



# Vapor Intrusion Application Note



**Introduction:** Active Soil Depressurization (ASD) radon mitigation systems are sometimes used as an interim measure to reduce building occupant exposure to chemical vapors or Volatile Organic Compounds (VOCs) arising from chemical plumes in the soil or groundwater under buildings. In addition to the requirements and precautions for installing a radon ASD system, special considerations must be taken into account for worker protection and chemicals in the system airstream. RadonAway and Spruce inline fans are not rated as explosion proof but may be used in this application as long as special precautions described herein are followed.

**Flammability & Explosion Hazards:** It is extremely important to limit the concentration of chemicals in the airstream of an Active Soil Depressurization to well below the Lower Explosion Limit (LEL) for that gas. Table 1 in this document shows the LEL for various chemical vapors. The installer **MUST** make certain that the gas concentrations inside the ASD system **NEVER** exceeds 10% of the LEL values shown in Table 1. **Failure to maintain gas concentrations below 10% of LEL could result in a fire, explosion and serious personal injury to workers and building occupants.** In any situation where the gas concentration should exceed 10% of LEL the electrical power should be disconnected from the fan unit. The installer should seek additional references for the LEL of gases not listed in Table 1. **Gasoline vapors and methane gas can be dangerously explosive!** Use extreme caution when working in the presence in of these gases. The installer should also be aware that certain petroleum products can produce methane gas through an anaerobic microbial process in the soil known as methanogenesis.

**Worker Personal Protection:** Chemicals present in the soil under a structure are likely to be much more concentrated than vapors sampled inside the structure. Care should be exercised to properly ventilate the workspace and to use Personal Protection Equipment (PPE), such as impermeable gloves and clothing, and possibly a respirator suitable for the chemicals workers may contact. In addition, OSHA mandates special requirements and worker training under certain circumstances:

*Who is covered by OSHA's HAZWOPER standard?*

*The Hazardous Waste Operations and Emergency Response Standard (HAZWOPER) applies to five distinct groups of employers and their employees. This includes any employees who are exposed or potentially exposed to hazardous substances -- including hazardous waste -- and who are engaged in one of the following operations as specified by [1910.120\(a\)\(1\)\(i-v\)](#) and [1926.65\(a\)\(1\)\(i-v\)](#):*

- *clean-up operations -- required by a governmental body, whether federal, state, local, or other involving hazardous substances -- that are conducted at uncontrolled hazardous waste sites;*
- *corrective actions involving clean-up operations at sites covered by the **Resource Conservation and Recovery Act of 1976 (RCRA)** as amended (42 U.S.C. 6901 et seq.);*
- *voluntary clean-up operations at sites recognized by federal, state, local, or other governmental body as uncontrolled hazardous waste sites;*
- *operations involving hazardous wastes that are conducted at treatment, storage, and disposal facilities regulated by **Title 40 Code of Federal Regulations** Parts 264 and 265 pursuant to RCRA, or by agencies under agreement with U.S. Environmental Protection Agency to implement RCRA regulations; and*
- *emergency response operations for releases of, or substantial threats of releases of, hazardous substances regardless of the location of the hazard.*

**Permits:** Certain jurisdictions may require a discharge permit for venting chemicals into the atmosphere. Check with your state environmental protection agency.

**Testing:** Post mitigation testing for chemical concentrations is required to confirm proper operation of the ASD system in reducing vapor intrusion. Testing VOCs in the effluent stream of the ASD stream is recommended to ensure concentrations below 10% of LEL.

**Maintenance:** Recommended annual maintenance of the ASD system includes visual inspection of the fan and fan electrical system, as well as, confirmatory VOC testing.

