



**TECHNICAL REVIEW AND EVALUATION
OF THE SOIL VAPOR EXTRACTION UNIT GENERAL PERMIT**

I. INTRODUCTION

The Soil Vapor Extraction Unit General Permit is a permit for a facility class (Soil Vapor Extraction Units) that contains 10 or more facilities that are similar in nature, have substantially similar emissions, and would be subject to the same or substantially similar requirements. Equipment that is covered under the general permit will be required to have an “Authorization To Operate” (ATO). The ATO will identify the piece of equipment by having the manufacturer, date of manufacture, maximum capacity, and serial number or equipment number along with the hours of operation limitation.

This General Permit allows for portable soil vapor extraction units to move to other locations statewide. The Permittee that applies for an ATO under the general permit shall pay the Department a flat application fee of \$500 with the submittal of the permit application. The Permittee must also continue to pay, for each calendar year, the applicable administrative or inspection fees as described in the Arizona Administrative Code Title 18, Chapter 2, Article 5, Section 511 (A.A.C. R18-2-511).

II. PROCESS DESCRIPTION

Soil vapor extraction units extract contaminants (typically solvents or gasoline) from below ground for treatment above ground. First, one or more extraction wells are drilled into the contaminated soil, and a blower or vacuum pump is attached. The vacuum pump pulls air and vapors through the soil and up to the ground. The air and vapor extracted from the ground is then directed to an air-water separator to remove moisture, and then treated to remove any harmful levels of contaminants. Treatment may be by either filtration or combustion. The treated air and remaining contaminants are then released to the atmosphere.

III. HALOGENATED COMPOUNDS

A. What is a halogenated compound?

A halogenated compound is defined as a compound in which the carbon atoms are bonded to a halogen such as chlorine, bromine and fluorine. For soils being treated with an SVEU device, the most common occurring halogenated compound are those which contain a chlorine atom such as trichloroethylene (TCE). TCE is one of the most prevalent pollutants and is most likely to lead to higher hydrochloric acid (HCL) and dioxin/furans (D/F) emissions.

The reopening in 2019 allowed soil vapor extraction units to remediate sites contaminated with halogenated compounds. Before this, the General Permit did not authorize the treatment of halogenated compounds as there were concerns that a high concentration of halogenated compounds could create the formation of D/F and acid gases such as HCL. During the 2019 reopening, an inlet concentration limit of 0.052 g/sec for halogenated compounds was established based on a conservative calculation ensuring protectiveness

for HCL under Acute/Chronic Ambient Air Concentrations (AAC) guidelines. During this renewal, a deep dive analysis was performed to further explore if the formation of D/F was a concern and if additional limits were needed. Based on the literature review and data analysis, the Department has concluded that, even under worst case modeling conditions, the modeled concentrations of D/F are well below screening values from the Arizona Ambient Air Quality Guidelines (AAAQG) and do not require the establishment of any additional limits.

B. Concerns about Halogenated Compounds in Catalytic/Thermal Units

1. Dioxin and Furans

Dioxins and furans is the abbreviated or short name for a family of toxic substances that all share a similar chemical structure. According to the EPA, prolonged exposure to high levels of D/F may cause hormone changes or cancer. Of all of the dioxins and furans, 2,3,7,8-tetrachloro-p-dibenzo-dioxin (2,3,7,8 TCDD) is considered the most toxic. Although D/F formation pathways are not yet well defined, current literature suggests that D/F formation is highly temperature dependent and has an ideal formation temperature range of 200°C to 500°C, with formation peaking at about 300°C to 350°C (Jansson, 2008) In the permit, thermal oxidizers must operate above 1400°F (760°C) and catalytic oxidizers must operate above 600°F (315°C). Thermal oxidizers operate above the ideal formation temperature range and are thus less likely to produce D/F emissions. A field study of 57 thermal oxidizer and catalytic oxidizer units was conducted by the California EPA in which the catalytic and thermal units operated at similar temperatures and remediated comparable sites to those covered by the permit (Hart, 2004). The study found that the thermal oxidizers did not form D/F compounds. For catalytic oxidizers, the maximum recorded stack emissions was 1.07 ng/m³ toxic equivalents (TEQ), which occurred at 293°C (Hart, 2004). To be conservative, the Department used the maximum emissions value to model ambient D/F concentration against the AAAQG.

