IH Exposure Assessment: Injector Tunnel, Sulfur hexafluoride (SF_6)

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Introduction

A sulfur hexafluoride (SF_6) tank houses the Glassman gun high voltage power supply within the CEBAF Injector Tunnel. The SF6 is an insulating gas for the gun high voltage power supply. SF_6 is a colorless, odorless gas with a vapor density five times heavier than air. The primary hazard for SF_6 is asphyxiation (Praxair, 2015) as a result of displacement of oxygen. Since the gas is 5 times heavier than air, the gas will accumulate along the floor and low areas creating an oxygen deficiency hazard area, defined as an area where the oxygen concentration is less than 19.5%.

SF_6 is chemically inert; however, toxic contaminants such as sulfur pentafluoride and sulfur tetrafluoride can be present in technical grade gas (Sulfur Hexafluoride - TLV documentation, 2001) or when the gas is subjected to electrical discharge (Compressed Gas Association, 1999).

The Glassman power supply located in CEBAF Accelerator Injector contains 45 lbs. (25 ft^3 @ 60 psi) of SF_6. The Injector is open to the North Linac, however a 2 foot wall is located 100 ft from the power supply.

This assessment analyzes hazards of oxygen deficiency hazard, related to displacement of oxygen and ensures that the ACGIH threshold limit value (TLV), 1000 ppm (ACGIH, 2016) averaged over an 8-hour shift, is not exceeded for staff entering and working in the Injector Tunnel.

IH Calculations

Table 1: Worst case contaminant & oxygen concentration (total release of SF_6)

Quantity of SF_6 (lbs.)	Volume of SF_6 (ft^3)	Volume of location (ft^3)	% Oxygen in case of release *	SF_6 concentration in case of release *
45	111	23,100	20.8%	4805

** Resulting concentration assumes perfect mixing of released gas with air throughout the location*

Table 2: Height of accumulation from floor after initial release

Volume of gas (ft^3)	Surface area of room (ft^2)	Resulting plume height on floor (assume 50% of floor contains equipment)
111	2100	1.3 inches

Table 3: Potential staff exposure

SF_6 concentration in air	TLV exposure limit	Allowable exposure time in case of total release of SF_6
4805 ppm	1000 ppm	1.5 hours

Discussion

Release scenarios show that the resulting SF_6 concentration exceeds the occupational exposure limit of 1000 ppm. These scenarios assume perfect mixing of the contaminant with air, however since the density of SF_6 is 5 times heavier than air it is assumed that the gas will fall to the floor. The maximum height from the floor after initial release is no more than 1.3 inches from floor level. The area of highest concentration remains along the floor and the risk to personal breathing zone is reduced unless a person is working at low levels or in the immediate vicinity of an active leak.

An exposure would result in exceedance of the TLV exposure limit only if a person were lying on the floor for more than 1 hour in the Injector Tunnel after total loss of the SF_6 gas. ACGIH allows for a one time excursion up to but not exceeding 5 times the TLV for a one-time exposure during a work day. In the case of SF_6 the excursion limit would be 5000 ppm, which is greater that the resulting concentration of 4805 ppm when accounting for the total volume of the Injector.

Resulting oxygen concentrations are within acceptable limits as calculated in Table 1.

Hazard Controls

The Accelerator Division's Center for Injectors and Sources has the following controls to mitigate exposures.

Table 3: Hazard controls in use in the Injector Tunnel:

Engineering controls:	Administrative controls:
○ Monitoring systems ○ Pressure systems	○ Training ○ Procedures/Task Hazard Analysis ○ Signs

Mitigations

Releases of SF_6 are monitored via the pressure within the SF6 tank that houses the Glassman gun high voltage power supply. There is a digital pressure gauge that monitors SF6 pressure, and can be configured to "alarm" when pressure falls below a User specified level. The alarm is a visual, yellow LED that illuminates at the SF6 tank. It will also trigger and EPICS signal to the control panel. The alarm is triggered when pressure drops from 60 to 58 psi. Finally, there is an Ashcroft pressure switch that will shut off the Glassman HV power supply when SF6 pressure falls below 45psi.

The Injector Tunnel is equipped with an oxygen monitoring system that alarms at 19.5% oxygen. While the quantity of SF_6 gas would not trigger the ODH alarm due to the low concentration, the oxygen sensors are placed in the tunnel at floor and ceiling levels to detect other inert gases such as helium and nitrogen. Release scenarios of those gases are evaluated in a separate assessment.

The Tunnel is equipment with exhaust fans which can be manually operated that exhaust air outdoors. An additional fan would need to be brought to the Injector Tunnel to provide mixing within the space. This fan will be placed on the floor to promote mixing in aid in exhausting the tunnel atmosphere.

IH Conclusion

Oxygen deficiency hazard and potential TLV exceedance mitigations are well addressed through engineering and administrative controls. While worst case scenarios have potential to exceed the TLV exposure limit, the gas properties and established controls reduce the hazard to workers.

References

ACGIH. (2016). *2016 TLVs and BEIs.*

Compressed Gas Association. (1999). *Handbook of Compressed Gases.* Kluwer Academic Publishers.

Praxair. (2015). *Safety Data Sheet, Sulfur Hexafluoride.*

(2001). *Sulfur Hexafluoride - TLV documentation.* ACGIH.

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