

MD-ENG-238: ODH Analysis for Liquid Argon - Dark Matter

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Description

100 argon high-pressure cylinders will be placed for storage in the MINOS hall area. Each cylinder holds 440 scf of argon gas at 4500 psig. Initially, they come connected in a rack of 15 bottles, but will be brought down into the MINOS hall individually. They will be setup in a 10x10 grid and individually stored. For the analysis, a forklift could accidentally knock one or two cylinders over. This analysis assumes that the valve stems break from the impact.

Inputs

$N_{\text{bottles}} := 2$	Number of bottles spilt or leaking
$V_{\text{bottle}} := 440\text{scf}$	
$V_a := N_{\text{bottles}} \cdot V_{\text{bottle}}$	Volume of argon released into the room

Properties

$\text{Area} := 9675\text{ft}^2$	MINOS Hall Floor Area from MINOS Construction Drawing No. 6-7-4 C-57
$h := 5\text{ft}$	Likely height someone's nose would be at relative to the ground

Calculations

$$V_{\text{room}} := \text{Area} \cdot h = 48375 \cdot \text{ft}^3 \quad V_{\text{O}_2} := 21\% \cdot (V_{\text{room}} - V_a) = 9974 \cdot \text{ft}^3$$

Results

$$\% \text{O}_2 := \frac{V_{\text{O}_2}}{V_{\text{room}}} = 20.6\% \quad \text{Oxygen \% in MINOS Hall}$$

Conclusion

8 argon cylinders would need to leak and/or fall over and break the valves at the same time before the area would be classified oxygen-deficient by OSHA. Since the bottles are individually stored, if a forklift comes by and knocks a cylinder over, it will not affect the other ones. With a pressure vessel failure rate of 1 per 10^6 years¹, an incident of more than one cylinder is unlikely.

The probability of a forklift knocking into a cylinder is 1 per 10^2 years¹. Recommendations to minimize the risk are supports between rows of argon cylinders and for each cylinder to wear its valve cap. Even with these probabilities, the failure rate is zero; thus the area is ODH class 0.

References

- ¹Crowl, D., & Louvar, J. (2007). Chemical Process Safety: Fundamentals with Applications (2nd ed.). Upper Saddle River, NJ: Prentice Halls, Inc.