FINAL

Vapor Intrusion Investigation Work Plan, Former Plant 5 Building and Attached West Building, Essex-Hope Site in Jamestown, New York

Site Number 907015

Prepared for

Essex Specialty Products, Inc.

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ch2m

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Acronyms and Abbreviations

µg/L	microgram per liter
µg/m^3	microgram per cubic meter
AST	aboveground storage tank
CBTEX	cumene, benzene, toluene, ethylbenzene, and xylenes
cfm	cubic feet per minute
CH2M	CH2M HILL
COC	constituent of concern
CPM	Custom Production Manufacturing Inc.
DCE	dichloroethene
HVAC	heating, ventilation, and air conditioning
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
OSHA	Occupational Safety and Health Administration
Pa	Pascal
PCE	tetrachloroethene
QC	quality control
RAO	remedial action objective
ROD	Record of Decision
site	former Essex-Hope State Superfund site located at 125 Blackstone Avenue in Jamestown, New York
SOP	standard operating procedure
SVE	soil vapor extraction
TCE	trichloroethene
URS	URS Corporation
USEPA	United States Environmental Protection Agency
UST	underground storage tank
VI	vapor intrusion
VOC	volatile organic compound
WBZ	water-bearing zone

SECTION 1

Introduction

This work plan presents the investigation activities that will be performed to further evaluate the potential for vapor intrusion (VI) at the former Plant 5 Building and attached West Building at the Essex-Hope State Superfund site located at 125 Blackstone Avenue in Jamestown, New York (site; Figure 1). The site, presently owned by Custom Production Manufacturing Inc. (CPM), is listed under the New York Superfund Program (Site Number 907015) and managed by the New York State Department of Environmental Conservation (NYSDEC). A Record of Decision (ROD) was issued in 1994 requiring the implementation of remedial actions at the site (NYSDEC 1994).

URS Corporation (URS) recently completed and submitted a VI summary report to NYSDEC (URS 2015). Results from that report indicated concentrations of volatile organic compounds (VOCs) exceeded the New York State Department of Health (NYSDOH) VI guideline values in the former Plant 5 Building, placing the building in the mitigation category decision matrix (NYSDOH 2006). However, based on the presence of documented background indoor sources of VOCs (TCE is still used at the site), it is unclear if indoor VOC concentrations are from VI or background indoor air sources. If the source is indoors and related to current facility operations, VI mitigation will be ineffective. This work plan presents a multiple lines of evidence approach to determine if VI is occurring or is significant in the former Plant 5 Building.

1.1 Purpose and Scope of this Investigation

This investigation is designed to collect additional data to be used to determine if indoor or subsurface sources are contributing to indoor air VOC concentrations and to assess the potential for VOCs linked to groundwater and soil at the site to migrate into the former Plant 5 Building (Figure 1). This will be accomplished by performing an indoor air HAPSITE survey coupled with building pressure manipulation activities. This investigation is focused on the former Plant 5 Building; however, a HAPSITE indoor air survey also will be performed in the attached West Building to verify indoor air VOC concentrations are consistent with the prior study and are not contributing to indoor air concentrations in Plant 5 (URS 2015).

The short-term results from this investigation will not be used to directly evaluate human health risk, but may be used to aid in identifying background indoor air sources to be removed before confirmation (if possible) VI sampling events. Information gathered may also be used to support mitigation design.

1.2 Regulatory Guidance

This work plan follows *Guidance for Evaluating Soil Vapor Intrusion in the State of New York* (NYSDOH 2006) in identifying locations where there is a potential for VI, identifying background sources of VOCs, assessing indoor and outdoor air VOC concentrations, and evaluating the potential impact of detected VOC concentrations. It is also consistent with VI provisions in NYCDEC DER-10 (2010) and the U.S. Environmental Protection Agency (USEPA) VI guide (2015). Field analytical methods will follow the Triad approach in *DER-10/Technical Guidance for Site Investigation and Remediation* (NYSDEC 2010). Up to four selected samples will be analyzed using USEPA Modified Method TO-15 (USEPA 1999) for a quality control (QC) check for VOCs collected during the VI and air assessments.

SECTION 2

Site Background

The 4.7-acre site, which CPM owns and occupies, is located at 125 Blackstone Avenue in Jamestown, New York (Figure 1). The site is in an industrialized area of the city that has seen various degrees of industrial use over the past 75 years. Contamination onsite is the result of historical practices conducted at the facility as discussed in a 1992 remedial investigation report.[1] Other sources of VOCs may be present in the area contributing to the overall shallow groundwater plume.

2.1 Historical Operations

Historically, two distinct operations occupied the site: Jamestown Finishes at the southern portion of the site (along Blackstone Avenue) and Hope’s Windows in the northern portion (along Hopkins Avenue).

2.1.1 West Building and Former AST and UST Areas

The southern portion of the site is divided into the following sub-areas for describing the site history and constituents of concern (COCs):

- West Building
- Former aboveground storage tank (AST) area
- Former underground storage tank (UST) area

The West Building was built in the early 1900s and subsequently was expanded several times. The West Building was used by a variety of owners/operators to produce paints, varnishes, and other industrial coatings under the name Jamestown Finishes or Jamestown Finishing Products (NYSDEC 1994). The former AST area was northwest of the West Building. Soils and the shallow water-bearing zone (WBZ) in the West Building and former AST areas historically have been impacted by cumene, benzene, toluene, ethylbenzene, and xylenes (CBTEX) and, to a lesser extent, trichloroethene (TCE) and daughter products cis-1,2-dichloroethene (cis-1,2-DCE) and vinyl chloride. To the east of the West Building is the former UST area, which historically contained USTs with acetone, xylenes, and other solvents used in the production of coatings. Historical impacts in this area included CBTEX in soils and the shallow WBZ.

2.1.2 Plant 5 Building and North Parking Lot

Hope’s Windows previously occupied the northern portion of the site (along Hopkins Avenue). This portion of the site is divided into the following sub-areas for describing the site history and COCs:

- Plant 5 Building
- North Parking Lot

The Plant 5 Building historically was used for the manufacture of window screens until the early 1970s, when manufacturing switched to production of aluminum windows (McFarlene 1991). The building also was used to store aluminum, and to cut, punch, notch, weld, and assemble aluminum parts.

A TCE degreaser and paint primer tank were present in the southwestern corner of the building, but were both removed before Essex Chemical Company purchased the site in 1985. The TCE degreasing pit reportedly was cleaned and pumped to a sump in the North Parking Lot (west of the Plant 5 Building) (Dow Chemical Company 1992). The sump and surrounding soils were excavated in the mid-1990s as one of the ROD remedies (NYSDEC 1994).

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[1] Because CH2M HILL (CH2M) has not obtained the main text of the remedial investigation reports, historical information for the site is relatively limited. CH2M requested these documents from NYSDEC, URS/AECOM, and The Dow Chemical Company.

Impacts to soil and groundwater have included polychlorinated biphenyls in soil in the North Parking Lot and TCE and its daughter products in soil, the shallow WBZ, and the deep WBZ under the North Parking Lot and the Plant 5 Building. Both shallow and deep groundwater impacts have been detected offsite to the north, and shallow groundwater impacts extend offsite east along Hopkins Avenue.

After Essex purchased the Plant 5 Building in 1985, the building reportedly was used as a raw materials warehouse. The building has been used for light metals fabrication since CPM purchased the site in 2000. During a 2014 VI survey, numerous chemicals, including TCE, tetrachloroethene (PCE), petroleum distillates, methyl isobutyl ketone, toluene, methylene chloride, trichloroethane, and acetone were observed stored at the facility (URS 2015).

2.2 Remedial Actions

Numerous remedial actions have been undertaken at the site in response to the 1994 ROD (NYSDEC 1994). Remedial actions have included a pump and treat system that extracts and treats shallow and deep groundwater; soil excavation in the North Parking Lot; air sparging of shallow WBZ in the North Parking Lot, former AST, and former UST areas; and soil vapor extraction (SVE) of vadose zone soils in these same areas. Supplemental and voluntary remedial actions implemented include removing the USTs and adjacent soil, conducting a pilot test of zero-valent iron injections in the North Parking Lot, installing a subslab vapor mitigation system at an offsite residence, and implementing in-situ chemical oxidation injections in the shallow WBZ in the former UST area and the deep WBZ near the northeastern corner of the Plant 5 Building.

2.3 Current Conditions

Shallow groundwater with COCs exceeding remedial action objectives (RAOs) exists onsite and offsite. The highest COC concentrations area occurs under the West Building, where CBTEX was detected during a 2013 investigation at concentrations up to 175,362 micrograms per liter (µg/L) (URS 2014a). This area of CBTEX appears to be related to the historical CBTEX found in groundwater east of the former UST area (which has been mostly remediated) and may exist under the building because of an area of mounded groundwater that caused localized flow to the west. In the former UST area, CBTEX concentrations have declined significantly because of remedial actions including pump and treat, air sparging, SVE, UST removal, and in-situ chemical oxidation treatments. Concentrations of cumene, ethylbenzene, and total xylenes above their RAOs are present in the eastern portion of the former UST area and appear to be migrating offsite northeast in the direction of regional groundwater flow. Results from the URS sampling suggest CBTEX concentrations are being substantially attenuated in the vadose zone.

The shallow WBZ pump and treat system consists of three recovery wells (RW-1S and RW-2S in the North Parking Lot area, and RW-3S in the former AST area) that have had declining recovery of VOC mass because of falling groundwater concentrations and low extraction rates (ranging annually from 0.03 gallon per minute at RW-3S to 0.74 gallon per minute at RW-2S). The limited saturated thickness in the shallow WBZ (generally 6 to 8 feet thick), coupled with well efficiency losses, has resulted in cycling of the pumping system at RW-3S as the water level is quickly drawn down by pumping, causing shutoff of the well until water levels recover, at which point the pump is reactivated.

CBTEX concentrations in the former AST area have declined significantly because of remedial actions including pump and treat, air sparging, and SVE. Recent concentrations of benzene, cumene, ethylbenzene, and total xylenes, however, exceeded their respective RAOs at RW-3S. Remedial actions, including soil excavation, pump and treat system, and air sparging/SVE, in the North Parking Lot area have resulted in a significant reduction in TCE, cis-1,2-DCE, and vinyl chloride concentrations.

Concentrations, however, remain above RAOs, with the highest detections in the southern portion of the North Parking Lot.

TCE, cis-1,2-DCE, and vinyl chloride are found in shallow groundwater north and east-northeast of the site along Hopkins Avenue, with the highest TCE concentration at MW-18 (221 μg/L in fall 2014). The original source area could be the North Parking Lot or Plant 5 Building areas (where concentrations are now lower than downgradient concentrations because of remedial actions).

Soil vapor and indoor air sampling was conducted at the site in 2014 in the West Building and Plant 5 Building. While TCE was detected in all four subslab soil vapor samples from the West Building at concentrations up to 52 micrograms per cubic meter ($\mu g/m^3$), it was not detected in the indoor air or outdoor air samples. One of four TCE sample subslab vapor concentrations exceeded the NYSDEC level for a recommendation to "Monitor." This location was in a small portion of the building linking the West Building and Plant 5 Building. Other VOCs, including PCE, ethylbenzene, xylene, toluene, 1,1,1-trichloroethane, carbon tetrachloride, and vinyl chloride, were detected in the West Building subslab vapor samples, but were at levels that fell within the NYSDOH decision matrix "No Further Action" criteria or were also detected in outdoor air and determined to not be related to subsurface soil or groundwater impacts (URS 2015).

In the Plant 5 Building, TCE was detected in all subslab soil vapor samples at concentrations up to 5,800 $\mu g/m^3$, and TCE was detected in the indoor air sample at a concentration of 100 $\mu g/m^3$. The highest subslab vapor samples were detected in samples collected in the southwestern portion (near MW-20) and northwestern portion (near GP-1S) of the building and appear to be related to volatilization from TCE-impacted shallow groundwater in the North Parking Lot. The detected concentrations in subslab soil vapor and indoor air fall into the "Mitigate" recommendation, although it was noted that TCE is stored and used in the building and could be the source of the indoor air detection. In 2015, notice of the observed concentrations was provided to the current tenant, CPM.

For comparison, USEPA's conservative regional screening target indoor air concentration for TCE is 8.8 $\mu g/m^3$ at a cancer risk of $1x10^{-5}$ and hazard quotient of 1 (USEPA 2015). In cases such as may be present here, where both background sources and VI sources could be present, USEPA recommends (2015):

> Information on 'background' contributions of site-related, vapor-forming chemicals in indoor air is important to risk managers because generally EPA does not clean up to concentrations below natural or anthropogenic background levels (EPA 2002)…. To determine if a subsurface vapor source(s) is (or are) responsible for indoor air contamination, EPA recommends that such background sources of site-specific analytes be identified and distinguished from vapor-forming chemicals arising from vapor intrusion...If background vapor sources (see Glossary) are found to be primarily responsible for indoor air concentrations …then response actions for vapor intrusion would generally not be warranted for current conditions.