**TABLE 1: Flammable / Combustible / Explosive Gases and Vapors**

A reference for Lower Explosion Limits (LEL) for certain common chemicals

A reference chart of Lower Explosion Limits (LEL)Gases and Vapors	LEL in % by volume of air	NFPA Class	Flash point
Acetaldehyde	4.0	IA	-39°C
Acetic acid (glacial)	4	II	39°C to 43°C
Acetic anhydride		II	54°C
Acetone	2.6 - 3	IB	-17°C
Acetonitrile		IB	2°C
Acetyl chloride	7.3	IB	5°C
Acetylene	2.5	IA	-18°C
Acrolein	2.8	IB	-26°C
Acrylonitrile	3.0	IB	0°C
Allyl chloride	2.9	IB	-32 °C
Ammonia	15	IIIB	11°C
Arsine	4.5 - 5.1	IA	Flammable gas
Benzene	1.2	IB	-11°C
1,3-Butadiene	2.0	IA	-85°C
Butane, n-Butane	1.6	IA	-60°C
n-Butyl acetate, Butyl acetate	1 - 1.7	IB	24°C
Butyl alcohol, Butanol	1	IC	29°C
n-Butanol	1.4	IC	35°C
n-Butyl chloride, 1-chlorobutane	1.8	IB	-6°C
n-Butyl mercaptan	1.4	IB	2°C
Butyl methyl ketone, 2-Hexanone	1	IC	25°C
Butylene, 1-Butylene, 1-Butene	1.98	IA	-80°C
Carbon disulfide	1.0	IB	-30°C
Carbon Monoxide	12	IA	-191°C Flammable gas
Chlorine monoxide		IA	Flammable gas
1-Chloro-1,1-difluoroethane	6.2	IA	-65°C Flammable Gas
Cyanogen	6.0 - 6.6	IA	Flammable gas
Cyclobutane	1.8	IA	-63.9°C[11]
Cyclohexane	1.3	IB	-18°C - -20°C
Cyclohexanol	1	IIIA	68°C

A reference chart of Lower Explosion Limits (LEL)Gases and Vapors	LEL in % by volume of air	NFPA Class	Flash point
Cyclohexanone	1 - 1.1	II	43.9 - 44°C
Cyclopentane	1.5 - 2	IB	- 37 to -38.9°C
Cyclopropane	2.4	IA	-94.4°C
Decane	0.8	II	46.1°C
Diborane	0.8	IA	-90°C Flammable gas
o-Dichlorobenzene, 1,2-Dichlorobenzene	2	IIIA	65°C
1,1-Dichloroethane	6	IB	14°C
1,2-Dichloroethane	6	IB	13°C
1,1-Dichloroethene	6.5	IA	-10°C Flammable gas
Dichlorofluoromethane			Non flammable, -36.1°C
Dichloromethane, Methylene chloride	16		Non flammable
Dichlorosilane	4 - 4.7	IA	-28 °C
Diesel fuel	0.6	IIIA	>62°C (143°F)
Diethanolamine	2	IB	169°C
Diethylamine	1.8	IB	-23°C to -26°C
Diethyl disulfide	1.2	II	38.9°C
Diethyl ether	1.9 - 2	IA	-45°C
Diethyl sulfide		IB	-10°C
1,1-Difluoroethane	3.7	IA	-81.1°C
1,1-Difluoroethylene	5.5		-126.1°C
Diisobutyl ketone	1		49°C
Diisopropyl ether	1	IB	-28°C
Dimethylamine	2.8	IA	Flammable gas
1,1-Dimethyl hydrazine		IB	
Dimethyl sulfide		IA	-49°C
Dimethyl sulfoxide	2.6 - 3	IIIB	88 - 95°C
1,4-Dioxane	2	IB	12°C
Epichlorohydrin	4		31°C
Ethane	3	IA	Flammable gas -135 °C

A reference chart of Lower Explosion Limits (LEL)Gases and Vapors	LEL in % by volume of air	NFPA Class	Flash point
Ethanol, Ethyl Alcohol	3 - 3.3	IB	12.8°C (55°F)
2-Ethoxyethanol	3		43°C
2-Ethoxyethyl acetate	2		56°C
Ethyl acetate	2	IA	-4°C
Ethylamine	3.5	IA	-17 °C
Ethylbenzene	1.0		15-20 °C
Ethylene	2.7	IA	
Ethylene glycol	3		111°C
Ethylene oxide	3	IA	-20 °C
Ethyl Chloride	3.8	IA	-50°C
Ethyl Mercaptan		IA	
Fuel oil No.1	0.7		
Furan	2	IA	-36°C
Gasoline (100 Octane)	1.4	IB	< -40°C (-40°F)
Glycerol	3		199°C
Heptane, n-Heptane	1.05		-4°C
Hexane, n-Hexane	1.1		-22°C
Hydrogen, dihydrogen, molecular H with two protons together	4	IA	Flammable gas
Hydrogen sulfide	4.3	IA	Flammable gas
Isobutane	1.8	IA	Flammable gas
Isobutyl alcohol	2		28°C
Isophorone	1		84°C
Isopropyl alcohol, Isopropanol	2	IB	12°C
Isopropyl chloride		IA	
Kerosene Jet A-1	0.6 - 0.7	II	>38°C (100°F) as jet fuel
Lithium Hydride		IA	
2-Mercaptoethanol		IIIA	
Methane (Natural Gas)	4.4 - 5	IA	Flammable gas
Methyl acetate	3		-10°C
Methyl Alcohol, Methanol	6 - 6.7	IB	11°C
Methylamine		IA	8°C
Methyl Chloride	10.7	IA	-46 °C
Methyl ether		IA	-41 °C
Methyl ethyl ether		IA	
Methyl ethyl ketone	1.8	IB	-6°C
Methyl formate		IA	