Equation 1:

$$Q_c = \frac{C_c \times F}{3.28^3 \frac{ft^3}{m^3} \times 10^9 \times 60 \frac{sec}{min}}$$

Where: Q_c = Mass Emission Rate of Pollutant c, g/s

C_c = Concentration of Pollutant c, ng/m³

F = Flowrate, SCFM

To be as conservative as possible, the Department used 500 SCFM for the flowrate as that is the maximum flowrate capacity of currently permitted units.



$$Q_c = \frac{1.07 \text{ ng}/\text{m}^3 \times 500 \text{ ft}^3/\text{min}}{3.28^3 \text{ ft}^3/\text{m}^3 \times 10^9 \times 60 \text{ sec}/\text{min}} = 2.52E - 10 \text{ g}/\text{sec}$$

2. Hydrochloric Acid

Another concern with halogenated compounds in the SVEU device is the formation of acid gases such as HCL. In order to limit the production of acid gases exiting the SVEU system, the Department calculated an inlet mass emission rate as seen in Equation 2 below. For this calculation the Department assumed an inlet limit for TCE at 40 ppmv, which is significantly higher than most test reports of contaminated sites the Department evaluated, and an inlet flowrate of 500 SCFM because this is the maximum flow capacity for currently permitted units. The calculation also assumed 100 percent conversion to HCL. In order to be conservative the source will sum the concentration of all halogenated compounds, not just TCE. The following equation calculates a mass emission rate for a pollutant based on data for concentration and flowrate.

Equation 2:

$$Q_c = \frac{(C_c \times F \times MW_c \times 60 \text{ min}/\text{hr} \times 24 \text{ hrs}/\text{day})}{(10^6 \times V)}$$

Where: Q_c = Mass Emission Rate of Pollutant c, lbs/day

C_c = Concentration of Pollutant c, ppmv

F = Flowrate, SCFM

MW_c = Molecular Weight of Contaminant c, = 131.4 lb/lb-mole for TCE

V = Molar Volume = 385.3 ft³/lb-mol

The assumptions used in this example are 500 SCFM and 40 ppmv of TCE. However, The Permittees must input the SVEU inlet stream data for the calculations. Inputting these values into the above equation is as follows:

$$Q_c = \frac{(40 \text{ ppmv} \times 500 \text{ Ft}^3/\text{min} \times 131.4 \text{ lb}/\text{lb-mole} \times 60 \text{ min}/\text{hr} \times 24 \text{ hrs}/\text{day})}{(10^6 \times 385.3 \text{ Ft}^3/\text{lb-mole})}$$

Q_c = 9.82 lbs/day – Converting to grams per minute = 0.052 g/sec = 3.1 g/min

This calculated concentration rate is the maximum allowable halogenated compound inlet concentration for the SVEU device. However, since this equation assumes a flowrate of 500 SCFM the permit limit will be expressed in the permit as the concentration multiplied by the flowrate. Rearranging equation 2 above to



solve for concentration multiplied by flowrate is as follows:

Equation 3:

$$C_c \times F = \frac{(3.1 \text{ g/min} \times 1 \text{ lb}/454 \text{ g} \times 385.3 \text{ Ft}^3/\text{lb-mole} \times 10^6)}{(131.4 \text{ lb}/\text{lb-mole})}$$

$$C_c \times F = 20,000$$

Where:

C_c = Sum of all halogenated compounds, ppmv

F = Flowrate, SCFM

Compliance with the permit limit will be calculated in equation 3 above, where the source will input its specific flowrate and sum of halogenated compounds in the inlet to ensure they are below 20,000.

In order to determine the outlet concentration of HCL to be used in the modeling analysis a simple ratio was calculated. Since one TCE molecule is assumed to produce 3 molecules of HCL a ratio was performed to determine the outlet HCL emission rate. This ratio is based on the molecular weight of the two molecules:

MW TCE = 131.4 lb/lb-mole,

MW HCL = 36 lb/lb-mole x 3 molecules = 108 lb/lb-mole

This follows as:

Equation 4:

$$\left(\frac{108 \text{ lb}/\text{lb-mole HCL}}{131.4 \text{ lb}/\text{lb-mole TCE}} \right) \times 0.052 \text{ g}/\text{sec TCE} = 0.042 \text{ g}/\text{sec HCL}$$

The mass emission rate calculated above for HCL was used in the modeling analysis to ensure it is within the guidelines set forth in the Acute/Chronic AAC.

IV. MODELING ANALYSIS

The Department performed dispersion modeling to estimate ambient concentrations for both D/F and HCL and compared them against Acute/Chronic AAC or AAAQG. The Department used AERSCREEN, the EPA recommended screening model. Table 1 lists the model parameters. The source inputs were based on a typical SVEU configuration.

Table 1: Modeling Parameters

Parameters	Inputs	Input values
Source	Source type	POINT
	Stack height	3.96 m
	Stack diameter	0.41 m
	Stack exit temperature	588 K
	Stack exit velocity	2.29 m/s
Building	Include building downwash	Yes
	Building height	10 m
	Maximum horizontal dimension	30 m
	Orientation of maximum building dimension to North	90°
	Minimum horizontal dimension	20 m
	Direction of stack from North	0°
	Distance from stack to building	20 m
Meteorology	Minimum temperature	267.6 K
	Maximum temperature	323.1 K
	Minimum wind speed	0.5 m/s
	Anemometer height	10 m
	Source of surface characteristics	Albedo: .25, B/R: 10, R/L: 0.15
Other inputs	Input units	Metric
	Rural/urban	Rural
	Ambient Distance	1 - 5000 m
	Use flagpole receptors	No

Table 2 summarizes the modeled results for D/F and HCL. The results demonstrate that the modeled concentrations of HCL based on a permit limit at 0.052 g/sec of halogenated compounds (assuming full conversion to HCL) are well below the Acute/Chronic AAC for HCL. Additionally, the modeled concentrations of D/F using the worst-case emission rate (2.52E-10 g/sec) are well below the AAAQG for 2,3,7,8-TCDD, the most stringent public health screening levels for D/F.