Thus, the ability to at least semi-quantitatively distinguish the contributions of indoor sources and VI to the observed indoor concentrations could be critical at this site to determining if mitigation is warranted.

SECTION 3

Identifying Constituents of Interest

Results from the URS report (URS 2015) indicate TCE is above subslab soil vapor and indoor air NYSDOH guideline values at the former Plant 5 Building and is the primary constituent of interest. However, several other chlorinated solvents also will be included for VOC fingerprinting to serve as a potential additional line of evidence in this investigation.

Target Compound List:
Trichloroethene
Tetrachloroethene
cis-1,2-Dichloroethene
Vinyl chloride

SECTION 4

Sampling Rationale and Approach

4.1 Sampling Rationale

Potential background indoor sources of TCE were identified during previous investigations, making it difficult to distinguish between potential background sources and VI. Sampling will be performed using onsite analysis coupled with building pressure manipulation to help understand the contribution from each.

4.2 Description of the Sampling Approach

A sampling event will be conducted in early 2016. The sampling approach consists of the following steps:

- Baseline differential pressure monitoring in the former Plant 5 Building
- HAPSITE survey of the former Plant 5 Building and the attached West Building
- Blower door pressurization/depressurization testing of the former Plant 5 Building
- Selected confirmation samples with Summa canisters (Method TO-15)

4.2.1 Baseline Pressure Monitoring

Conducting the baseline pressure monitoring will help evaluate the range of differential pressure that a particular building experiences (as measured within the primary compartment) under normal operating conditions. For this study, approximately 2 weeks of baseline data will be collected with an Omniguard 4 micromanometer before conducting the pressure cycle testing. These data will be used to verify that the building pressure conditions are generally within the typical negative 1–5 Pascal (Pa) target differential pressure range as reported by McHugh et al. (2012a). McHugh et al. (2012b) show that differential pressure across the building envelope can be used to determine the predominant direction of soil gas flow across the building foundation. The potential for VI is favorable when the building differential pressure is negative, as defined by the following equation:

$$\Delta P = P_i - P_{\mathrm{ss}}$$

Where: ΔP is the differential pressure
P_{ss} is the subslab soil vapor pressure
P_i is the indoor pressure

Surveys of building conditions suggest the differential pressures may be modest, since the heating is inconsistent, no major exhaust ventilation systems have been observed, and the building envelope is leaky. However, the wind effect may be substantial, since strong winds from the south and southwest are fairly common in Jamestown and the building has extensive windows on the southern side. In addition, the building height would add to the strength of the stack effect.

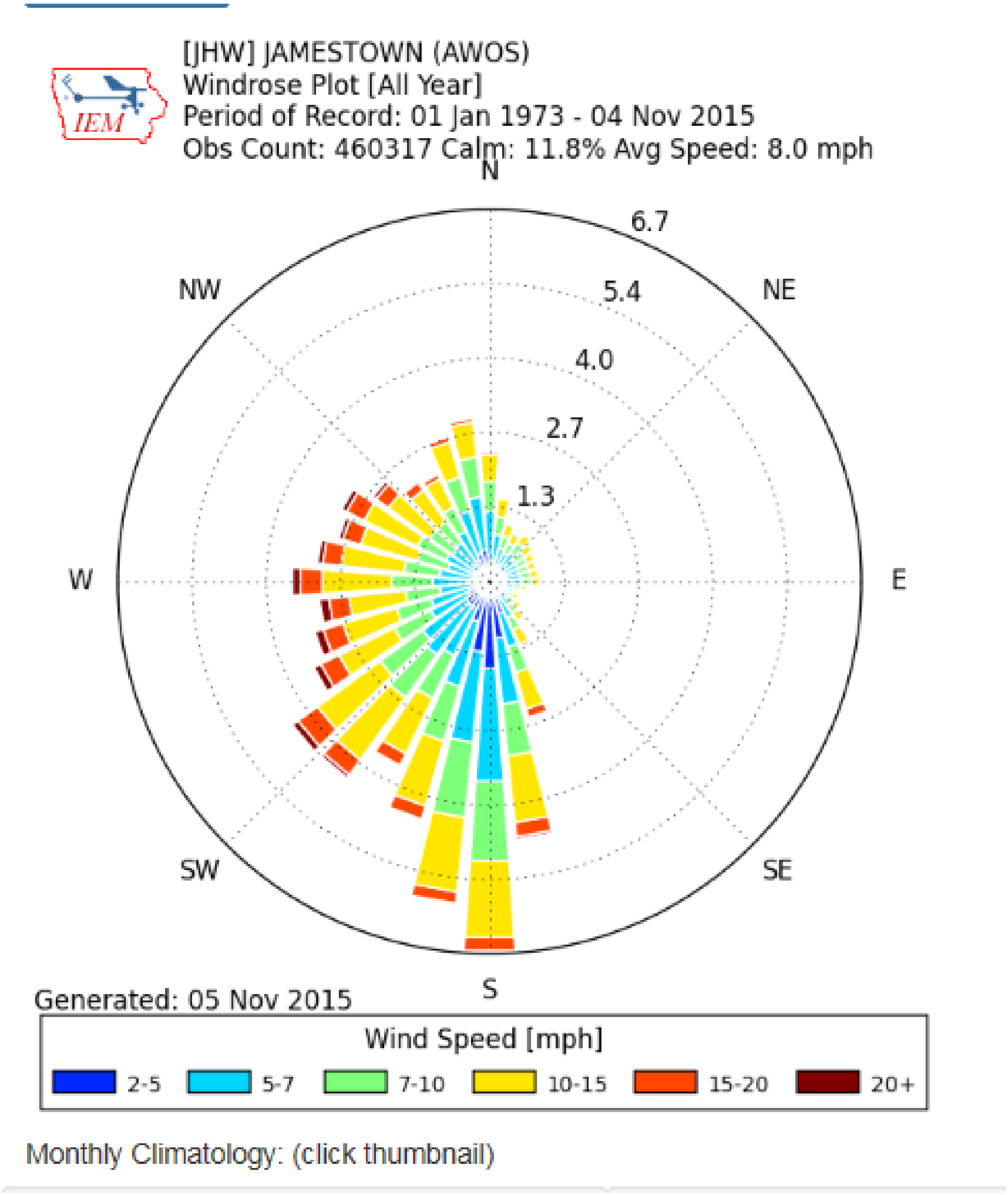

Exhibit 1. Wind Rose for Jamestown, New York

(Source: Iowa State University of Science and Technology 2015)

Based on the work of McHugh et al. (2012a), a target differential pressure of negative 5 Pa will likely be established to represent the practical upper bound on differential pressure that is likely to occur across the building envelope under natural conditions. In addition, a differential pressure as low as negative 10 Pa may also be used to assess conditions that stress the building envelope outside the practical negative 5 Pa condition.

4.2.2 HAPSITE Survey

An initial field screening with the HAPSITE will be conducted in the former Plant 5 Building and the attached West Building. The HAPSITE is a portable gas chromatograph/mass spectrometer (GC/MS) that is used to quickly acquire VOC concentration in indoor air down to subpart per billion levels. This instrument will be used to collect and analyze short-term indoor air samples at multiple locations in the building to help understand indoor air VOC concentration ranges and spatial distributions. If areas of elevated concentrations of VOCs are observed, the HAPSITE will be used to determine if background indoor air VOC sources and potential preferential pathways for VI are present. The screening may not identify all potential indoor air sources; however, the screening may be able to quickly identify and remove (with CPM's cooperation) some obvious sources that were not previously noted. Potential indoor VOC source items that cannot be removed because they are too large or are critical to the operations conducted inside the building will be noted in the project logbook and considered during the data evaluation.

4.2.3 Blower Door Pressurization/Depressurization Testing

This VI investigation will employ the results of pressure-enhanced indoor air sampling (pressure cycling) as a primary line of evidence. The strategy is based on onsite analysis methods presented in scientific literature (Nazaroff et al. 1987; Mosley et al. 2008, 2010; GSI Environmental 2008; McHugh et al. 2012a, 2012b; Beckley et al. 2013, 2014; Holton et al. 2015) and can be used to determine the potential for VI impacts in a building with a single sampling event. It also can be used to identify background indoor sources of VOCs not discovered by conventional approaches. The pressure cycling approach uses a fan to create negative pressure conditions that are favorable to VI, or positive pressure conditions that are unfavorable to VI.

The intent of the pressure cycling method is to measure indoor air concentrations under known and uniform negative or positive pressure conditions. The manipulation of VI conditions in this controlled manner reduces the uncertainty in indoor air concentrations created by natural temporal variability, eliminating the multiple sampling events required to assess variability by conventional VI investigation methods. This results in a more streamlined and cost-effective VI investigation approach that can yield a robust assessment of whether or not VI is occurring or is significant in a building.

The pressure cycling approach uses the indoor air sampling results under baseline, negative, and positive pressure conditions to make definitive conclusions regarding the significance of VI as follows:

- Baseline conditions of differential pressure and indoor VOC concentrations are observed.
- The negative pressure cycle(s) (i.e., resulting in a consistent pressure gradient from the subslab soil gas to indoor air) can be used to stress the driving force for VI across the slab in a series of controlled steps that are within and in excess of those reasonably expected under normal operating conditions.
- The positive pressure cycle (i.e., resulting in a consistent pressure gradient from the indoor air to the subslab) can be used to create an enhanced pressure condition that inhibits the potential for VI.
- The difference between the positive and negative pressure cycles provides information concerning the source of the target analyte in indoor air (i.e., subsurface source versus indoor source). If the target analyte concentration is similar under positive and negative pressure, an indoor source is suspected. If the target analyte concentration is higher under the negative pressure condition, a subsurface source is possible.

An initial interpretation can be made based on comparison of concentrations in indoor air under baseline and (de)pressurized conditions. However, a more quantitative level of interpretation can be performed that uses a measurement or estimate of air exchange rates under baseline and depressurized conditions to calculate the flux of VOCs into the building.

The procedures presented in this work plan will help establish a range of conditions, including ideally a pair of equal and opposite pressure conditions that are conducive to VI and conducive to conditions that inhibit VI. At equal and opposite differential pressures, in theory, the air exchange rate of the building should be equal; thus, the effect of dilution on indoor concentration are expected to cancel out.

However, it may not be possible to achieve equal and opposite pressure conditions in this test. For example, the natural depressurization of the building, driven by the stack effect and wind loads may make it difficult to achieve substantial positive pressurization of the building. If this occurs, data on naturally occurring radon can be a considerable aid in distinguishing the effects of indoor and subsurface sources. The mathematics of this technique are presented in Mosley (2010). Radon levels in Jamestown and Chautauqua County are generally high enough that it should serve as a useful tracer (NYSDOH 2015). A sensitive real-time instrument for radon can be cost-effectively rented and deployed to monitor indoor air concentrations in the former Plant 5 Building, should this set of conditions be encountered.

SECTION 5

Field Sampling Plan

This section describes the sampling and analysis procedures that will be used to implement the sampling approach described in the previous section. Standard operating procedures (SOPs) and field data collection forms are provided in Appendixes A and B, respectively.

5.1 Baseline Pressure Monitoring

Approximately 2 weeks before the pressure cycling is expected to begin, two subslab probes (Cox Colvin Vapor Pins) will be installed in the former Plant 5 Building (SOP for Installing and Abandoning Cox-Colvin & Associates, Inc. Vapor Pins in Appendix A). The probes will be placed a distance apart close to the middle of the building in inconspicuous locations. Differential pressure monitors (OmniGuard 4 or equivalent) will be attached to each probe. Pressure differentials between the indoor and subslab will be recorded with the electronic data logger at 15-minute intervals. The differential pressure monitors will be left in place until the pressure cycle testing is completed. During this period, indoor temperature information will also be obtained with a “Track-it”, “Hobo”, or similar data logger. Weather data can be obtained online from a local recording station. This will allow wind speed and direction to be observed and differential temperature (inside/outside) to be calculated. Comparing these key weather drivers of building pressurization to the differential pressure will provide insight into the likely “reasonable worst-case” differential pressure conditions for the building that are most favorable for VI.

During this mobilization, the building occupants (CPM) will be interviewed to understand current manufacturing or other processes, which include the use of TCE. The CPM operations are believed to be intermittent and project based. The frequency of TCE use in those operations is unknown. The building occupants (CPM) will be asked to remove all known sources of TCE, if present, from the building 1 to 2 weeks before the survey. The information also will be used to help schedule the HAPSITE survey and pressure testing around CPM operations that use TCE.