A reference chart of Lower Explosion Limits (LEL)Gases and Vapors	LEL in % by volume of air	NFPA Class	Flash point
Methyl mercaptan	3.9	IA	-53°C
Methyl-t-Butyl Ether (MTBE)	1.6	IB	-10°C
Morpholine	1.8	IC	31 - 37.7°C
Naphthalene	0.9	IIIA	79 - 87 °C
Neohexane	1.19		-29 °C
Nickel tetracarbonyl	2		4 °C
Nitrobenzene	2	IIIA	88°C
Nitromethane	7.3		35°C
Octane	1		13°C
iso-Octane	0.79		
Pentane	1.5	IA	-40 to -49°C
n-Pentane	1.4	IA	
iso-Pentane	1.32	IA	
Perchloroethylene (PERC)	13		none
Phosphine		IA	
Propane	2.1	IA	Flammable gas
Propyl acetate	2		13°C
Propylene	2.0	IA	-108°C
Propylene Oxide	2.3	IA	
Pyridine	2		20
Silane	1.5	IA	
Styrene	1.1	IB	31 - 32.2°C
Tetrachloroethene (PCE)			none
Tetrafluoroethylene		IA	
Tetrahydrofuran	2	IB	-14°C
Toluene	1.2 -1.27	IB	4.4°C
Trichloroethene (TCE)	6		none
Triethylborane			-20°C
Trimethylamine		IA	Flammable gas
Trinitrobenzene		IA	
Turpentine	0.8	IC	35°C
Vegetable oil		IIIB	327°C
Vinyl acetate	2.6		-8 °C
Vinyl chloride	3.6		
Xylenes	0.9 - 1.0	IC	27 - 32°C
m-Xylene	1.1	IC	25°C
o-Xylene		IC	17 °C
p-Xylene	1.0	IC	27.2°C

## Other Resources

- Agency for Toxic Substances and Disease Registry (ATSDR). 2008. *Evaluating Vapor Intrusion Pathways at Hazardous Waste Sites*. Currently available online at: [http://www.atsdr.cdc.gov/document/evaluating\\_vapor\\_intrusion.pdf](http://www.atsdr.cdc.gov/document/evaluating_vapor_intrusion.pdf)
- American Society for Testing and Materials (ASTM). 2003. *E 2121: Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings*.
- California Environmental Protection Agency. 2005. Guidance for the Evaluation and Migration of Subsurface Vapor Intrusion to Indoor Air. Department of Toxic Substances Control.
- Folkes, D.J. and D.W. Kurz. 2002. Efficacy of sub-slab depressurization for mitigation of vapor intrusion of chlorinated organic compounds. *In Proceedings of Indoor Air 2002: The 9th International Conference on Indoor Air and Climate*. June 30-July 5.
- Interstate Technology & Regulatory Council (ITRC). 2007a. *Vapor Intrusion Pathway: A Practical Guideline*. VI-1. ITRC Vapor Intrusion Team. Washington, D.C. January. Currently available online at: <http://www.itrcweb.org/documents/VI-1.pdf>
- Johnson, P.C., and R.A. Ettinger. 1991. Heuristic Model for Predicting the Intrusion Rate of Contaminant Vapors into Buildings. *Environmental Science & Technology* 25:1445-1452.
- Massachusetts Department of Environmental Protection (MADEP). 2011. *Interim Final Vapor Intrusion Guidance*. WSC#-11-435. December. Currently available online at: <http://www.mass.gov/dep/cleanup/iawg.htm>
- Maupins, K. and D.T. Hitchins. 1998. Reducing employee exposure potential using the ANSI/ASHRAE 110 Method of Testing Performance of Laboratory Fume Hoods as a diagnostic tool. *In American Industrial Hygiene Association Journal* 59(2): 133-138.
- McAlary, T.A., J. Provoost, and H.D. Dawson. 2011. Vapor intrusion, *In Dealing with Contaminated Sites. From Theory towards Practical Applications*, Chapter 10. F.A. Swartjes [ed.], Springer Science.
- New Jersey Department of Environmental Protection. 2013 Vapor Intrusion Technical Guidance.
- New York State Department of Health. 2006. Final Guidance for Evaluating Soil Vapor Intrusion in the State of New York. Center for Environmental Health, Bureau of Environmental Exposure Investigation. October 2006
- U.S. Department of Defense (DoD). 2009. *DoD Vapor Intrusion Handbook*. January. Currently available online at: <http://www.environmental.usace.army.mil/docs/DoD%20VI%20Handbook%20Final%20Jan%2009.pdf?syspage=documents&id=129239>

