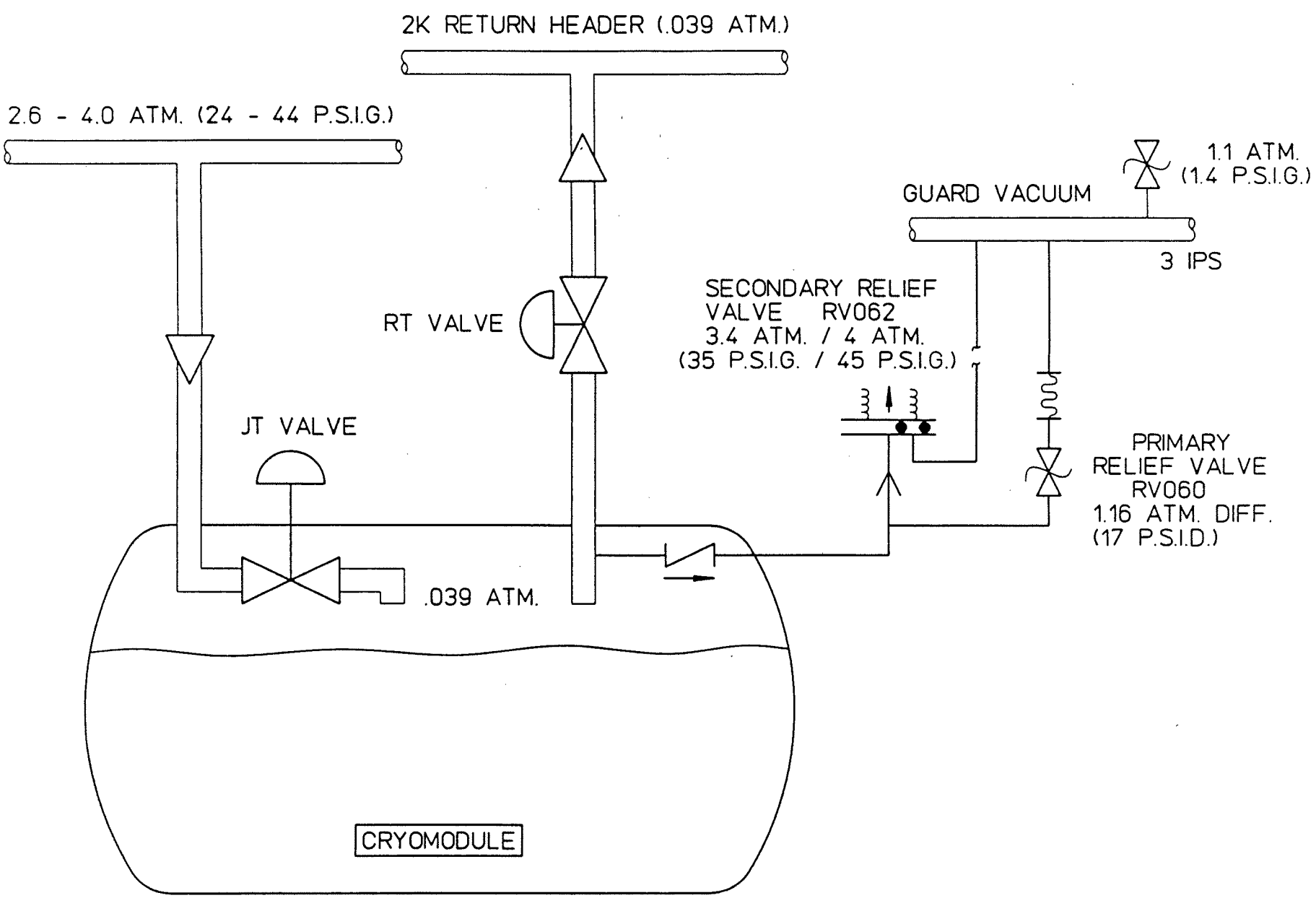
EVENT	SPILL RATE, cfm	SPILL, scfm	%O2	P_j	Fi
U-Tube[1]	6250	125,000	<9[1]	4×10^{-4}	1

Super Scrip Notes:

Note 1: Flex line 4K supply connection sting, no isolation valving on 4K supply

ODH Analysis Results

1. Steady-State 2K and 4K operations with 3-1/4 cryomodules, sealed floor penetrations to the second floor, and SOP controlled locked open 2K cryomodule return valves into the 2K return header.....Rating **ODH-0** ($<10^{-7}$) for the **FEL enclosure behind and in front of the cryomodules** per TABLE 6 of the JLAB EH+S manual Appendix 6500-T3..
2. Steady-State 2K and 4K operations for the **FEL second floor** with minor allowable leakage rate listed above with sealed floor penetrations.**Rating ODH-0** (per TABLE 6 of the JLAB EH+S manual Appendix 6500-T3.
3. **Cryomodule U-Tube Change-out Procedure**.....**ODH-2** ($<10^{-4}$) per TABLE 6 of the JLAB EH+S manual Appendix 6500-T3



HELIUM SPILL

TJNAF

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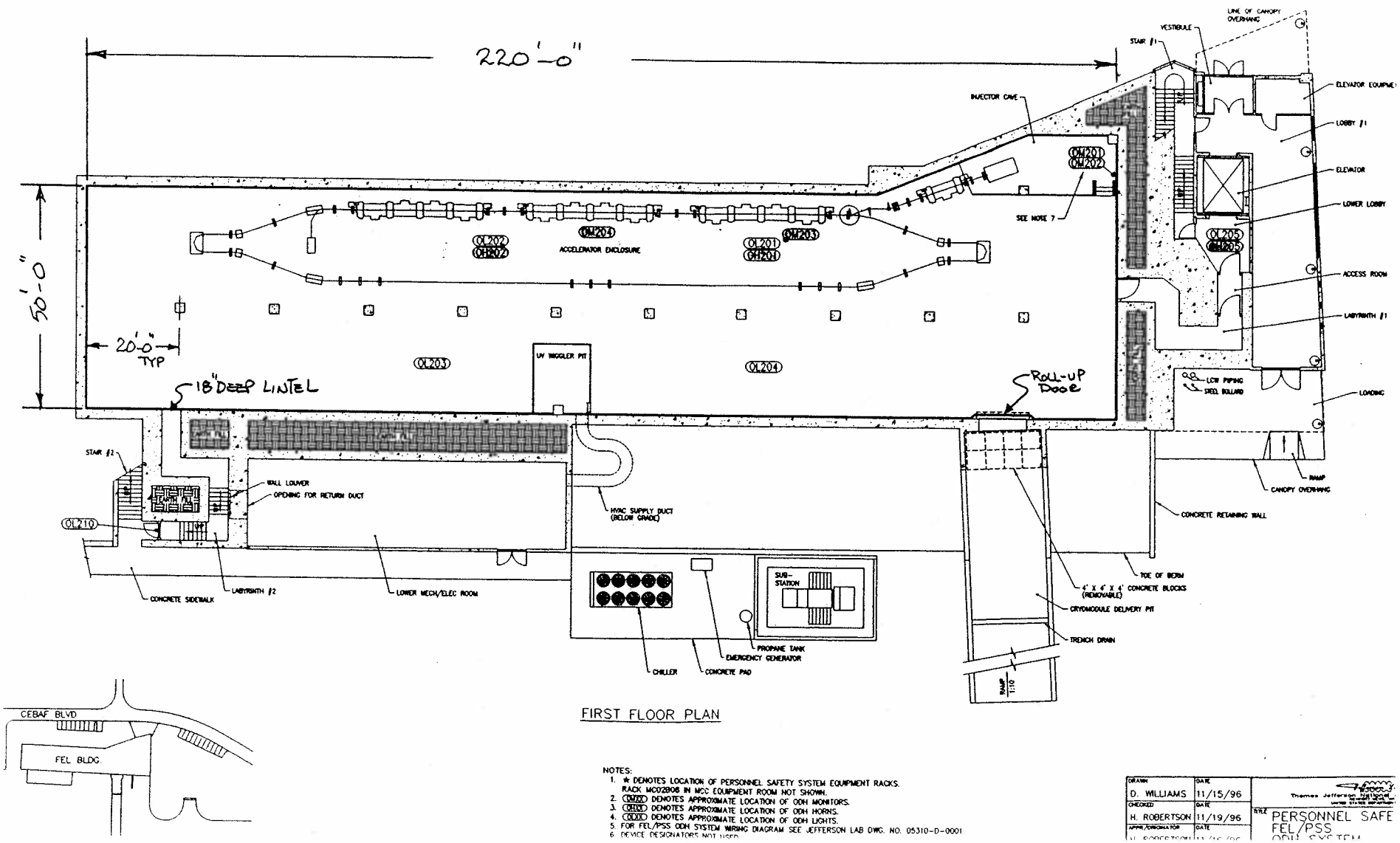
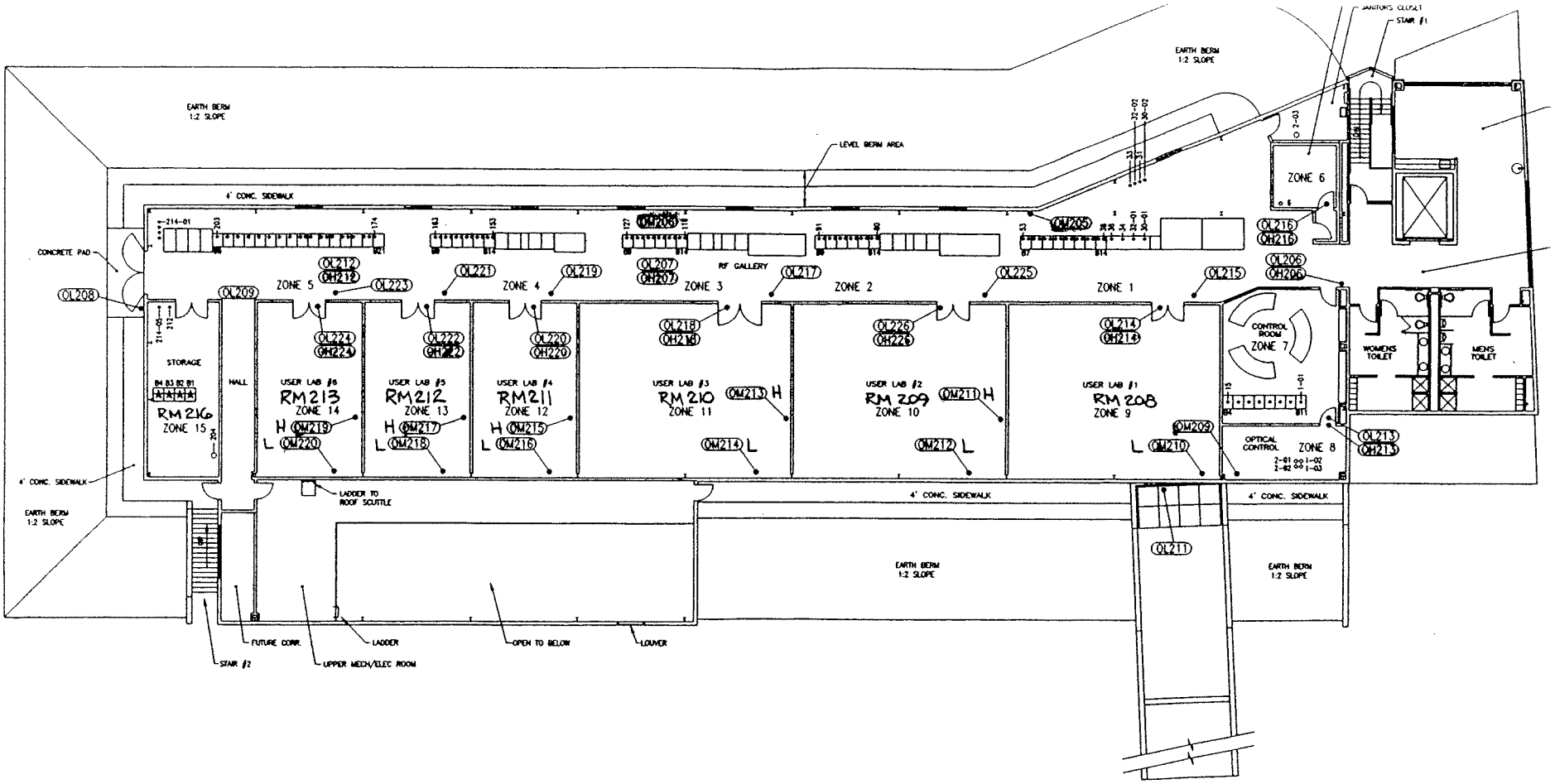


FIRST FLOOR PLAN

NOTES:
1. ★ DENOTES LOCATION OF PERSONNEL SAFETY SYSTEM EQUIPMENT RACKS. RACK MC02908 IN MCC EQUIPMENT ROOM NOT SHOWN.
2. (OM200) DENOTES APPROXIMATE LOCATION OF ODH MONITORS.
3. (OH200) DENOTES APPROXIMATE LOCATION OF ODH HORNS.
4. (OL200) DENOTES APPROXIMATE LOCATION OF ODH LIGHTS.
5. FOR FEL/PSS ODH SYSTEM WIRING DIAGRAM SEE JEFFERSON LAB DWG. NO. 05310-D-0001
6. DEVICE DESIGNATORS NOT USED

DRAWN	DATE	Thomas Jefferson National Accelerator Facility
D. WILLIAMS	11/15/96	
CHECKED	DATE	
H. ROBERTSON	11/19/96	
APPR./ORIGINATOR	DATE	TITLE: PERSONNEL SAFE FEL/PSS ODH SYSTEM



SECOND FLOOR PLAN

FEL/PSS ODH SYSTEM
SITE LAYOUT