5.2 HAPSITE Survey

The initial field screening will consist of short-duration air samples (approximately 10 minutes) that will be collected and analyzed with the HAPSITE in the former Plant 5 Building and the attached West Building. In buildings with multiple compartments, screening may be conducted in compartments adjacent to the primary compartment to determine whether any significant concentration differences are between compartments (e.g., West Building and Plant 5 Building). When sampling within the primary compartment, the screening will take place by moving from larger areas within the building to smaller and smaller subareas, focusing on those areas with the highest detected concentrations (if any) of the target analytes. If elevated concentrations are detected, then the HAPSITE may be operated in survey or ‘sniff’ mode to help determine if background sources or points of VI entry are present. Detailed HAPSITE procedures, QC measures, and reporting limits are included in SOP HAP01.02a in Appendix A.

Samples of soil gas also will be analyzed with the HAPSITE from available subslab ports before (and if time allows) after pressure testing is performed.

A building survey also will be performed to document important building conditions, including:

- Building dimensions.
- Presence of any sources of VOCs (site-specific compounds).
- Indoor temperature (can be approximate if thermostatically controlled).

- Wind speed and direction and outdoor temperature (hourly meteorological information from a nearby recording station will often be adequate).
- Heating, ventilation, and air conditioning (HVAC) operational conditions, position of all windows and doors. HVAC dampers and registers should not normally be adjusted unless the HVAC system is being used with the permission of the building owner to conduct the pressure test.
- Recent rain, surface flooding, or snow cover. If snow cover is present, note its condition (wet, dry, crusted, etc.).

Appendix B contains a building survey form, which will update and supplement the survey performed by URS in March 2014.

5.3 Blower Door Pressurization/Depressurization Testing

5.3.1 Baseline VOC Sampling

When the pressure cycling sampling event is set to begin in the former Plant 5 Building, all exterior doors and windows (to the primary compartment) should be closed, and the HVAC system setting should not be changed relative to normal operating conditions. Back drafting of the heating unit’s exhaust is not anticipated because of the presence of exhaust duct fans. These small fans are typically designed to overcome a negative indoor to outdoor pressure differential of greater than what is proposed in this investigation. During the testing, indoor air will be monitored with a carbon monoxide detector. Should back drafting become a problem, then the heating units will be temporarily turned off. All interconnecting interior doors within the tested compartment, except for closets, should be open. An initial outdoor air sample will be collected for HAPSITE analysis to determine ambient (outdoor) concentrations of the target analytes at a location well away and upwind from the building and the treatment system.

An initial round of indoor air samples will be collected using the HAPSITE to document baseline conditions. The number of actual sample locations will vary based on compartment size and the number of rooms, but a minimum of three sample locations will be selected and sampled with the field screening instrument. The three sample locations will be used during the pressure control phases to assess temporal and spatial variability under the influence of the various target pressures. Because each HAPSITE sample takes approximately 10 minutes to process, cycling repetitively through the three locations will take approximately 30 minutes to complete. Therefore, two cycles through the sampling locations can be made through the locations per hour, which is appropriate to observe the changes anticipated during pressure cycling. Up to three additional indoor air samples may be collected if the HAPSITE indicates variability at different locations within the primary compartment. However, three representative locations will be selected, from a maximum of six locations, for use in sampling during the pressure cycling phases.

5.3.2 Building Pressure Control and Sampling

After sampling in the former Plant 5 Building under baseline conditions has been completed, the project team will install a blower door to pull indoor air from inside the building (induced negative pressure) or blow air into the building (induced positive pressure). The blower door assembly will be connected to the building or compartment envelope using a window, door, or vent. The blower door location should have minimal obstruction between it and the rest of the tested compartment. The building differential pressure monitors will remain in place from the baseline monitoring phase and will be used during the pressure cycling phase. Efforts will be made to maintain the specific target pressure differentials defined below; however, obtaining all target pressures may not be possible for all buildings because of some building characteristics (e.g., leakiness, size, air-handling systems). In some buildings (or building compartments), it may be possible to use the HVAC system to achieve all or some of the target pressures or work in combination with the blower door to obtain the target pressures.

During the pressure testing, three differential pressures can be monitored:

- Two, between the subslab ports installed and the indoor air
- One, near the blower door, using the blower doors built in capability to monitor outside vs. inside differential pressure

If pressurization/depressurization of the building envelope proves unfeasible, a temporary total enclosure or large flux chamber approach may be attempted using a tarp or plastic film to estimate emissions from particular features, such as the wood block floor, open floor pit, or solvent storage cabinets (Exhibits 2, 3, and 4). Those procedures would be based broadly on USEPA Methods 204 and 204D (temporary total enclosure) and USEPA guidance on flux chambers (Klenbusch 1986).

5.3.2.1 Building Depressurization

Since CPM has drum quantities of TCE and numerous other solvents in its facility, and the small staff is apparently involved in production activities, CH2M HILL (CH2M) presumes that all workers are subject to Occupational Safety and Health Administration (OSHA) hazard communication requirements. Therefore, CH2M will stop induced depressurization before the concentration reaches 10 percent of the OSHA permissible exposure limit (10 percent of 100 parts per million [ppm] = 10 ppm = 53,000 µg/m^3). This is consistent with the USEPA acute exposure guideline Level 1 for TCE of 77 ppm for 8-hour exposure. In practice, CH2M does not expect indoor air concentrations to exceed 2,000 µg/m^3 during the test since the peak observed subslab concentration is 5,800 µg/m^3. The periods of depressurization are expected to be brief, totaling less than 16 hours, so the project team can determine the source of ongoing TCE exposure in the facility while minimizing increases during testing.

Building depressurization will serve to create negative pressure conditions favorable for VI and will occur in three phases. The fan will be oriented to blow air out of the building at a target rate that will induce 2.5, 5, and 10 Pa negative differential pressure relative to the subslab. Actual target differential pressures used in the testing may vary based on baseline pressure monitoring results as well as the differential pressures achievable by the blower door flow rates and building envelope leakiness. CH2M's calculations indicate that for a typical commercial building of this size, a flow of 50,000 to 60,000 cubic feet per minute (cfm) would be needed to reach the 50 Pa differential pressure often used by energy auditors. To achieve 5 Pa, differential pressure will likely require 5,000 to 16,000 cfm.

CH2M plans to use a pair of blower doors that together are each capable of achieving 6,300 cfm at free air or 5,300 cfm at 50 Pa. If this is insufficient, supplementary fans will be used. At each stage in building depressurization, the flow rate used should be recorded at steady state. Typically, blower doors are provided with a calibrated orifice for this purpose. If supplementary fans are used, their flow rate can be estimated from differential pressure and their manufacturers published flow curves.

During each building depressurization phase, the HAPSITE will be moved throughout the primary compartment being depressurized and samples will be collected from the same locations as the baseline samples. Each pressure step will be performed until at least three air exchanges have been induced by the airflow through the blower door fan and or the HAPSITE readings are not trending notably in one direction. An air exchange is estimated by calculating how long it takes to replace the volume of air in the compartment being tested at the flow rate the blower door is operating. The approximate volume of the Plant 5 Building is at 600,000 cubic feet. One of the following conditions typically occur under depressurization. Other conditions may occur and will be evaluated on a case-by-case basis.

- The indoor air VOC concentrations increase and then stabilize, suggesting VI is occurring and has reached its steady-state maximum for the pressure condition.

- The indoor air VOC concentrations decrease and then stabilize, suggesting dilution with outdoor air is occurring through leaks in the building envelope and has reached its steady-state minimum for the pressure condition.
- No change in indoor air VOC concentrations is observed. If VOC concentrations are low (near outdoor air levels), this could indicate VI is not occurring. If VOC concentrations are elevated above outdoor air levels, this could indicate VI is occurring, but being balanced by dilution air leaking through the building envelope.

If elevated concentrations of VOCs are noted in indoor air samples during the depressurization phases, then potential vapor entry points may be evaluated for evidence of VI, if time permits. These may be screened using the HAPSITE or a ppbRAE. Potential vapor entry points are penetrations through the building walls and foundation such as floor drains, plumbing penetrations, cracks, and expansion joints. This can be a time-consuming process and will be conducted using professional judgment based on the availability of readily identifiable vapor entry points.

5.3.2.2 Building Pressurization

Building pressurization will serve to create positive pressure conditions unfavorable for VI and will occur in only one phase. The fan will be oriented to blow air into the building at a rate that will induce 5 Pa positive differential pressure (or the opposite of the maximum differential pressure achieved during depressurization if negative 5 Pa was not achieved) relative to the subslab. The purpose of the positive pressure cycle is to evaluate the contribution from potential indoor sources (McHugh et al. 2012a). A target positive pressure equal to positive 5 Pa was selected to facilitate direct comparison to the target negative pressure condition under assumed equivalent air exchange rate conditions. Only one positive pressure is needed to make this assessment. At each stage in building pressurization, the flow rate used should be recorded at steady state. Typically, blower doors are provided with a calibrated orifice for this purpose.

During the building pressurization, the HAPSITE will be moved throughout the primary compartment being sampled. Periodic samples will be collected from the same locations as the baseline samples. The positive pressure step will continue to be performed until at least three air exchanges have been induced by the airflow through the blower door fan and the HAPSITE readings are not trending consistently and markedly in one direction. One of the following conditions is expected to occur under pressurization:

- The indoor air VOC concentrations decrease and then stabilize at the outdoor air concentration: suggesting dilution with outdoor air is occurring, a strong indoor source is not present, and that VI may have been occurring previously.
- The indoor air VOC concentrations decrease and then stabilize above the outdoor air concentration: suggesting dilution with outdoor air is occurring, an indoor source may be present, and that VI may have been occurring previously.
- No change in indoor air VOC concentrations is observed and VOC concentrations are elevated above outdoor air levels: suggesting a strong indoor source is likely present, and that VI may not have been occurring previously. If VOC concentrations were low before pressurization (near outdoor air levels), the indoor air concentrations would not be expected to change.

5.3.2.3 Re-Baseline Sampling

After pressure cycling is complete, the HAPSITE will be used to monitor the return of indoor air concentrations to original baseline building conditions. Since the building no longer has a fan inducing rapid air exchange, the building may have to be allowed to rest overnight until baseline concentrations are again observed. The post-test baseline samples can be compared to the pretest baseline samples as an indication of short-term temporal variability. Time permitting, additional measurements can be taken under baseline conditions to better understand temporal variability, entry points, or indoor sources. The differential pressure monitors will be removed from the building once the testing is complete. The vapor probes will be left in place and covered with a flush-mount protective cap.

5.4 Quality Assurance/Quality Control

Quality assurance/QC procedures for this investigation are included in SOPs HAP01.02a in Appendix A for the HAPSITE instrument, subslab probe installation, and differential pressure monitoring.

A water dam leak check will be conducted on the installed subslab ports. Differential pressure monitors will be factory calibrated. Zero checks can be performed in the field by opening both ports to the same atmosphere.

Up to four short duration Summa canister samples will be collected during the program to verify HAPSITE results. Those samples will be selected to represent a range of concentrations and will have an objective of a relative percent difference of less than 40 in the intermethod comparison for the key samples.

Exhibit 2. Wood Block Floor

Essex-Hope Site, Jamestown, New York

Exhibit 3. Open Pit in Floor

Essex-Hope Site, Jamestown, New York

Exhibit 4. Chemical Storage

Essex-Hope Site, Jamestown, New York

(Source: Photo from URS 2015)

SECTION 6

Data Evaluation, Interpretation, and Reporting

A summary report of the VI investigation for the former Plant 5 Building and West Building will document the field activities and findings as well as provide conclusions and recommendations. The report will include:

- Description of the work performed, including dates for removing suspected indoor sources.
- Description of important building-related features (e.g., preferential pathways, background indoor sources found, etc.).
- HAPSITE and pressure cycling results.
- Evaluation and interpretation of the HAPSITE and pressure cycling data. This can initially be performed on a semiquantitative basis in which the response of indoor VOC concentrations to differential pressure is interpreted as discussed in Section 5.3.2. If it appears that both an indoor source and a VI source are significantly contributing, CH2M will attempt to quantitatively estimate the relative contribution of indoor and VI sources using methods presented in literature (Nazaroff et al. 1987; Mosley et al. 2008, 2010; GSI Environmental 2008; McHugh et al. 2012a, 2012b; Beckley et al. 2013, 2014; Holton et al. 2015).
- Conclusions based on the multiple lines of evidence gathered to the presence of background sources, preferential pathways, or both.
- Recommendations for future VI activities as well as potential indoor source management and/or mitigation options (if necessary).