- U.S. Department of the Navy (DoN). 2011a. *Guidance for Environmental Background Analysis, Volume IV: Vapor Intrusion Pathway*. Naval Facilities Engineering Command. Washington, D.C. April. Currently available online at:  
[https://portal.navfac.navy.mil/portal/page/portal/navfac/navfac\\_ww\\_pp/navfac\\_nfesc\\_pp/environmental/erb/resourceerb/ug-2091-env-vi\\_bkgd\\_guid2011.pdf](https://portal.navfac.navy.mil/portal/page/portal/navfac/navfac_ww_pp/navfac_nfesc_pp/environmental/erb/resourceerb/ug-2091-env-vi_bkgd_guid2011.pdf)
- U.S. Department of the Navy (DoN). 2011b. *Vapor Intrusion Mitigation in Existing Buildings Fact Sheet*. Naval Facilities Engineering Command. Washington, D.C. May. Currently available online at:  
[https://portal.navfac.navy.mil/portal/page/portal/navfac/navfac\\_ww\\_pp/navfac\\_nfesc\\_pp/environmental/erb/resourceerb/vi\\_mit\\_exist\\_bldgs\\_fs\\_201105.pdf](https://portal.navfac.navy.mil/portal/page/portal/navfac/navfac_ww_pp/navfac_nfesc_pp/environmental/erb/resourceerb/vi_mit_exist_bldgs_fs_201105.pdf)
- U.S. Department of the Navy (DoN). 2011c. *Vapor Intrusion Mitigation in Construction of New Buildings Fact Sheet*. Naval Facilities Engineering Command. Washington, D.C. August. Currently available online at:  
[https://portal.navfac.navy.mil/portal/page/portal/navfac/navfac\\_ww\\_pp/navfac\\_nfesc\\_pp/environmental/erb/resourceerb/vi\\_mit\\_new\\_bldg\\_fs.pdf](https://portal.navfac.navy.mil/portal/page/portal/navfac/navfac_ww_pp/navfac_nfesc_pp/environmental/erb/resourceerb/vi_mit_new_bldg_fs.pdf)
- U.S. Environmental Protection Agency (EPA). 2013d. *Guidance for Addressing Petroleum Vapor Intrusion at Leaking Underground Storage Tank Sites* [EPA 530-R-##-###]. In preparation. [<http://www.epa.gov/oswer/vaporintrusion/documents/>]
- U.S. Environmental Protection Agency (EPA). 2013e. *User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings Using the Johnson-Ettinger Model* [EPA 530-R-##-###]. In preparation. [<http://www.epa.gov/oswer/vaporintrusion/documents/>]
- U.S. Environmental Protection Agency (EPA). 2012b. *Conceptual Model Scenarios for the Vapor Intrusion Pathway* [EPA 530-R-10-003]. Currently available online at:  
<http://www.epa.gov/oswer/vaporintrusion/documents/vi-cms-v11final-2-24-2012.pdf>
- U.S. Environmental Protection Agency (EPA). 2012g. *Fluctuation of Indoor Radon and VOC Concentrations Due to Seasonal Variations*. EPA/600/R-12/673.
- U.S. Environmental Protection Agency (EPA). 1993a. *Radon Reduction Techniques for Existing Detached Houses: Technical Guidance (Third Edition) for Active Soil Depressurization Systems*.
- EPA 625-R-93-011. October. U.S. Environmental Protection Agency (EPA). 2008c. *Engineering Issue: Indoor Air Vapor Intrusion Mitigation Approaches*. EPA/600/R-08-115. Office of Research and Development. October. Currently available online at:  
<http://www.clu-in.org/download/char/600r08115.pdf>
- U.S. Environmental Protection Agency (EPA). 2002c. *OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance)*. EPA 530-D-02-004. Office of Solid Waste and Emergency Response. Washington, D.C.. November. Currently available online at:  
<http://www.epa.gov/osw/hazard/correctiveaction/eis/vapor.htm>