Table 2: Modeled Results

HAPs	Emission Rate (g/s)	Averaging Period	Modeled Concentration ($\mu\text{g}/\text{m}^3$)	Acute/Chronic AAC or AAAQG ($\mu\text{g}/\text{m}^3$)
dioxin /furans	2.52E-10	1-hour	7.99E-07	4.20E-02 (1-hr AAAQG ¹)
		24-hour	4.79E-07	1.10E-02 (24-hr AAAQG ¹)
		Annual	7.99E-08	2.40E-05 (Annual AAAQG ¹)
HCL	0.042	1-hour	132.9	16,000 (Acute AAC)
		Annual	13.3	20.9 (Chronic AAC)

¹ The modeled concentrations of D/F were compared to the AAAQG for 2,3,7,8-TCDD, the most toxic of D/F.

V. APPLICABLE REGULATIONS

The Department has identified the applicable regulations that apply to the soil vapor extraction system. Table 3 summarizes the findings of the Department with respect to the regulations that are applicable to SVEU.

Table 1: Applicable Regulations

Equipment	Control Equipment	Applicable Regulation	Verification
Soil Vapor Extraction System	Thermal Oxidizer or Catalytic Converter or Carbon Adsorption	A.A.C. R18-2-702.B.3 and R18-2-730	There are no specific standard for SVEU in Arizona Administrative Code. This standard is applicable to all un-classified sources.

VI. MONITORING, RECORDKEEPING, AND REPORTING REQUIREMENTS

Table 4 contains an inclusive but not an exhaustive list of the monitoring, recordkeeping and reporting requirements prescribed by the air quality permit. The table below is intended to provide insight to the public for how the Permittee is required to demonstrate compliance with the emission limits in the permit.

Table 4: Monitoring, Recordkeeping and Reporting Requirements

Pollutant	Emission Limit	Monitoring Requirements	Recordkeeping Requirements	Reporting Requirements
VOC	90 TPY	Take a representative grab sample of the inlet and outlet vapor stream of the SVEU device upon startup	Calculate and record a 12-month rolling total of VOC emissions at the end of each month.	A written report of the results of all the grab samples performed during the compliance

Pollutant	Emission Limit	Monitoring Requirements	Recordkeeping Requirements	Reporting Requirements
Halogenated Compounds	0.052 g/s	at each new location, and then once every two weeks for the first six weeks, then monthly for the following six months, and then quarterly thereafter. The samples should be analyzed using EPA Reference Method 8260B or EPA Method TO-15, or equivalent methods approved by the Director.	Calculate and record mass flowrate. Retain records of all required monitoring data and support information for a minimum of five years from the date of generation.	term specified in Section VII of Attachment "A" shall be submitted to the Director in accordance with the reporting requirements in Section XIV of Attachment "A"
SO ₂	600 ppm			
NO _x	500 ppm			
PM	20% opacity	Method 9 Observations		

VII. LIST OF ABBREVIATIONS

2,3,7,8-TCDD.....	2,3,7,8-tetrachlorodibenzo-p-dioxin
AAAC.....	Acute Ambient Air Concentrations
AAAQG.....	Arizona Ambient Air Quality Guidelines
CAAC.....	Chronic Ambient Air Concentrations
EPA.....	The Environmental Protection Agency
D/F.....	Dioxin/Furans
ft ³	Cubic Feet
ft.....	Feet
g.....	Grams
HCL.....	Hydrochloric Acid
hr.....	Hour
lb.....	Pound
m.....	Meter
s.....	Seconds
TCE.....	Trichloroethylene
TEQ.....	Toxic Equivalency
µg/m ³	Microgram per Cubic Meter



VIII. REFERENCES

- [1] Hart JR. Emissions of polychlorinated dibenzo-p-dioxins and dibenzofurans from catalytic and thermal oxidizers burning dilute chlorinated vapors. *Chemosphere*. 2004 Mar;54(10):1539-47. doi: 10.1016/j.chemosphere.2003.10.017. PMID: 14659956.
- [2] Jansson, S. (2008). Thermal formation and chlorination of dioxins and dioxin-like compounds (PhD dissertation, Kemi). Retrieved from <http://urn.kb.se/resolve?urn=urn:nbn:se:umu:diva-1881>