SECTION 7

Schedule

Schedule milestones have been established based on the assumption that a revised work plan is submitted to NYSDEC and NYSDOH in February 2016. Field activities will not proceed until NYSDEC and NYSDOH approve the work plan. In the event of changes in availability of regulatory staff, project approach, or site conditions, a revised schedule will be provided to NYSDEC and NYSDOH. The anticipated schedule milestones are as follows:

Date	Milestone
February 2016	Submit work plan to NYSDEC and NYSDOH for review
March 2016	Receive comments and approval from NYSDEC and NYSDOH on draft work plan and finalize work plan
March 2016	Install subslab sampling probes, start baseline pressure monitoring
April 2016	Perform HAPSITE survey and building pressure testing
May 2016	Prepare and review of draft technical memorandum of vapor intrusion investigation results
June 2016	Submit draft vapor intrusion investigation technical memorandum presenting results to NYSDEC

SECTION 8

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Figure

C:\Work\Boston\Jamestown\Mapfiles\CSM\Jamestown_CSM_Fig01-01_SiteAreas.mxd mcotterb 10/16/2015

Legend

— Approximate Site Boundary

▨ Parcel Boundary

N

0 60 120

Feet

1 inch = 60 feet

FIGURE 1-1

ESSEX/HOPE SITE AREAS

CONCEPTUAL SITE MODEL

JAMESTOWN, NEW YORK

ch2m

Appendix A
Standard Operating Procedures

Standard Operating Procedure for Installing and Abandoning Cox-Colvin & Associates, Inc. Vapor Pins

Quality Management

SOP NO. : VAPOR_PIN_INSTALL_ABANDON
ORIGINAL VERSION 10/01/2005 BY BFT
REVISION 1 – 06/23/2008 BY BFT
REVISION 2 - 02/19/2009 BY BFT
REVISION 3 - 01/11/2011 BY KAS
REVISION 4 - 08/07/2011 BY JNS
REVISION 5 – 01/19/2012 BY JNS
REVISION 6 – 06/14/2012 BY JAL
REVISION 7 – 06/27/2014 BY LAB
REVISION 8 – 3/11/2015 BY BFT

PAGES: 11

File Name:
SOP_Subslab_Soil_Gas_Installation_and_Abandonment_Vapor_Pin_03112015.Doc

Location: Vapor Intrusion SharePoint Site/Best Practices and OPs/Standard Operating Procedures (SOPs)

Primary Contact(s): Ben Thompson/CVO, Jennifer Simms/PHL, Kim Stokes/DFW, and Shirley Steinmacher/SLC

Quality Assurance/Quality Control Review: Ben Thompson/CVO and Jennifer Simms/PHL

Associated Internal Resources:

Excel sampling logs are available at Vapor Intrusion SharePoint Site/Best Practices and OPs/Standard Operating Procedures (SOPs).

Manufacturer (Cox-Colvin & Associates, Inc.) installation standard operating procedure (SOP) and installation, extraction, secure cover installation, and extraction videos available at http://www.coxcolvin.com/video.php and http://www.coxcolvin.com/VaporPin.php

Example project reports using this SOP can be found at VI Practitioners Site (Limited Access)/Project Document Library

For vapor intrusion evaluations in residential areas, a community outreach plan should be developed and the field team should be trained on how to interact with residents. Internal Public Involvement Specialists who can be consulted for this include Amy Brand/VBO and Ginny Farris/WDC.

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Standard Operating Procedure for Installing and Abandoning Cox Colvin Vapor Pins

Revision Log

REVISION 6 – 06/14/2012: 1) added specification for a calibrated digital vacuum gauge; 2) revised language for measuring and interpreting initial field vacuum measurements; 3) revised language for measuring and interpreting final field vacuum measurements; 4) added requirement for posting an informational sign on canisters being left unattended; 5) revised language and a revised table for estimating initial and final vacuums at different elevations

REVISION 7 – 06/27/2014: 1) separated sampling of subslab soil gas probes/Vapor Pin from the combined installation and sampling SOP because it was too long; 2) omitted traditional subslab soil gas probes from this SOP in order to create a stand-alone SOP for Installing and Abandoning Traditional Subslab Soil Gas Probes; 3) added section on wet-drilling techniques; and 4) added warning on asbestos-containing material in flooring

REVISION 8 – 03/11/15: 1) added language to address state specific equilibration time requirements

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Standard Operating Procedure for Installing and Abandoning Cox Colvin Vapor Pins™

1.0 Scope and Application

This standard operating procedure (SOP) describes the approach for installing and abandoning Cox-Colvin & Associates, Inc. (Cox-Colvin), Vapor Pins. This procedure should be used in conjunction with project data quality objectives. The project team is responsible for ensuring this procedure meets all applicable regulatory standards and receives approval/concurrence from the leading regulatory agency for the project. Vapor intrusion (VI) subject-matter experts should be consulted as needed to address technical, regulatory, or field implementation issues associated with the use of this SOP. Only persons trained in the installation and abandonment of subslab soil gas probes should attempt this procedure.

The Cox-Colvin Vapor Pin is a re-usable subslab soil gas sampling device designed to eliminate many of the problems associated with traditional subslab soil gas probes. Advantages of the Cox-Colvin Vapor Pin include:

- Design reduces the potential for leaks during sample collection, improving sample quality
- Built-in seal eliminates the need for cement grout
- Connects easily to sampling equipment
- Easily installed and sampled within same day
- Easily removed
- Reduces damage to concrete slab
- Reusable
- Reduces installation time allowing collection of more samples for less cost

2.0 Project-Specific Considerations

2.1 Sampling locations should be selected in accordance with the work plan. Subslab probes should be placed at least 5 feet away from exterior walls and penetrations in the slab (large cracks, sumps, drains, utilities, and so forth) to avoid short-circuiting of ambient air. Try and chose locations that are out of the way. High traffic areas (such as areas where forklifts are routinely driven) can cause damage to the vapor pin.

2.2 A utility clearance must be performed by a private utility locating contractor prior to drilling through the slab, as with all intrusive site work. The utility clearance should be performed with a concrete scanner (small, hand-held ground-penetrating radarunit designed for “seeing through” concrete slabs) to identify utilities, wire mesh, and/or rebar in the slab prior to drilling. The sampling team should also look around the building to locate where utilities come into the building. Utility shut-off valves should be located in case an underground utility is encountered.

2.3 The Cox-Colvin Vapor Pins should be made of stainless steel and may be re-used if they are decontaminated. Options for decontamination include: 1) purging with air (only acceptable if there was no contact with contaminated soil or groundwater); 2) washing with Liqui-nox (**do not use Alcon-nox**) followed by hot water rinse; or 3) rinsing with methanol followed by hot water rinse. The parts must be completely dry before reuse. It is advisable to heat the parts in an oven to a temperature of 130 degrees Celsius (266 degrees Fahrenheit) after rinsing with water. The appropriate decontamination process should be selected during the work planning phase for each project. Typically subslab soil gas sampling does not generate investigation-derived waste (IDW) other than items that can be disposed of as solid waste; however, decontaminating with liquids will generate IDW. Compare the cost of buying new parts to the cost of managing and disposing of the IDW. The silicone sleeves cannot be reused or decontaminated.

2.4 The Cox-Colvin Vapor Pins will be installed as described below and in accordance with the Cox-Colvin SOP: *Installation and Extraction of the Vapor Pin™* and *Use of the Vapor Pin™ Drilling Guide and Secure Cover* available either on the Vapor Intrusion SharePoint Site or the Cox-Colvin website.

2.5 Cox-Colvin offers add-on products for use with the Vapor Pins, including filters, sieves, extensions, and barbed extensions.

3.0 Health and Safety

There are several health and safety topics to consider when installing and abandoning Cox-Colvin Vapor Pins:

3.1 Field teams should work in pairs at residential buildings or at industrial/commercial buildings where a relationship with the building occupant has not yet been established. A field team member should never enter a building alone for the first time. The mental stability of a building occupant should not be taken for granted. Probe installation should also be performed in pairs because the drilling is a high-risk activity.

3.2 Common hazards encountered during subslab soil gas probe installation and abandonment include low ceilings, slip, trip, and fall hazards (from installation equipment and items stored in sampled areas), wet surfaces, biological hazards (spiders, rodents, residential pets, and so forth), sanitary hazards (animal feces), and low lighting levels.

3.3 Floor coverings, including floor tile, linoleum, sheet flooring, and ceramic tile, and floor tile mastics and carpet adhesives at proposed subslab locations can be compiled of asbestos-containing materials (ACMs). The ACM content of these materials should be evaluated if they must be removed for sampling by having state-licensed asbestos inspectors collect samples of the materials, and having the samples analyzed for ACM content by a certified asbestos laboratory. A state-licensed asbestos management planner, project Regional Health and Safety Manager, and/or other enterprise risk managers should review the laboratory results to determine how to address these materials in accordance with corporate ACM policies. Finding alternate bare concrete sampling locations is the often the best option.

3.4 The hammer drill is a large and powerful hand tool. When drilling, do not apply downward pressure, allow the drill to do the work. The drill bit is likely to become stuck if the operator is pushing down on the drill. Be prepared for the drill bit to catch and for the drill to stop suddenly; it can twist the operator’s wrist badly if unexpected.

3.5 Have a properly calibrated multi-gas meter (including lower explosive limit meter) and photoionization detector (as required by the project Health and Safety Plan) ready to screen the breathing zone during installation and sampling. Potentially explosive atmospheres and significant volatile organic compound concentrations may be present in sampling areas and subslab soil gas.

3.6 The presence of methane or other combustible gases beneath a slab are a significant health and safety concern when drilling through slabs. Existing site data should be evaluated to determine whether there is a potential for combustible gases to be present beneath the building. If so, or if there is uncertainty, then wet drilling techniques should be employed (see Section 5.3 for discussion of wet drilling techniques).

3.7 Beware of pinch points and use the correct hand tools and personal protective equipment, such as leather gloves, to avoid hand injuries.

4.0 Materials

4.1 Cox-Colvin Vapor Pin Installation

- Hammer drill and drill bits [$1^{1/2}$-inch (for flush mount applications) and/or 5/8-inch (for both temporary and flush mount applications)]. NOTE: It is a good idea to have an extra-long 5/8-inch drill bit available to drill through the occasional extra-thick slab (commonly present at airports, truck loading docks and other heavily trafficked industrial, commercial, and military facilities). 36-inch long drill bits may be obtained from Grainger.
- Vacuum cleaner (shop-vac-type or handheld, with both a dust bag and high-efficiency particulate air [HEPA] filter) for removing concrete dust generated while drilling through the slab for probe installation. Continuously vacuum the dust as it is generated during the drilling process.
- Power extension cord with multiple outlets and ground fault current interrupter.
- Assembled Vapor Pin (Vapor Pin and silicone sleeve). Vapor Pins come in either brass or stainless steel. Use stainless steel due to its superior corrosion resistance. See Figure 1 for an expanded view of the Assembled Vapor Pin.
- Vapor Pin ¾-inch bottle brush (provided with Vapor Pin kit)
- Vapor Pin white protective caps (provided with Vapor Pin kit)
- Vapor Pin Stainless Steel Secure Cover and Stainless Steel Drilling Guide for secured flush mount installation
- Vapor Pin Spanner Screwdriver for Secure Cover
- Vapor Pin Installation/Extraction Tool (provided with Vapor Pin™ kit)
- Dead-blow hammer or rubber mallet
- Large cotton swabs or paper towels and non-chlorinated (de-ionized or distilled) water for cleaning the concrete dust out of the hole
- Tape measure to measure the thickness of the slab (measured off of a long screwdriver, bent pin flag, or drill bit)
- Tools required to cut carpet and/or tools needed for removal of other floor coverings and adhesive or two sided tape or carpet glue to re-attach carpet or floor covering to concrete.
- Optional (for high traffic areas): 2-inch coring bit

- Optional (required by some regulatory agencies): glass "seed beads" (available at a craft store, Geoprobe Product Number AT84, or Environmental Service Products on-line) to fill the void space created in the subslab during installation.

FIGURE 1
Assembled Vapor Pin

4.2 Extraction/Abandonment of Cox-Colvin Vapor Pin

- Installation/Extraction tool (provided with Vapor Pin kit)
- Concrete patch (either pre-mixed cement patch or portland cement)
- Trowel for applying cement patch or cement

5.0 Cox-Colvin Vapor Pin Installation Procedure

5.1 Select the sampling locations in accordance with the work plan. Note the location of the probe, locations of significant features (walls, cracks, sumps, drains, and so forth), and condition of the slab. Subslab probes should be placed at least 5 feet away from exterior walls and penetrations in the slab (large cracks, sumps, drains, utilities, and so forth) to avoid short-circuiting of ambient air.

