Demeritt 103 Risk Assessment

Risk assessment undertaken as a result of change of use of the room. A superconducting magnet with associated cryogens (liquid helium and nitrogen) is planned to be used in the room. Also, solid ammonia will be used in the room.

Room details
Dimensions: 40’9” x 27’3” X 13’6”.
Volume = 14991 cubic feet = 424498 liters

963 cfm measured at main exhaust duct. This exhaust may, under peak heating or cooling periods, recirculate among the other labs in the building.

533 cfm measured at 6” lab exhaust duct. This exhaust is shared by other labs in the building. Volume of exhaust is specified in this room in the building plan as 150 CFM. The duct must be capped in other rooms, resulting in higher flow in room 103. The exhaust duct terminates at the roof.

Air changes
963+533=1496 cfm total exhaust
(1496*60)/14991=5.988 air changes per hour (ACH)

Cryogens
250 liter tanks of helium and nitrogen (1 or 2 of each) will be stored in the room. They will be used for initial cool down of the magnet and for refilling the magnet during operation. For calculations, expansion ratio of helium is 782:1 and nitrogen is 694:1.

Occupational hazards associated with cryogens include: explosion and pressurization, oxygen deficiency, oxygen enrichment, contact hazard (frostbite), high noise levels, and material embrittlement. Lab members should take cryogen safety training offered by OEHS.

Magnet cool-down procedure
Capacity of cryostat with insert and magnet installed: 50 liters

Day 1: cool with LN2. Magnet initially cooled with LN2 then left overnight to attain stable temperature. 70 liters of LN2 used during this procedure. Approximately 55 liters of LN2 vaporize during this procedure which takes about 1 hour. Details on p. 27 of AMI magnet manual.

55 L * 694 = 38170 L

Resulting O2 concentration:
0.21*e^(-38170 /424498)=19.19%

19.19% is an oxygen deficient environment according to OSHA. Measured air change rate in the room is 6 ach. At this air change rate, it unlikely the room would fall below 19.5% O2. However, mixing in the room is limited which could put occupants near the cool-down procedure at risk of O2 levels lower than 19.5%. Recommend wearing personal oxygen monitors during routine cool-down. Also, recommend utilizing a snorkel exhaust near the nitrogen vent to capture the nitrogen as it boils off.

Day 2: Final cool-down with LHe. Total volume of LHe used: 86 L. Approximately 36 liters of LHe vaporize during this procedure. Details on p. 31 of AMI magnet manual.

36 L * 782 = 28152 L

Resulting O2 concentration:
0.21*e^(-28152 /424498)=19.65%

19.65% is not is an oxygen deficient environment according to OSHA. Also, gaseous helium will rise to the ceiling and is not expected to present risk to workers. Workers should use personal oxygen monitors during the work as a conservative measure.

Magnet Quench

Volume of cryostat: 50 liters of liquid helium.

LHe expands 782:1
782 * 50 = 39100 liters

Assuming perfect mixing in a magnet quench scenario where the cryostat is full of LHe, 37850 liters of helium would reduce oxygen concentration as follows:

Resulting O2 concentration:
0.21*e^(-39100/424498)=19.15%

19.15% is an oxygen deficient environment according to OSHA. But, the helium will rise to the ceiling. Assuming zero ventilation, the helium would accumulate to a depth of approximately 15 inches at the ceiling; this layer of helium would be approximately 12’3” off the floor. In a quench scenario, occupants should exit the room.

Ammonia

Ammonia exposure limits:

Short Term Exposure Limit (STEL; 15 minutes): 35 PPM;
Time Weighted Average (TWA; 8 hour average): 25 PPM; and
Immediately Dangerous to Life and Health (IDLH): 300 PPM.

“Ammonia's pungent odor and irritating properties usually provide adequate warning of its presence; however, olfactory fatigue can occur. Inhalation can result in fatalities.” CDC Agency for Toxic Substances and Disease Registry.

Ammonia samples are 1 mm pieces of solid ammonia in a cylindrical volume of 3 cm long X 2.54 cm diameter.
Volume of cylinder is 1.521e-5/cubic meters.
Ammonia pieces comprise about 70% of total volume of the cylinder.
Ammonia weighs 817kg/cubic meter as a solid.
Sample is 1.521e-5/cubic meters which equals 0.0124 kg.
0.0124kg*70% = 0.0087kg or 8700 mg.
The STEL of 35 PPM is equal to 27mg/m3.

Assuming perfect mixing and zero ventilation, one ammonia sample could produce an environment that is 8700 mg / 424.498 m3 = 20.495 mg/m3, a value lower than the STEL and TWA. However, the ammonia would rise to the ceiling, preventing perfect mixing. Local concentration in the area of use or a spill is of particular concern, considering the high toxicity of ammonia. Thorough review of work practices and spill scenario is warranted.

Magnet installation and change-out
The magnet is installed in the magnet dewar with a lifting device such as an overhead chain hoist or a tripod hoist. A tripod hoist is currently used by the University Instrumentation Center for this purpose and may be borrowed. If the tripod hoist is not adequate, a chain hoist may be purchase and affixed to an overhead beam. Crane operator training and an annual crane inspection will be required for installation and use of the chain hoist.

Recommendations:

1. A snorkel exhaust should be installed near the magnet. It should be able to be used to capture venting gas during cool-down the procedure and in the area where ammonia will be handled. The snorkel could be connected to the lab ventilation duct in the room. A local alarm should be installed on the snorkel to notify users of air flow failure.
2. Measure worker exposure to ammonia during standard work practice to confirm published exposure limits are not exceeded. Can be performed/managed by OEHS.
3. Monitor oxygen concentration in work area during a routine cool-down procedure to confirm the environment is not oxygen deficient. Can be performed/managed by OEHS.
4. Personal oxygen monitoring devices should be utilized during cool-down operation. Can be purchased with support from OEHS.
5. Use appropriate PPE for work utilizing cryogens including face shields, cryo gloves, lab coats, and appropriate clothing.
6. Develop Standard Operating Procedures for all cryogen and ammonia procedures including: magnet cool-down, refilling cryostat, handling and transporting ammonia, handling and use of cryogen dewars, and lifting the magnet. OEHS can assist with this.

7. Lab workers should take OEHS cryogen safety training.
8. Perform in-depth review of ammonia handling procedures with OEHS to assess risks.