5.2 If needed, expose the concrete by cutting the carpet or other loose floor coverings (Note: carpet need not be removed, but rather an 'L' shape should be cut to expose the concrete for drilling and the leak-check enclosure). See Section 3.3 for a discussion of asbestos content of floor coverings.

5.3 In locations with potential high levels of methane or other combustible gases present in the subslab, wet drilling methods should be used. Water used during drilling will reduce the potential for sparking of the drill bit if it encounters hard gravel, rebar, or wire mesh in the concrete. Wet drilling methods involve continually adding water to the concrete hole as it is being drilled. The drilling should proceed slowly to prevent the drilled hole from drying out.

5.4 Two installations types of the Vapor Pin are possible, a stick-up (temporary) and flush mount (semi-permanent and permanent).

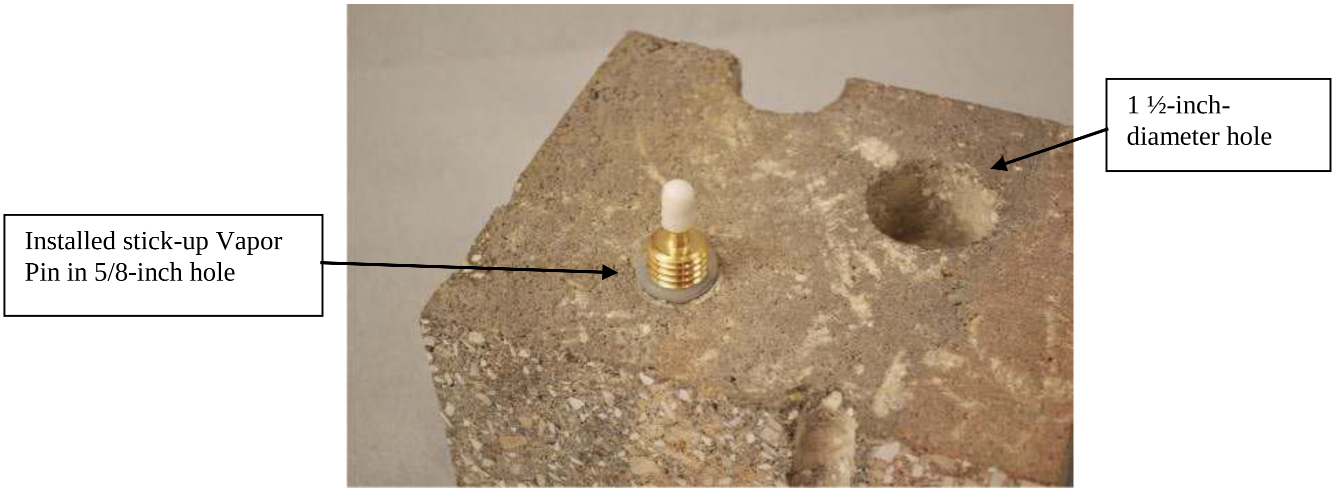
5.4.1 For the stick-up installation, only the 5/8-inch-diameter hole is drilled through the concrete and the Vapor Pin is installed with the barbed fitting and the extraction threads above the concrete surface (see Figure 2). **For stick-up applications, drill a 5/8-inch hole through the entire slab as discussed in Step 5.6 but without the Drilling Guide.**

5.4.2 For flush mount application, drill a 1 ½-inch-diameter hole to a depth of 1 ¾ inches (use the Drilling Guide to measure the hole depth as described in Step 5.5) to allow room for installing the Vapor Pin (See Figures 2 and 3).

5.4.3 Optional, for installation in high traffic areas: Before drilling the 1 ½-inch-diameter hole, use a 2-inch coring bit to drill approximately 1/8" into the slab. This will allow the top of the flush mount cover to truly be flush with the slab surface

5.4.4 Remove the cuttings using the shop vac with HEPA filter. Be careful to not compromise the integrity of the slab during drilling (for example, cracking it), although make a note if this occurs. It is important that the slab and the probe hole remain airtight for sampling and that cracks are noted.

Figure 2



5.5 Place the Drilling Guide in the hole with the conical end down (Figure 3). The hole is sufficiently deep if the flange of the Drilling Guide lies flush with the surface of the slab. Deepen the hole as necessary, but avoid drilling more than 2 inches into the slab as the threads on the Secure Cover will not engage properly with the threads on the Vapor Pin.

Figure 3

Installing the Drilling Guide

5.6 Drill a 5/8-inch-diameter hole through the remainder of the slab using the Drilling Guide previously inserted into the hole and approximately 3 inches down into the subslab material (See Figures 3 and 4). Drilling into the subslab material creates a void that is free of obstructions that might plug the probe during sampling. Record the total depth of the slab and the depth drilled into the subslab material on the Subslab Soil Gas Sampling Log.

Figure 4

Using the Drilling Guide

5.7 Remove the Drilling Guide from the hole.

5.8 Clean out the drilled hole with the shop vac with HEPA filter (equipped with a micro tip), 3/4-inch bottle brush, and paper towel. This removes any remaining dust, allowing the silicon sleeve to adhere to the hole wall better.

5.9 Place the lower end of the Vapor Pin assembly into the drilled hole. Place the small hole located in the handle of the extraction/installation tool over the Vapor Pin to protect the barb fitting and cap, and tap the Vapor Pin into place using a dead-blow hammer (Figure 5). Avoid damaging the bard fittings by lining up the tool perpendicular to the Vapor Pin. For a flush mount installation, the installation tool is turned horizontally to allow for the Vapor Pin to be driven into the boring the remainder of the way (Figure 6).

Figure 5

Installing the Vapor Pin

Figure 6

Flush Mount Installation of the Vapor Pin

5.10 During installation, the silicon sleeve will form a slight bulge between the slab and the Vapor Pin shoulder. Place the white protective cap on the Vapor Pin to prevent vapor loss prior to sampling (Figure 2).

5.11 Place the secure cover onto the Vapor Pin and tighten using a #14 spanner wrench by rotating it clockwise (Figure 7). Rotate the cover counter clockwise to remove it for subsequent access.

Figure 7

Tightening Flush Mount Secure Cover

5.12 Allow **an adequate amount of time** for the subslab soil gas conditions to equilibrate prior to sampling. The manufacturer recommends at least 20 minutes. However, local state guidances typically recommend from 2 hours (CA DTSC) up to 24 hours. Be sure to verify wth a VI SME before field work.

6.0 Vapor Pin Extraction and Hole Abandonment

6.1 After sampling, it is critical that the probe either be removed or securely plugged (with cap and cover) to prevent the creation of a new pathway for VI.

6.2 To remove the Vapor Pin, remove the protective silicone cap and thread the extraction tool onto the barrel of the Vapor Pin. Continue turning the tool to aid in extraction, then pull the Vapor Pin from the hole (Figure 8).

Figure 8

Removing the Vapor Pin

6.3 Fill the hole with portland cement mix and return the surface as near to pre-sampling conditions as possible.

7.0 Attachments

7.1 ***Subslab Soil Gas Probe Installation and Sampling Log - Canister Method***

SOP No.: HAP01.02a
Revision: 1
Date: Dec. 2015/BFT
Page: 1 of 10

CH2M HILL Standard Operating Procedure

ANALYTICAL METHOD FOR THE DETERMINATION OF VOLATILE ORGANICS IN AIR USING THE HAPSITE FIELD GC/MS

APPROVED:

Ben Thompson 11/19/14

Author Date

ANALYTICAL METHOD FOR THE DETERMINATION OF VOLATILE ORGANICS IN AIR USING THE HAPSITE FIELD GC/MS

1.0 SCOPE AND APPLICATION

This document provides standard operating procedures for using a HAPSITE gas chromatograph/mass spectrometer (GC/MS) for use at field projects using EPA Method TO-15 as guidance. This procedure is intended to be used by GC/MS chemists with proper training and experience. These procedures are based upon EPA Method TO-15 as published in "Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air", Second Edition, January 1999 and the HAPSITE user manual. This method is applicable to specific Volatile Organic Compounds (VOCs) in air. Table 1 presents a list of VOC's with reporting limits which can be analyzed with this procedure. This SOP covers the standard operating procedures for the HAPSITE, however, site specific requirements provided in other project specific documents (such as a QAPP or SAP) may override this SOP. Additionally, field conditions encountered during field work may require modifications to the procedures.

2.0 OVERVIEW OF THE ANALYTICAL PROCESS

2.1 Air samples are collected through the sampling probe at ambient pressure.

2.2 The HAPSITE can be operated in two different modes. Analytical mode for quantitative and qualitative results, or survey (sniff) mode for qualitative screening.

2.3 Analytical mode: Samples are introduced into the GC/MS system by way of a sample probe and concentrator. The concentrator traps the sample onto an adsorbent trap which allows atmospheric gases to pass through (CO2, O2, N2, etc). The trap is then heated and the analytes are transferred to the GC column, then to the MS detector.

2.4 Survey mode: Samples are introduced through the sample probe directly into the MS detector.

2.5 Data is collected and stored into the HAPSITE system memory. The data can then be used by an external computer for calibration, data processing, reporting of samples, and data archiving.

2.6 SIM and SCAN: The MS system is capable of operating in SCAN or SIM mode, depending on analytical or specific project requirements. SCAN mode is used for more conventional TO-15 analysis or if tentatively identified compounds (TIC) are required. In this mode the MS scans a range of ions (typically 35-250 amu). This range contains all ions necessary to identify and quantitate all compounds in the TO-15 list. If lower detection levels are required, SIM mode may be utilized. In SIM mode, the analyzer only looks at ions specific to the target compounds. Up to three ions are used per compound, 1 for quantitation, and 1 or 2 for qualification. This increases the dwell time that the analyzer spends scanning for each specified ion, which increases sensitivity at the cost of selectivity. Because of this, it is not possible to produce TIC reports in SIM mode.

2.7 After samples are analyzed, processed, and meet all acceptance criteria herein, a client report is generated and typically reviewed by a peer.

3.0 TARGET ANALYTES, REPORTING LIMITS, AND DETECTION LIMITS

Standard target analytes and reporting limits for the base analyte list for analysis in SIM mode are listed in Table 1. In order to keep the analysis time as short as possible, the analyte list should be kept to the minimum number of compounds of interest. In order to produce the analyte list and reporting limits in Table 1, it takes approximately 10-15 minutes from injection to injection (including sampling time, analytical run time, post run instrument cool down.)

3.1 The reporting limits (RL) shall be at or above the lowest calibrated point on the initial calibration curve. Reporting limits may increase or decrease based on the amount of time the sample is loaded onto the concentrator. Typical achievable limits for a 1 minute fill time are listed in Table 1 for SIM mode.

4.0 INTERFERENCES

4.1 Contamination may occur in the sampling system if it is not properly cleaned before use. Therefore, the probe should be heated and an ambient system flush performed at the start of each day, or between samples with elevated concentrations of VOCs.

4.2 Contamination may occur from impurities in the carrier gases and from background sources. These sources of contamination are monitored through analysis of method blanks.

4.3 Cross-contamination can occur whenever samples containing high VOC concentrations are analyzed. Therefore, whenever an unusually concentrated sample is encountered, the analyst uses professional judgment when reviewing the following samples to determine whether reanalysis is necessary.

5.0 SAMPLE COLLECTION, STORAGE, HOLDING TIMES, AND PRESERVATION

5.1 Samples are typically drawn directly through the sampling probe, therefore no sample media is necessary. However, it is possible to analyze a diluted sample collected in a Tedlar bag. Analysis of Tedlar bags should be performed immediately after sample collection. As this procedure will most typically be performed immediately in the field, holding times and preservation are typically not applicable.

6.0 APPARATUS AND MATERIALS

6.1 Inficon HAPSITE Smart, Smart Plus or ER GC/MS.

6.2 GC Column – 100% methyl silicone phase, 15m or 30m x 0.32 mm ID x 1 um film.

6.3 Tedlar® bags in various sizes as needed. Include Summa to bag adapter for calibration standards.

6.4 Gastite® syringes in various sizes from 25uL to 100mL with Teflon plunger and rounded needle tip.

6.5 Two stage regulator for nitrogen cylinder (optional if HAPSITE will be used in a fixed location). CGA 580 fitting.

6.6 A portable Windows based lap top computer. The computer utilizes the HAPSITE Smart IQ software for acquisition, integration, quantitation, and storage of mass spectral data. The HAPSITE can operate without connection to a computer, but a computer is necessary for higher quality data reprocessing.

6.7 Power source. Either line power or an automobile power inverter. The HAPSITE has an onboard battery, but it needs to be re-charged periodically.

7.0 STANDARDS, GASES, AND REAGENTS

All standards are logged into the chemical inventory database upon receipt. Any standard that is prepared in the laboratory shall be verified against current standards prior to use.

7.1 <u>Calibration standards</u> - Purchase a pre-made standard or have a vendor prepare a calibration standard in a 6 L SUMMA canister. Actual concentration and composition varies by project, but typically 5ppbv and 0.5 ppbv are good targets.

7.1.1 <u>Stock standards</u> - standards are purchased as custom made mixtures in gas cylinders. Cylinders purchased from vendors are traceable to a National Institute of Standards and Technology (NIST). 62-component mixture from Scott Gases (catalog number 41973-U). Stock standard is 1000 ppbv.

7.1.2 <u>Primary Field Standard (5 ppbv)</u> – Dilute the 1000 ppbv primary standard(s) 1:200. Evacuate a clean 6L canister. Add 50 ul of DI water. Add 90 mls of 1000 ppbv standard. Fill canister to final pressure of 2280 torr using UHP N2. This provides 12 L of usable 5 ppbv standard (16L total).

7.1.3 <u>Primary Field Standard (0.5 ppbv)</u> – Dilute the 1000 ppbv primary standard(s) 1:2000. Evacuate a clean 6L canister. Add 50 ul of DI water. Add 9 mls of 1000 ppbv standard. Fill canister to final pressure of 2280 torr using UHP N2. This provides 12 L of usable 0.5 ppbv standard (16L total).

7.1.4 Daily Field Calibration standards – Primary Field Daily Calibration Standard –Fill a 1 liter Tedlar bag with 5 ppbv primary field standard.

7.2 Internal/Surrogate/Tuning standard – The internal/surrogate/tuning standard mix is provided with the HAPSITE in a disposable gas cylinder. Each cylinder is prepared with bromopentafluorobenzene (BPFB) and 1,3,5-Tris (trifluoromethyl) benzene (TRIS) at approximately 5 ppbv with nitrogen as the balance gas.

7.3 Nitrogen Carrier Gas – Ultra High Purity (UHP) 99.999% or better. Either in disposable Inficon canisters or commercially provided cylinder (if HAPSITE will be used in a fixed location and large quantities are required.)

8.0 QA/QC

All reporting limits, QC frequency, and QC acceptance criteria are subject to change on a project specific basis.

8.1 The instrument is tuned using BPFB and TRIS. This is generally performed before analysis each day. The HAPSITE software runs a tuning program set to optimize its instrument parameters for analysis. This program optimizes sensitivity and enables library matching of the spectra.

8.1.1 There are short and long tune algorithms. Typically, the short tune is performed. A long tune is typically performed only after major instrument maintenance.

8.1.2 After running a successful tune (tune passes internal instrument criteria), it is saved to the default tune file.

8.1.3 The HAPSITE is not designed to pass the typical TO-15 bromofluorobenzene (BFB) tune criteria to operate at its highest potential. Therefore, BFB tune criteria are not relevant for this SOP.

8.2 Initial Calibration

An initial calibration curve is required to demonstrate adequate instrument performance for sensitivity, linearity, resolution, and absence of active sites.

8.2.1 A valid initial calibration curve must be established before samples can be analyzed. The GC/MS is calibrated following the outline below. Variations from this standard calibration scheme are sometimes necessary because of project reporting limit requirements.

8.2.2 As the reporting limit is driven by the lowest calibration point, any lowering of the RL will require either A) calibrating to a lower level of B) injection of more sample volume.

8.2.3 Calibration Schemes

The following calibration schemes have been successfully used, the actual scheme used should be tailored to the instrument and project requirements. It is based on a 1 minute sampling period (1 minutes at 100 mls/min = 100 mls)

Cal Levels (1 minute sampling time normalization)

Cal level - SIM	Std Concentration, ppbv	Sampling time, (min)	Concentration, ppbv
Level 1	0.5	0.2	0.1
Level 2	0.5	1.0	0.5
Level 3	0.5	2.0	1.0
Level 4	5.0	1.0	5.0
Level 5	5.0	5.0	25.0

8.2.4 The curve can be shifted to be more or less sensitive by increasing or decreasing the sampling time. Longer sampling time increases sensitivity, and vice versa.

8.2.5 For the initial calibration a response factor (RF) and a percent relative standard deviation (RSD) are calculated for each analyte.

8.2.6 After a new calibration is performed the method needs to be saved with the correct filename. The method name should be the date followed by an identifier. For example, an ICAL performed on October 29, 2014 for client x shall be named 102914X.

8.2.7 There must be at least 3 points to have a valid calibration curve. The lowest point must be at or below the reporting limit.

8.2.8 The %RSD for all compounds must be less than 30%.

8.2.9 If the %RSD >30%, then a linear curve fit may be used as long as the curve fit >0.995.

8.2.10 If the above requirements are not met, then a new initial calibration must be performed. If this does not result in an acceptable initial calibration then system maintenance may be necessary.

8.2.11 Calibrations are valid for one year (or until the end of the project, whichever occurs first) as long as QC continues to meet acceptance criteria.

8.2.12 In the following instances, a new calibration shall be required:

9.3.12.1 Major instrument maintenance such as cleaning the MS.

9.3.12.2 Repeated failure to pass continued calibration criteria.

8.2.13 If an analyzed sample falls above the calibrated range of the instrument, it should be diluted (if possible).

8.3 Method Blanks – method blanks are required at a rate of one per day. Method blanks are analyzed to monitor possible instrument contamination. Laboratory method blanks are prepared with UHP nitrogen in a Tedlar bag every day samples are to be analyzed. The method blank is carried through the same analytical procedure as a field sample.

8.3.1 Method blanks are analyzed by injecting the full normalized volume of nitrogen (varies by system) into the HAPSITE and following procedures outlined in section 9.

8.3.2 The blank must not contain any target analyte at a concentration greater than the RL and must not contain additional compounds with elution characteristics and mass spectral features that would interfere with identification and measurement of a method analyte. If target analytes are found in the method blank above the reporting limit, the source of the contamination must be considered. Usually, re-running the blank will resolve most problems (especially if the sample run prior to the blank was high in target analyte concentration.) If blank contamination is still present, the analyst should perform system maintenance. Some common problems that cause a blank to show contamination are:

9.6.2.1 Cold spots - check heated zones for failure.

9.6.2.2 Contaminated sample probe – flush the probe

9.6.2.3 Dirty Tedlar bag - flush and refill the bag or use new bag.

8.3.3 Note: In situations where expected concentrations are going to be significantly greater than the reporting limit and/or outdoor air, a background air sample may be substituted for nitrogen.

8.4 Continuing Calibration Verifications (CCV) – a primary source standard analyzed at the beginning of an analytical batch to ensure that the instrument continues to meet the instrument sensitivity and linearity requirements originally established by the initial calibration.

8.1 The opening calibration verification for each compound of interest shall be verified prior to sample analysis using the same introduction technique and conditions as used for samples. This is accomplished by analyzing one of the calibration standards used for initial calibration.

8.1.1 Typical concentrations for calibration verification are at or below the midpoint of the instrument calibration curve.

8.2 No closing calibration check is required for TO-15 analysis. However, if time allows, it is good practice to analyze a closing calibration check to increase confidence in data quality.

8.3 The %D for each compound may not exceed 30 percent.

8.4 Failure to pass continuing calibration criteria requires corrective action are performed. Repeated failure to pass response factor criteria requires the performance of a new initial calibration.

9.0 PROCEDURE

9.1 Startup when the HAPSITE is received:

9.1.1 Unpack the HAPSITE. It is usually shipped with the power off and the mass spec pumped down. Be sure that it has a significant amount of time (at least an hour, but overnight if possible) to warm up and equilibrate before use.

9.1.2 Insert the carrier gas (or attach external supply) and internal standard gas cylinders. Verify that the sample trap has not broken during shipment.

9.1.3 Plug the HAPSITE into an external power source. The HAPSITE has an onboard battery, but it needs to be re-charged periodically.

9.1.4 Attach the computer (turn on and start software). Then push the power button on the HAPSITE. The HAPSITE will go through a warm up routine, then a tune. When prompted for a trap clean out, press 'yes' on the HAPSITE screen.

9.1.5 Load the desired method on the HAPSITE screen and then denote this method as the default method. This is important because otherwise it will default to a different method at the end of each run and change zone temperature settings. Note: All files (method, tune, data) reside on the HAPSITE not the PC.

9.1.6 To keep data files in an orderly manner, it is recommended to create a new subdirectory each day. This can be done in the method editor (Data page)

9.2 Startup from extended standby:

9.2.1 Press power button

9.2.2 Insert internal standard and carrier gas.

9.2.3 Wait for instrument to warm up and run tune.

9.3 Analytical standards and/or diluted samples in Tedlar bags are attached to the sample probe manifold with a compression fitting. Ambient air samples are simply drawn directly into the probe. Pressurized or evacuated sample or standard sources cannot be used as they will significantly change instrument response.

9.4 Survey mode (Sniff mode)

9.4.1 Load the appropriate survey method on the HAPSITE. This can either be done from the touch screen or the PC. Be sure that the method is appropriate for the target compounds. If necessary, sensitivity can be increased by using SIM to target the most important ions of interest.

9.4.2 Once the instrument starts sampling, place the probe in the locations (cracks, drums, etc) to be sampled.

9.4.3 Record on the field log the elapsed time into the run and the location of each sampling.

9.4.4 When complete, press the stop button on either the HAPSITE screen or the PC.

9.4.5 Note: It requires about 2 ppmv of total VOCs to register a discernable change in baseline in scan mode and about 100 ppbv in SIM mode.

9.5 Quantitation mode

9.5.1 Using the method editor on the PC, verify that the desired sample time is set correctly in the method to be used for analysis. Typically this will be 1 minute, but may differ depending on project requirements or dilutions. Save the method.

9.5.2 Load the appropriate quantitation method onto the HAPSITE. This can either be done from the touch screen or the PC. Be sure that the method is appropriate for the target compounds. If necessary, sensitivity can be increased by using SIM to target the most important ions of interest

9.5.3 Run the QC (either an ICAL or CV and blank). Attach a Tedlar bag containing the standard or UHP blank gas to the sample probe. Open the bag and press run on the HAPSITE. Once QC has passed criteria then sample analysis can begin.

9.5.4 Place the probe in the location to be sampled. Press the run button on the HAPSITE. Once the desired sample time has been completed, the probe can be removed from the sampling location.

9.5.5 Once the analysis is complete, allow the GC oven to cool, then inject the next sample.

9.5.6 All of the sample and QC information for an analytical run such as lab and client sample IDs, injection volumes, standard IDs, and run methods, (etc.), are added to the field log

9.6 Sample Dilution

9.6.1 Any sample that has target analytes over the calibrated range of the instrument should be diluted if possible. The subsequent dilution should be run such that the final value of the maximum concentration analyte recovers within the calibrated range on the instrument (before dilution factors are applied).

9.6.2 Required dilutions for HAPSITE analysis can be achieved in two different ways.

9.6.2.1 Concentrator fill time: Inject a smaller sample volume. Record all dilutions in the field form. For example, normalized to a 1 minute fill time (100 mls), a dilution of 5x can be performed by only sampling for 0.2 minute (20 mls). Using the method editor on the PC, set the desired sample time in the method to be used for analysis. Save the method. Then load the appropriate quantitation method onto the HAPSITE. This can either be done from the touch screen or the PC

9.6.2.2 Tedlar bag dilution: Take a sample with a syringe and inject it into a Tedlar bag with a known volume of clean air. Attach the bag to the instrument sampling port and withdraw an aliquot. The aliquot can be less than the normalized value (as in the section before). Both the Tedlar bag dilution factor and concentrator fill injection factors are applied to the final instrument result.

9.7 At the end of the day, put the HAPSITE into external standby and remove carrier gas and ISTD if the instrument is going to be used again next day. Otherwise the HAPSITE can be powered off.

Tables

Table 1: Method Analytes (SIM Mode, 1 minute fill time)

Standard Analytes	**Reporting limit ug/m3**
1,2-DCE (cis)	2.0
1,1,1-TCA	2.8
PCE	0.69
TCE	0.55
Vinyl Chloride	1.3

*All reporting limits are subject to change on a client specified basis as requested by that client.

Hapsite Log Sheet
Quant Mode

Site ______________________

Date ______________________

Operator ______________________

SubDirectory ______________________

Location	Time	File ID	Fill Time	DF	Notes

Comments: ______________________

Hapsite Log Sheet
Sniff Mode

Site ____________________

Date ____________________

Operator ____________________

General Location ____________________

SubDirectory ____________________

File ID ____________________

Start time ____________________

Location	Time	Notes

Comments: ____________________

STANDARD OPERATING PROCEDURE

Long-Term Measurement of Subslab/Indoor Air Differential Pressure for Vapor Intrusion Investigations

Quality Management

SOP No. : PRESDIFF-LONGTERM1
Revision: 2.0
Date: 10/25/2009
Pages: 11

File Name: SOP_VI_DifferentialPressureMonitoring_Date.doc
Location: Vapor Intrusion VOC Share Point site/Key Documents/Best Practices/SOPs

Primary Contact(s): Dave MacPhaul/GNV; Kimberly Stokes/DFW

QA/QC Review: Dave MacPhaul/GNV; Jennifer Simms/PHL; Mike Bedan/DEN; Ben Thompson/CVO

Associated Internal Resources:

An Excel template of differential pressure data reduction tool is available at Vapor Intrusion VOC Share Point site/Key Vapor Intrusion Related Sources /SOPs/Building Evaluation.

Example project reports using this SOP can be found at Vapor Intrusion VOC Share Point Site/Key Vapor Intrusion Related Sources/Vapor Intrusion Practitioner (Limited Access) Site/VI Project Repository/ReportsUsingDiffPressData

STANDARD OPERATING PROCEDURE

Long-Term Measurement of Subslab/Indoor Air Differential Pressure for Vapor Intrusion Investigations

1. Background

Vapor intrusion is often driven by advective transport of air from soil to indoor air. The movement of vapors located near a building foundation is often affected within an area referred to as the "zone of influence". This zone is usually no larger than a few feet, horizontal and vertical) from the building foundation (ITRC, 2007). Contaminants in soil gas entering this zone are drawn into the building via advection (the movement of gas driven by pressure gradients) and convection (the movement of gas driven by temperature gradients) resulting from building interiors that exhibit a negative pressure or cooler temperature relative to the ambient exterior and the subsurface soil environment.

According to regulatory guidance (EPA, 2002; ITRC, 2007), this pressure differential can occur from one or more factors:

- Operation of HVAC system including inadequate makeup air and unbalanced air supply and exhaust systems;
- The use of fireplaces and other combustion sources, which results in venting of exhaust gases to the exterior;
- Exhaust fans in bathrooms and kitchens that may not be adequately balanced
- Cooler temperatures indoors relative to outdoors during the cooling season;
- Higher temperatures indoors relative to outdoors during the heating season or as a result of solar radiation on rooftops (stack effect); and
- Pressure exerted on the wall of a building caused by wind movement over the building (Bernoulli's principle).

The combination of these actions/conditions results in a net convective flow of soil gas from the subsurface through the building foundation to the building interior. Measurements can be made to evaluate the potential for convective flow of soil gas, and hence evaluate the potential for vapor intrusion into a building.

Pressure gradient measurements between the inside of the structure and the subslab can assist in interpreting subslab and indoor data and assessing the potential for migration of VOCs detected in the subslab into the indoor air. As discussed by the Interstate Technology and Regulatory Council (ITRC) Vapor Intrusion Guidance (2007), a default negative pressure of 4 Pascals (Pa) between the indoor and subslab is typically assumed, suggesting that there is always an advective flow of vapors into a structure. However, a number of presentations have been given at the U.S. Environmental Protection Agency (USEPA)-sponsored vapor intrusion workshops (http://iavi.rti.org/WorkshopsAndConferences.cfm) to support the conclusion that pressure differences between the indoor and subslab may be positive, negative, or fluctuate between the two (i.e., the building "breathes").

2. Purpose and Objectives

This Standard Operating Procedure (SOP) identifies procedures to provide data for understanding pressures differences between building interior and beneath the building slab (i.e. subslab). This SOP does not include procedures for building observation; these are covered in the Building Survey SOPs.

3. Project Specific Considerations

Pressure monitoring generally should be performed in preparation for mitigation, not in early stages of vapor intrusion evaluation. It is suggested to wait until a potential vapor intrusion pathway is identified before acquiring pressure monitoring data.

A subslab soil gas probe is necessary for performing pressure differential monitoring, if the building does not have an existing subslab soil gas probe one will have to be installed before pressure differential monitoring can be performed.

The Omniguard 4 must be plugged into an outlet, make sure there is an outlet in the building that can be used, an extension cord may be necessary.

It is necessary to periodically check on the Omniguard 4 to ensure that the unit's power has not been interrupted or that the unit has not been tampered with. If there is a power outage in the building the Omniguard 4 must be restarted.

Long-term differential pressure monitoring may be conducted concurrently with building surveys and/or subslab soil gas sampling.

Long term pressure differential monitoring should be employed to meet project-specific data quality objectives (DQOs).

When the project DQOs call for concurrent subslab soil gas sampling and differential pressure monitoring, probe utilization needs to be considered. In the event where 24 hour samples will be collected at existing subslab probes, a separate subslab probe will need to be installed and dedicated for the sole purpose of differential pressure monitoring so as not to interfere with subslab sampling.

4. Health and Safety

Standard health and safety practices should be followed when conducting long-term differential pressure monitoring. Consult your project's Health and Safety Plan.

Follow the proper operating procedures in the instruction manuals when using the required materials and equipment.

Inspect any extension cords and outlets that are to supply power to the differential pressure recorder to avoid shocks and/or power shortages. Ensure that the placement of the recorder is in a safe, out of the way area that is not in danger of encountering water or the elements.

5. Materials

5.1. Install subslab probes in accordance with CH2M HILL's SOP *Standard Operating Procedure for the Installation of Sub-Slab Probes and the Collection of Vapor Samples Using Summa® Canisters*

5.2. Omniguard 4 differential pressure recorder with data logger (http://www.engsolinc.com/docs/og/OG4broch.pdf).

5.3. Barometric data logger (Solinst http://www.solinst.com/Downloads/3001/3001Manual/Introduction/Barologger.html)

5.4. Hand-held digital micromanometer (TEC DG500 or equivalent http://www.energyconservatory.com/download/dg500brochure.pdf) and Tygon tubing (optional)

5.5. An extension cord to connect the Omniguard 4 to an outlet.

5.6. Equipment to connect the Omniguard 4 to the subslab soil gas probe

5.6.1. Swagelok stainless steel gas tight fittings including a nut and ferrule set (SS-400-NFSET) and a sampling union (SS-400-1-2)

5.6.2. ¼" O.D. Teflon tubing and larger diameter flexible tubing

5.6.3. Hand tools including a 9/16" wrench and an adjustable wrench

6. Field Procedures

6.1. Differential pressure data logging (using the Omniguard 4differential pressure recorder) is performed at one or more locations within the building (typically a single centrally-located location).

6.2. An existing subslab soil gas probe can be used for these measurements (see Section 3.0); if needed, install and leak-test a subslab soil gas probe using the subslab probe installation SOP.

6.3. Set up the differential pressure recorder in accordance with the manufacturer's instructions. See Section 6.3.1 for quick startup notes

6.3.1. Omniguard 4 - Quick Startup Notes

(1) Download OmniGuard 4 CD software onto a laptop computer.

(2) Attach Teflon tubing from subslab probe to inlet port #2 (reference). Inlet port #1 will remain open to indoor air. The tubing can be connected directly to the port if the diameter of the tubing allows; if not, utilize the flexible tubing to affix the Teflon tubing onto the inlet port.

(3) Turn on the unit. Use the [MENU] button to bring up the unit settings list. Set the Date and Time and press SAVE. Set the data unit setting to pascals [Pa] and press SAVE. Set the Alarm Range from +62 Pa to -62 Pa and press Save. Set the Log Rate for every 5 minutes and Alarm Rate for every 5 seconds and press

SAVE; this should be a default when you scroll to that menu item. Set the Contractor Name and press SAVE, if necessary.

(4) Begin the pressure readings by pressing the [Start Job] button. The Job Name option will appear on the display. The Job number can be changed using the up/down arrows and press SAVE.

(5) If the unit is set up for multiple days in a public, commonly used area and cannot be monitored in person, the audible alarm can be disabled by pressing the [Alarm Silence] button on the keypad of the unit. The printer can also be disabled by pressing the [Printer On/Off] button on the keypad of the unit. The readings will continue to be logged on the hard drive of the unit.

6.4. Allow the pressure monitor to operate for a minimum of three to five days with a recommended duration of seven days. It is necessary to periodically check on the Omniguard 4 to ensure that the unit's power has not been interrupted or that the unit has not been tampered with. If there is a power outage in the building the Omniguard 4 must be restarted.

6.5. Indoor barometric pressure logging should also be performed during the same period as differential pressure logging. Follow the manufacturer's instructions for operation of the Solinst barometric pressure logger. See Section 6.5.1 for quick startup notes

6.5.1. Barologger Gold - Quick Startup Notes

(1) Download Levelogger CD software onto a laptop computer.

(2) Plug the USB cable into the PC before turning on the computer and opening the Levelogger software.

(3) Open Levelogger software and press [Retrieve Settings from Levelogger] to connect Barologger unit to the PC.

If an error code appears [Files Needed], the USB driver needs to be updated.

a. Go through configuration:

Start Menu> right-click My Computer>Properties>Hardware>Device Manager>expand list of Universal Serial Bus (USB) controllers

(1) Look for USB driver that has a yellow exclamation point

Right-click this driver>click Update Driver>Wizard will appear and choose Install from a List or Specific Location>Search>Check Include this location in the search>Browse C: drive>Program Files>Solinst/Levelogger 3.0>USB Drivers>winxp>click OK

If an error code appears [-200 Communication Time Out! Check COM Port], the correct USB port needs to be configured.

a. Go through System Configuration:

Start>right-click My Computer>Properties>Hardware>Device Manager>Ports (COM &LPT)

(2) If USB Port is listed under the Ports(COM &LPT) folder, choose USB port number in COM Port Selection drop down menu in Levelogger software startup Page

(3) If USB Port is not listed under the Ports (COM &LPT) folder, unplug the USB cable and re-plug. The new hardware wizard should appear.

(4) Once the Levelogger is synched to the computer in use, the settings may be changed to make them project specific. The project ID, location, and site's altitude (previously researched) should be entered.

(5) At this point the data logging mode needs to be set by choosing either [Slate Logging Mode] or [Continuous Logging Mode]

  i. Slate Logging Mode – collects data for 30 days straight and will stop recording data when the memory is full (preferred)

  ii. Continuous Logging Mode – collects data for as long as the Barologger is allowed to run; once the memory is full, the records will begin to write over the original files.

(6) Synchronize the time of the Barologger to real-time on using the drop-down menu on the right side of the screen by choosing either [System Time] or [to]

  i. System time – synchronizes to computer time in use (preferred)

  ii. To – synchronizes to a pre-set time in the future

(7) It is preferable to synch the OmniGuard 4 and Barologger log times for ease of data analysis.

(8) Once the settings are chosen, select [Program Settings from Levelogger] to connect the PC settings with the Barologger.

(9) Select [Start the Levelogger] green arrow on the top of the screen.

  i. Note: The barometric pressure readings will be collected in feet or meters and will then need to be converted to inches (inches of water column) for data analysis.

(10) The Barologger can now be disconnected from the USB cable and set inside or next to the OmniGuard 4 data recorder box.

6.5.2. After pressure monitoring is complete, download the differential pressure log and the indoor barometric pressure log to a personal computer for data reduction. See section 6.5.2.1 for quick download notes. Data reduction is discussed below.

6.5.2.1. OmniGuard 4 data download:

  i. Connect the OmniGuard 4 unit to the PC with the USB cable.

ii. Select [Receive Current Job Log] or [Receive All Job Logs] under [Job Logs] in the OmniGuard 4 menu

iii. When uploading is complete, the log will be displayed in the box on the left side of the window. If the data appears to be valid, reports will be generated and the first one will be displayed in the right side of the window.

iv. Select the [Save Current Report] as a .txt file. This file can be opened in Notepad program and then copied into Excel for data manipulation.

6.5.2.2. Barologger data download:

v. Connect the Barlogger to the PC with the USB cable.

vi. Select [Stop the Levelogger] red arrow.

vii. Select the [Date Control] tab and select the red arrow [Download Data from Levelogger]

viii. The log will appear in the left side of the screen and a tabular and graphical view of the data will appear in the right side of the screen.

ix. Select [Save As] (floppy disk icon) to save the data as a .lev file. This file can be opened in Excel for data manipulation.

6.6. At a minimum, the following data should be collected:

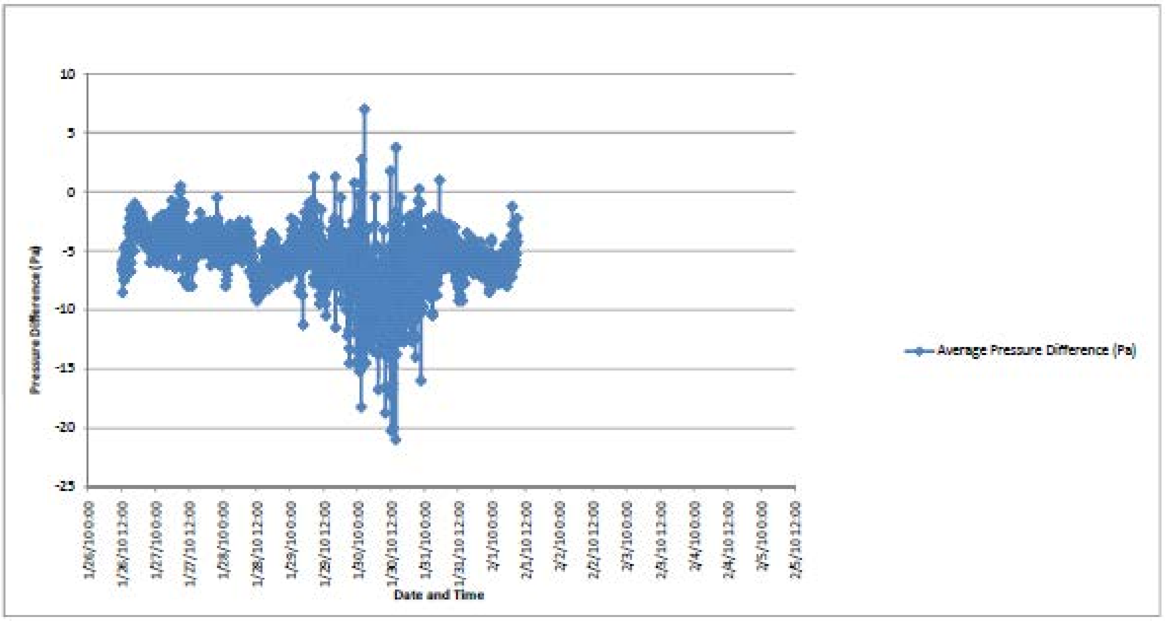
Operator Name
Equipment Used
Date
Time
Maximum Differential Pressure (Pa)
Note: May be reported in mm Water Column (WC) or inches WC. PA = inches WC*0.036*6895
Minimum Differential Pressure (Pa)
Barometric Press Level (in) (optional, recommended)
Temperature (Deg C) (optional, recommended)

(*Optional*). Due to cost and schedule constraints, long-term differential pressure monitoring generally can be completed only at a limited number of locations (typically, one location). If there is a concern about spatial variation in pressure measurements in large buildings, and if multiple subslab probes have been installed, "snapshot" pressure measurements can be made at these locations using a hand-held digital micromanometer. The date, time and location of these measurements should be recorded on a data form or field notebook, for comparison with the integrated differential pressure measurements. See the Building Survey SOP for additional information on using the hand-held digital micromanometer.

7. Data Reduction and Evaluation

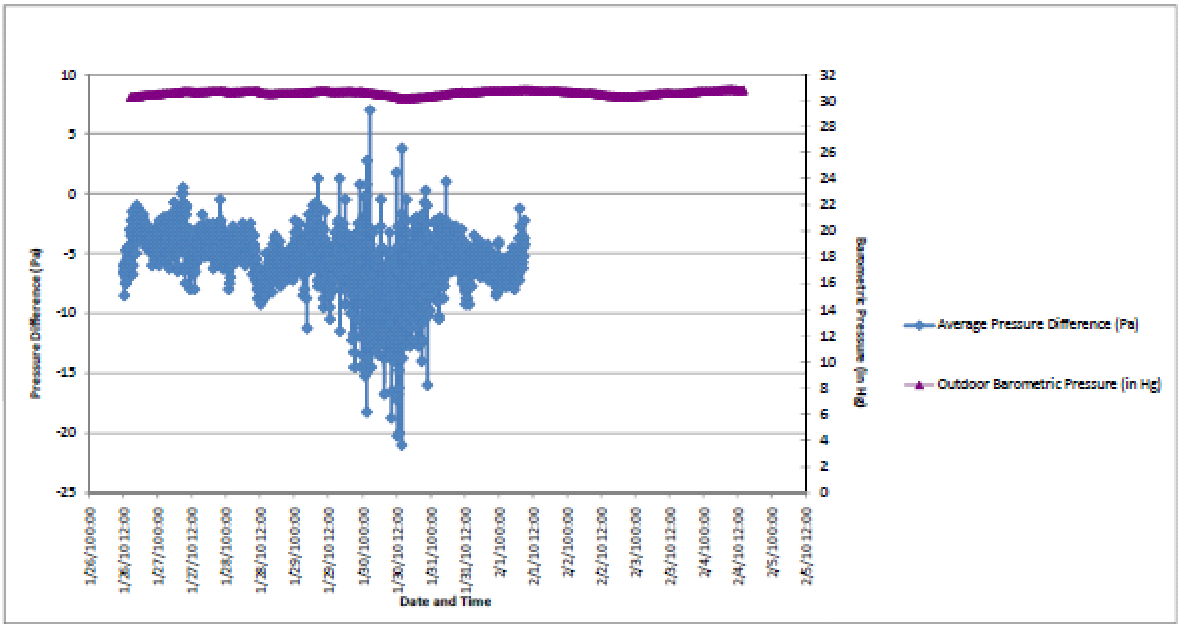
7.1. Differential pressure measurements and barometric pressure measurements should be exported to Microsoft Excel or similar software application for generating tables and plots.

7.2. Minimum and maximum pressure measurements averaged at each time stamp should be plotted against time. An example of a data plot is presented below:



7.3. In addition, the individual measurements can be averaged over a specified time period (for example, a 9-hour work shift) to estimate a longer-period average pressure difference. The longer-term average value can then be used to determine if, overall, a building is positively pressurized (hence vapor resistant) or negatively pressurized (hence prone to vapor intrusion). These measurements can then be used to identify "worst-case" time periods for collecting indoor air samples. It may be useful to collect subslab samples for analysis of volatile organic compounds under rising or falling pressure conditions, in order to better understand spatial and temporal variability in subslab concentrations.

7.4. The plot of pressure differences also can be overlain on barometric pressure measurements as shown below, to observe the effects of atmospheric conditions on potential vapor intrusion pathways:



There are no regulatory screening levels for interpreting differential pressure measurements. However, long-term average pressure differences between indoor air and subslab can be interpreted using EPA guidance for radon mitigation (EPA, 1993). Subslab depressurization systems for radon mitigation are designed to achieve a 6 to 9 Pa pressure difference between the subsurface and indoors. This represents the pressure difference needed to prevent soil gas intrusion into a structure where indoor pressures are governed by heating and the operation of appliances or fans. A matrix outlining the levels used to interpret pressure measurements is presented in Table 1. The need for further investigation of the potential vapor intrusion pathway can be assessed based on the magnitude and direction of the pressure measurements (i.e. positive relative to outdoors, or negative relative to outdoors).

Table 1
Suggested Interpretation of Pressure Level Measurements

Condition	Description	Comments	Possible Outcome
Positively Pressurized	Consistent pressure measurements of > 6 to 9 Pa relative to outdoors or subsurface.	Based on the pressure difference needed to prevent soil gas intrusion in a structure with combined heating and appliance or fan operation effects (0.025 to 0.035 in water, based on USEPA, 1993).	No apparent driver for vapor intrusion pathway. Further investigation may not be needed
Neutral to Positively Pressurized	Consistent pressure measurements of <2 to 5 Pa relative to outdoors or subsurface. OR Highly variable pressure measurements typically greater than zero.	Minimum acceptable pressure difference needed to prevent in a structure with either heating effects OR appliance/fan effects (0.01 to 0.02 in water, based on USEPA, 1993).	Potential transient (intermittent) driver for vapor intrusion pathway may be present. Further investigation may be warranted to identify a potential source for vapor intrusion (i.e. groundwater sampling).
Neutral to Negatively Pressurized	Consistent pressure measurements of -5 to <2 Pa relative to outdoors or subsurface. OR Highly variable pressure measurements <5 Pa	Range of depressurization that could occur either from heating effects OR appliance/fan effects (0.01 to 0.02 in water, based on USEPA, 1993).	Potential transient (intermittent) driver for vapor intrusion pathway may be present. Further investigation may be warranted to identify a potential source and transport pathways for vapor intrusion (i.e. groundwater and near slab sampling).
Negatively Pressurized	Consistent pressure measurements of > -6 to -9 Pa relative to outdoors or subsurface.	Range of depressurization that could occur from heating effects and appliance/fan effects (0.025 to 0.035 in water, based on USEPA, 1993).	Potential driver for vapor intrusion pathway. Further investigation may be warranted. Consideration may need to be given to sub slab and/or indoor air sampling.

Note: 1 Pa = 0.004 inches of water

Table Adapted from U.S. Environmental Protection Agency (USEPA). 1993. *Radon Reduction Techniques for Existing Detached Houses. Technical Guidance (Third Edition) for Active Soil Depressurization Systems.* EPA/625/R-03/011.

8. Quality Control

Follow operating procedures in the instruction manuals when using the required materials and equipment.

Ensure there is a tight seal between the Teflon tubing and the flexible tubing.

Periodically check on long-term pressure measurement equipment (i.e. Omniguard 4) to ensure that the unit's power has not been interrupted or that the unit has not been tampered with.

9. References

Interstate Technology Regulatory Council (ITRC). 2007. *Vapor Intrusion Pathway: A Practical Guideline.* VI-1. Washington, D.C. ITRC Vapor Intrusion Team. January. www.itrcweb.org.

U.S. Environmental Protection Agency (EPA). 1993. *Radon Reduction Techniques for Existing Detached Houses. Technical Guidance (Third Edition) for Active Soil Depressurization Systems.* EPA/625/R-03/011.

U.S. Environmental Protection Agency (EPA). 2002. *OSWER Guidance fir Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance).* November.

Appendix B
Field Data Collection Forms

Structure Sampling Questionnaire and Building Inventory

New York State Department of Environmental Conservation

Site Name: ESSEX-HOPE JAMESTOWN Site Code: 907015 Operable Unit:

Building Code: Building Name: CUSTOM PRODUCTION MANUFACTURING (CPM)

Address: 125 BLACKSTONE AVENUE Apt/Suite No:

City: JAMESTOWN State: NY Zip: 14701 County: Chautauqua

Contact Information

Preparer's Name: THOMAS URBAN Phone No: (716) 923-1128

Preparer's Affiliation: URS CORPORATION Company Code:

Purpose of Investigation: VAPOR INTRUSION SAMPLING Date of Inspection: Mar 25, 2014

Contact Name: CHESTER VAN ARSDALE Affiliation: MANAGER

Phone No: (716) 665-3515 Alt. Phone No: Email:

Number of Occupants (total): 3 Number of Children: 0

☒ Occupant Interviewed? ☐ Owner Occupied? ☐ Owner Interviewed?

Owner Name (if different): CARLO MONTISANO Owner Phone: (732) 450-2488

Owner Mailing Address: 20 THOMAS AVENUE SHREWSBURY NJ 07702

Building Details

Bldg Type (Res/Com/Ind/Mixed): INDUSTRIAL Bldg Size (S/M/L): LARGE

If Commercial or Industrial Facility, Select Operations: MANUFACTURING

If Residential Select Structure Type:

Number of Floors: 2 Approx. Year Construction: 1950 ☒ Building Insulated? ☐ Attached Garage?

Describe Overall Building 'Tightness' and Airflows(e.g., results of smoke tests):

SOMEWHAT TIGHT - DRAFTS AROUND OVERHEAD DOORS AND WINDOWS. AIR FLOWS FREELY FROM FIRST AND SECOND FLOORS, DUE TO "OPEN" NATURE OF CONSTRUCTION.

Foundation Description

Foundation Type: NO BASEMENT/SLAB Foundation Depth (bgs): 0 Unit: FEET

Foundation Floor Material: POURED CONCRETE Foundation Floor Thickness: 6 Unit: INCHES

Foundation Wall Material: CONCRETE BLOCK Foundation Wall Thickness:

☒ Floor penetrations? Describe Floor Penetrations: CRACKS THROUGHOUT SLAB

☐ Wall penetrations? Describe Wall Penetrations:

Basement is: Basement is: ☐ Sumps/Drains? Water In Sump?:

Describe Foundation Condition (cracks, seepage, etc.) : LARGE DUG PIT IN NW CORNER NEAR MAIN ENTRANCE

☐ Radon Mitigation System Installed? ☐ VOC Mitigation System Installed? ☐ Mitigation System On?

Heating/Cooling/Ventilation Systems

Heating System: OTHER Heat Fuel Type: GAS ☐ Central A/C Present?

Vented Appliances

Water Heater Fuel Type: ELECTRIC Clothes Dryer Fuel Type:

Water Htr Vent Location: Dryer Vent Location: