

**SURVEY OF AIRBORNE BENZENE AND  
OTHER VOLATILE ORGANIC COMPOUNDS  
AT THE QUINTE MOHAWK SCHOOL**

Phoenix OHC Ref. No.: 6015  
Dec 5, 2012

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OTHER VOLATILE ORGANIC COMPOUNDS  
AT THE QUINTE MOHAWK SCHOOL**

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ON: December 5, 2012  
REFERENCE NO: 6015

**SUMMARY**

A survey of airborne benzene and other volatile organic compounds (VOC) was conducted on December 5, 2012, at the Quinte Mohawk School. Air sampling was conducted at 1 outdoor and 8 indoor locations following an EPA method. Each of the 9 samples was analyzed for benzene, and 4 samples were additionally “scanned” by an open characterization method using gas chromatography/mass spectroscopy to identify the compounds present in highest concentration.

The individual VOC compounds detected by this method were found in low airborne concentrations, and generally below conservative indoor air quality guidelines. Levels of the total VOC mixtures (TVOC) were also below an often cited office air quality guideline, but in two locations were higher than the lowest target level proposed for “healthy schools”, indicative of a potential for irritative effects among some occupants.

Airborne benzene levels were low. The calculated incremental lifetime cancer risk from occupying the school 8 hours per day was less than 1 in 100,000 and in the range considered to represent negligible incremental risk by Health Canada.

## INTRODUCTION

At the request of the Mohawks of the Bay of Quinte, a survey of airborne benzene and other volatile organic compounds (VOC) was conducted on December 5, 2012, at the Quinte Mohawk School. A low level of benzene was reported to be present in the groundwater, which is pumped to a reservoir located in a mechanical room (Rm 26) at the school.

The school is a single storey structure that includes 13 classrooms, a gym, library, computer lab and a daycare centre. There have been no recent renovations reported, apart from the construction of particle board storage cabinets on the auditorium stage (July 2012) and the painting of a decorative mural, approximately 70 ft by 8 ft in dimension, located near the front entrance (September 2012).

A 1 hour morning survey was conducted, commencing at 9 am, representing realistic occupied conditions, but worst-case in terms of temperature differential between the indoor and outdoor environment (potentially maximizing the migration of benzene and other VOC from ground sources). The school would also have been closed-up for more than 12 hours prior to the sampling, other than the normal opening of doors when staff and children entered the building at the start of day. The school and daycare centre are in session from 08:45 to 15:15 hr with a first break/recess from 10:28 to 11:08.

Air sampling was conducted at 8 locations distributed throughout the school, as well as at 1 outdoor (upwind) location. Indoor locations included a kindergarten, 5 other classrooms, the daycare and the mechanical room (Rm 26). The monitored classrooms were “home rooms” where students remain for a majority of the school day (excluding gym class and recess/break periods).

All 9 air samples were analyzed for benzene, 4 of these samples (3 indoor and 1 outdoor) were also evaluated by an open characterization method to identify the specific compounds present in highest concentration. Total VOC results were also determined, representing a summation of all of the detected compounds.

## **METHODS**

Air sampling was conducted by EPA method TO-17, involving collection on thermal desorption tubes and analysis by gas chromatography/mass spectroscopy (GC/MS). Air was drawn into the tubes by means of constant flow sampling pumps, calibrated before and after the survey with a primary standard. The samplers were positioned on tripods, 3½ feet above the floor (breathing height for a seated person). Analyses were performed at Cassen Testing Laboratories, an AIHA and ISO 17025 accredited laboratory located in Etobicoke, Ontario.

All samples were quantitatively analysed for benzene. Three indoor and 1 outdoor samples were additionally “scanned” for other individual chemicals present in highest concentration (tentatively identified according to the best mass spectral match). A field blank (control sample) was also collected and analysed in the same manner, except that no air was drawn through it. For the scanned samples, a total VOC level was also determined by a summation of the semi-quantitative concentrations of all VOC peaks in the chromatograms. The results depend on the response of each individual VOC compared to selected reference compounds.

The air sampling was conducted for 1 hour at the start of the school day, with sampler start times ranging from 9:00 to 9:40 am.

## **OBSERVATIONS**

Hand sanitiser solutions and disinfectant wipes were present in each of the monitored classrooms. Arts and craft supplies were also commonly observed, but most notably in the daycare centre. Numerous solvent-based paints, cleaning products and other facility maintenance products were observed in the storeroom, daycare mechanical room and laundry room, all located within the daycare centre. None of these products were observed to be in use during the survey.

Vinyl tile flooring was present in all monitored classrooms and the daycare centre. The mechanical room had a concrete floor.

## RESULTS

The VOC results are reported in Table 1 and the airborne benzene levels are shown separately in Table 2. In each table the results are compared to indoor and outdoor air quality guidelines. Certificates of analysis are also appended.

At the time of the sampling, the outdoor temperature was 2 °C, the relative humidity was 55% and winds were from the northwest at 5 to 8 kph. It was cloudy, with no precipitation. Barometric pressure was 102 kPa. The indoor temperature was 20 °C in the mechanical room and 21 to 22 °C in the classrooms.

**Table 1. Volatile Organic Compounds Detected at Quinte Mohawk School, Dec. 5, 2012**

Airborne Compound (Tentative ID)	Airborne Concentration ( $\mu\text{g}/\text{m}^3$ )				Guideline Limits	
	Kindergarten (Room 41)	Daycare	Room 28	Outdoor	1/100 TLV ( $\mu\text{g}/\text{m}^3$ )	AAQC ( $\mu\text{g}/\text{m}^3$ )
Decamethylcyclopentasiloxane	110	100	13	-	-	-
Ethanol	43	75	5	1	19,000	19,000 (O)
2-Butoxyethanol	2	38	-	-	970	2,400 (H)
Propene + Propane	5	37	-	-	8,600	4,000 (H)
Pentane	12	28	3	3	17,700	-
D-Limonene	27	17	9	-	1,670 (W)	-
Acetic acid	12	26	2	-	250	2,500 (O)
Acetone	12	24	6	1	12,000	11,880 (H)
Isopropyl Alcohol	16	6	1	-	4,900	7,300 (H)
1,1-Dichloro-1-fluoroethane	-	15	1	1	-	-
Propanoic acid, 2-methyl-, 3-hydroxy-2,4,4-trimethylpentyl ester	13	-	1	-	-	-
1-Propanol	7	11	-	-	2,500	16,000 (H)
2,2,4-Trimethyl-1,3-pentanediol diisobutyrate	10	4	-	-	-	-
Dichlorodifluoromethane	5	9	7	10	50,000	500,000 (H)
Cyclohexasiloxane, dodecamethyl-	9	5	1	-	-	-
Isobutylene (1-Propene, 2-methyl-)	-	7	-	-	5,700	-
1-Butoxy-2-propanol	-	7	-	-	-	3,300 (H)
Octamethylcyclotetrasiloxane	7	5	1	< 1	-	-
Acetaldehyde	-	6	2	1	450 (C)	500 (H)
Tetradecane	5	6	1	1	-	-
2-Methylbutane	-	5	1	2	17,700	-
Decanal	5	-	-	< 1	-	-
Dodecane	-	-	5	-	-	-
2,6,10-Trimethyldodecane	4	5	-	-	-	-
Nonanal	4	5	1	1	-	-
Trichloromonofluoromethane	3	5	3	7	56,000	6,000 (H)
2-Methyl-1,3-butadiene,	5	4	3	-	-	-
1-Butanol	-	4	-	-	600	920 (H)
2-Ethylhexylbenzoate	2	4	-	-	-	-
1-Ethyl-2-methyl-benzene	-	4	-	-	-	-
Carbon Tetrachloride	4	4	2	4	320	2.4 (H)
Hexanal	4	4	2	-	-	-
Pentadecane	4	4	-	2	-	-
Diethyl Phthalate	3	-	-	-	50	125 (H)
Tridecane	3	-	-	1	-	-
3-Methyltetradecane,	3	-	-	-	-	-
5,8-Diethyldodecane,	3	-	-	-	-	-
Cyclohexane, (1,2-dimethylpropyl)-	3	-	-	-	-	-
4,6-Dimethyldodecane,	3	-	-	-	-	-
1,2,4-Trimethylbenzene,	-	3	-	-	1,200	220 (H)
1,1,2-Trichloro-1,2,2-trifluoroethane	-	-	1	3	77,000	800,000 (H)

Airborne Compound (Tentative ID)	Airborne Concentration ( $\mu\text{g}/\text{m}^3$ )				Guideline Limits	
	Kindergarten (Room 41)	Daycare	Room 28	Outdoor	1/100 TLV ( $\mu\text{g}/\text{m}^3$ )	AAQC ( $\mu\text{g}/\text{m}^3$ )
2-Ethyl-1-hexanol,	-	-	3	-	-	600 (O)
Decane	-	2	-	-	-	60,000 (H&O)
Ethyl Acetate	-	2	<1	-	14,000	19,000 (O)
Hexadecane	-	2	-	1	-	-
Methylene Chloride	-	2	-	1	1,700	220 (H)
2-Methylpropanal	2	-	-	-	-	-
2,6-Dimethylundecane	2	-	-	-	-	-
4-Ethylundecane	2	-	-	-	-	-
1,1-Dimethyl-2-propyl- cyclohexane	2	-	-	-	-	-
Tetrachloroethylene	-	-	2	-	1,700	360 (H)
Toluene	-	-	1	< 1	750	2,000 (O)
Phenol	-	-	1	< 1	190	30 (H)
Pentanal (n-Valeraldehyde)	-	-	1	-	1,800	-
Cyclohexane	-	-	1	< 1	3,400	6,100 (H)
1-Octene	-	-	1	-	-	50,000 (H)
Butanal	-	-	1	-	-	-
Octanal	-	-	1	< 1	-	-
Pentafluoroethane	-	-	-	1	-	-
9-Methylheptadecane	-	-	-	1	-	-
Camphene	-	-	-	< 1	-	-
alpha-Pinene	-	-	-	< 1	1,100	-
Methylcyclopentane	-	-	-	< 1	-	-
Ethylbenzene	-	-	-	< 1	870	1,000 (H)
Styrene	-	-	-	< 1	850	400 (H)
Benzaldehyde	-	-	-	< 1	170 (ON)	-
Acrolein	-	-	-	< 1	2 (C)	0.4 (H)
Xylenes	-	-	-	< 1	4,300	730 (H)
Hexane	-	-	-	< 1	1,800	2,500 (H)
2-Ethylhexanoic acid	-	-	-	< 1	50	-
3-Methylhexane	-	-	-	< 1	-	-
Biphenyl	-	-	< 1	-	13	60 (O)
Cyclohexanone	-	-	< 1	-	800	-
alpha-p-Dimethylstyrene (p- Cymenene)	-	-	< 1	-	-	-
TVOC	600	570	99	48	*	*

TLV: Threshold Limit Value published by the American Conference of Governmental Industrial Hygienists (ACGIH)

AAQC: Ambient Air Quality Criteria (24 hr) published by the Ontario Ministry of Environment .

(H) based on health effect (O) based on odour (C): ceiling exposure limit

(W): denotes 1/100th of AIHA WEEL guideline (used where TLV and AAQS are not available)

ON: denotes 1/100th of O. Reg 833 occupational exposure limit (used where TLV and AAQS are not available)

TVOC: Total volatile organic compounds

\* There are no TLVs or AAQC for TVOC levels. Health Canada has cited a guideline of  $1,000 \mu\text{g}/\text{m}^3$  for offices. An ideal limit/goal for healthy schools of  $200 \mu\text{g}/\text{m}^3$  is cited by some groups such as Greenguard in the USA, likely based on the lowest value reported in the scientific literature for irritative effects (see discussion).



**Table 2. Airborne Benzene Levels Sampled at Quinte Mohawk School, Dec. 5, 2012**

Sampled Location	Airborne Benzene Concentration ( $\mu\text{g}/\text{m}^3$ )
Room 32 (Classroom)	0.2
Mechanical Room (Rm 26)	0.4
Room 30 (Classroom)	0.2
Room 7 (Classroom)	0.5
Room 10 (Classroom)	0.3
Kindergarten (Rm 41)	0.6
Daycare (Front activity room)	2.9
Room 28 (Classroom)	1.3
Outdoor (40 ft NW / upwind of school)	2.1
<b>Guideline Limits</b>  <div style="text-align: right;"> <b>1/100 TLV:</b>  <b>AAQS:</b> </div>	  <div style="text-align: center;"> 16.0  2.3 </div>

## DISCUSSION

### **Volatile Organic Compounds and Exposure Guidelines**

The term volatile organic compounds (VOC) refers to the complex mixture of gases and vapours present due to off-gassing from building materials, furnishings, procedures / processes, as well as from the people themselves (e.g. exhaled compounds, shampoo fragrance etc.).

An “open characterization” of the specific VOCs present in highest concentration was conducted at 3 locations within the school and daycare, as well as at one outdoor location. The total VOC level, (TVOC) representing the sum of all individual VOC, was also determined for these locations. The results are shown in Table 1.

There are no widely accepted limits that can be applied in the school setting, but two commonly cited guidelines are provided for each compound, where available. Some advocates for healthier schools, such as Greenguard Environmental Institute in the USA propose using 1/100th of the threshold limit values (TLVs<sup>®</sup>) published by the American Conference of Governmental Hygienists (ACGIH<sup>®</sup>).

TLVs are the most widely recognized occupational exposure limits based on current scientific information. The TLV concept is based on there being a threshold level of exposure, below which the health effect of concern is unlikely to occur in the working population. It is well documented that children can be more susceptible to chemical exposures than adults, such that lower exposure limits are needed. Using TLVs reduced by 100, as guidelines for children, is an arbitrary approach that is not well founded in health science. Nevertheless, these are “starting points” for providing perspective to the air sampling results in schools and are provided here for reference purposes.

The other guideline limits shown in the table are Ambient Air Quality Criteria (AAQC) published by the Ontario Ministry of Environment. An AAQC is defined as “a desirable concentration of a contaminant in air, based on protection against adverse effects on health or the environment”. They are used for environmental assessments in communities, including children, as well as the sick and elderly. Different limits for different averaging times are available for some compounds (e.g. 10 min, 30 min, 1 hour, 24 hour and annual). For this study the 24 hour AAQCs are shown (where available),

which may result in some overestimation of the risk if the school occupants are only exposed for 8 hours of the day.

For TVOC limits, ASHRAE had proposed a target concentration of 1,000  $\mu\text{g}/\text{m}^3$  for office buildings which was never adopted, but continues to be applied as an indoor air quality guideline in the absence of a more definitive limit. This level is also cited in Health Canada's Indoor Air Quality in Office Buildings: A Technical Guide (1995). There is also a European Collaborative Action (ECA) Report 11 (with recommendations based on a Danish researcher's 1990 model) suggesting possible irritative effects at TVOC levels as low as 200  $\mu\text{g}/\text{m}^3$  (when additional conditions, such as dry air, are present), but more commonly occurring at levels above 3,000  $\mu\text{g}/\text{m}^3$ . Some groups, such as Greenguard, propose using 200  $\mu\text{g}/\text{m}^3$  as a TVOC guideline for schools, although this level can be challenging to achieve.

Lastly, an outdoor air sample was collected upwind of the school for comparative purposes. Any contaminant found indoors at the same or lower concentration than is determined outdoors, is not considered to have a significant indoor source.

### **Outdoor VOC**

The outdoor air sample contained many VOCs in low concentrations. Some of these were hydrocarbons associated with vehicle or heating emissions. There were also ozone depleting substances, which despite their banned or restricted use, remain persistent in the environment (e.g. off-gassing from soil and groundwater). These included two chlorofluorocarbons, as well as carbon tetrachloride, which was most notable, since the sampled 4  $\mu\text{g}/\text{m}^3$  level exceeded the AAQC of 2.4  $\mu\text{g}/\text{m}^3$ .

Background levels of carbon tetrachloride in outdoor air have been reported to typically range from 0.34 to 1.02  $\mu\text{g}/\text{m}^3$ , and in a survey of homes in Windsor during the summer of 2005, indoor air concentrations ranged from 0.24 to 7.30  $\mu\text{g}/\text{m}^3$  (Heath Canada 2009)<sup>1</sup>.

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<sup>1</sup> Health Canada (2009) Carbon Tetrachloride in Drinking Water: Document for Public Comment.

The same and lower concentrations of carbon tetrachloride were sampled indoors at the school (2 to 4  $\mu\text{g}/\text{m}^3$ , Table 1), but since outdoor air appears to be the source, no incremental risk from this compound can be associated with spending time indoors at the school.

### **Indoor VOC**

The other Table 1 compounds detected in the indoor air were all present at levels below the corresponding AAQC and 1/100 TLVs, where available. Therefore, the health risk from the individual compounds is considered low. Some discussion of specific compounds found in highest concentration and the differences between rooms is provided below for interest, and as a means for identifying possible sources that could be minimized, should there be a desire to further reduce VOC levels.

The compound found in highest concentration in all 3 indoor air samples was decamethylcyclopentasiloxane. This compound is commonly used in skin lotions, cosmetics and hair spray, as well as in silicone adhesives, sealant material and carpet. It is often found with ethanol in personal care products and d-limonene in cleaning products. These other 2 compounds were also among the top 10, by concentration, in the indoor air. Ethanol is also a primary ingredient in many hand sanitisers, as may be isopropyl alcohol and 1-propanol (detected in the samples). All three alcohols can have numerous other sources including other antiseptics, personal care products, cleaning products and paints.

Total VOC levels were highest in the kindergarten and daycare (600 and 570  $\mu\text{g}/\text{m}^3$ ) where they were also higher than the ideal guideline of 200  $\mu\text{g}/\text{m}^3$ , but below ASHRAE's proposed value of 1,000  $\mu\text{g}/\text{m}^3$ . The TVOC level in the other evaluated classroom (Room 28) was much lower (99  $\mu\text{g}/\text{m}^3$ ).

Higher TVOC levels in the kindergarten and daycare may relate to more arts and craft-type activities (including off-gassing from stored products), as well as textiles and plastic play items used at these age levels. The daycare centre was also observed to have many stored cleaning and maintenance products in several locked rooms (storeroom, laundry and mechanical room), including spray adhesive, spray paint, cans of oil-based and acrylic paints, disinfectants and a wide variety of cleaning products. This may account for the higher airborne concentrations of certain compounds sampled in the daycare,

including: 2-butoxyethanol and 1-butoxy-2-propanol (found in paints, varnishes and many cleaning products), pentane (found in aerosol paints), acetic acid (found in paints, sealants and cleaning products) and acetone (found in lacquers, thinners, adhesives and cleaning products).

There were also a number of compounds (in very low concentrations) more often associated with exhaust from vehicles and/or heating systems, including propene, isobutylene and acetaldehyde.

The evaluated kindergarten, Room 41, had a similar total VOC result to the daycare but with some differences in composition. The air sample contained an ester (propanoic acid, 2-methyl-, 3-hydroxy-2,4,4-trimethylpentyl ester) commonly found in latex paint. There were also numerous heavier molecular weight aliphatic hydrocarbons ( $C_{12}$  to  $C_{14}$  range) which can be emitted from adhesives used with vinyl flooring. Diethyl phthalate was also present here but not in the other samples. This compound is a plasticiser which can off-gas from plastics.

VOC in Room 28 was unremarkable, as compared to the other rooms, and the TVOC level was quite low, at  $99 \mu\text{g}/\text{m}^3$ .

While TVOC results are one way in which effects of the overall mixture can be anticipated, mixture exposure levels can also be calculated for chemicals which may exert similar and additive health effects. Mixture exposures were considered in the context of the results and all values were below the  $1/100 \text{ TLV}_{\text{mix}}$ .<sup>2</sup>

### **Airborne Benzene**

The airborne benzene results are presented separately in Table 2. Benzene was included as a compound of interest in the VOC scans (reported above) but also sampled and analysed separately at 5 additional locations. Benzene is the only known human carcinogen among the volatile compounds sampled during this survey. The cancer of concern is leukemia.

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<sup>2</sup> A mixture level (ML) is considered when chemical agents exert additive health effects. It is calculated as the sum of the airborne concentration (C) of each chemical divided by its corresponding exposure limit (EL):

$$\text{ML} = \frac{C_1}{\text{EL}_1} + \frac{C_2}{\text{EL}_2} + \dots + \frac{C_n}{\text{EL}_n}$$

The result must not exceed 1.

Low levels of benzene are present in the environment. Cigarette smoking and second hand smoke are the greatest direct sources of benzene exposure in the general population. For the non-smokers, the main source of exposure has typically been the outdoor air. Benzene enters the air from combustion of fuels (including gasoline, diesel and wood), as well as through evaporation from petroleum products, for example at fuelling stations, and from contaminated soil and groundwater. Increases above the outdoor level will occur in homes and other buildings. Vehicle exhaust and fuel evaporation from attached garages have been identified as significant contributors to indoor levels. Small amounts can also off-gas from many oil-based products used indoors.

Ambient benzene levels in Canada have been reduced over time. The national average has dropping from more the 3  $\mu\text{g}/\text{m}^3$  in the late 1990s to 0.9  $\mu\text{g}/\text{m}^3$  by 2009.<sup>3</sup> However, the range in values from one location to the next can be quite large. In 2003, city to city averages ranged from 0.6 to 5.5  $\mu\text{g}/\text{m}^3$ , despite a national average of 1.7  $\mu\text{g}/\text{m}^3$ .<sup>4</sup> The outdoor benzene level sampled at the Quinte Mohawk School of 2.1  $\mu\text{g}/\text{m}^3$  (Table 2) was somewhat high compared to the recent national average, but within a range that could be expected, and marginally below the AAQC of 2.3  $\mu\text{g}/\text{m}^3$ .

Indoor air concentrations of benzene are typically higher than outdoors. For example, a study of 185 homes of non-smokers in the USA determined average levels of benzene to be 7  $\mu\text{g}/\text{m}^3$ .<sup>5</sup> In a Canada-wide study of 754 randomly selected homes, average benzene levels of 6.39, 5.60, 2.72 and 6.98  $\mu\text{g}/\text{m}^3$  were determined, in the winter, spring, summer and fall, respectively.<sup>6</sup>

Indoors at the Quinte Mohawk School, the sampled benzene levels were mostly lower than was found outdoors, which is unusual since outdoor air concentrations are normally the baseline upon which small amounts of benzene are added indoors. One explanation could be the presence of a localized

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<sup>3</sup> Canada-Wide Standard for Benzene, 2010 Final Report. Canadian Council of Ministers of the Environment (2012).

<sup>4</sup> Ambient Air Benzene - 2003 Update. Analysis and Air Quality Division of Environment Canada (2003). Accessed on-line at [http://www.ccme.ca/assets/pdf/ambient\\_air\\_benzene03.pdf](http://www.ccme.ca/assets/pdf/ambient_air_benzene03.pdf)

<sup>5</sup> Wallace L.A. 1989. Major sources of benzene exposure. *Environ Health Perspect* 82:165-169.

<sup>6</sup> Cited in *Indoor Air Quality Handbook*. Spengler J.D., Samet, J. M. and McCarthy J.F. editors. McGraw-Hill 2000 p.p. 33.11

and/or short-duration source of benzene, such as vehicle exhaust, that impacted the outdoor sample during the survey.

There was one sample collected indoors, in the daycare centre, with a benzene concentration of 2.9  $\mu\text{g}/\text{m}^3$ , that marginally exceeded the outdoor concentration and the 24 hour AAQC of 2.3  $\mu\text{g}/\text{m}^3$ . It should be noted, however, that children likely spend only one third of the 24 hour day and 5 days per week in the daycare, such that their long term exposures will likely be different than what was sampled.

In human health risk assessment, other standards are typically used to quantify the health risk. In Canada, these include Health Canada's Toxicological Reference Values (TRVs) and in the US, values from the EPA Integrated Risk Information System (IRIS) are typically cited. For benzene, Health Canada's TRV is 3.3  $\mu\text{g}/\text{m}^3$  and the corresponding value from the EPA is 1.3  $\mu\text{g}/\text{m}^3$ . These are the long term inhalation levels to which an incremental lifetime risk of developing leukemia is believed to be about 1 in 100,000 ( $1 \times 10^{-5}$ ). Incremental risks below this level are considered negligible by Health Canada.

Even without adjustment for time spent in the school, the benzene results of this survey were already below Health Canada's TRV of 3.3  $\mu\text{g}/\text{m}^3$ , however, the result from the daycare (2.9  $\mu\text{g}/\text{m}^3$ ) exceeded the EPA IRIS value of 1.3  $\mu\text{g}/\text{m}^3$ . Adjusting for the fraction of time exposed (e.g. 8 hours per day and up to 48 weeks per year), the incremental lifetime cancer risk (ILCR) using the EPA's reference value is  $0.5 \times 10^{-5}$  for the daycare.<sup>7</sup> If attendance is lower and consistent with the standard school year (194 days per year) then the ILCR drops to  $0.4 \times 10^{-5}$ . In other words the risk levels are in the 4 to 5 in one million range. If Health Canada's TRV is to be used, then the risk is less than one half of this range. All results are well below 1 in 100,000 and would, therefore, be considered by Health Canada to represent negligible incremental risk.

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<sup>7</sup> Incremental Lifetime Cancer Risk (ILCR) = Air concentration ( $\mu\text{g}/\text{m}^3$ ) x Fraction of Time Exposed x Cancer Unit Risk ( $\mu\text{g}/\text{m}^3$ )<sup>-1</sup>.

## CONCLUSIONS

Under the conditions that existed at the time of the survey, levels of the individual volatile organic compounds detected in the school air were generally within cited guidelines. Airborne benzene levels were also low from a health risk standpoint. Exposure to the highest sampled benzene level was determined to represent an incremental lifetime cancer risk of less than 1 in 100,000, falling within the risk range considered by Health Canada to be negligible.

Total VOC levels in all sampled locations were below the proposed limit for office buildings, but in the kindergarten and daycare they exceeded the ideal and/or target level of 200  $\mu\text{g}/\text{m}^3$ , which is sometimes referenced for schools. The most likely observable effects (if any) at such TVOC levels would be irritative in nature (e.g. of the eye and potentially the upper respiratory tract).

There could be some simple measures available to the school for reducing VOC levels, including maintaining a low-fragrance policy, promoting hand washing to replace some uses of hand sanitiser, the use of low VOC cleaning and maintenance products, reducing the number of chemical products stored in the school, and using low VOC building materials in any future renovation or repair. An increase in the supply of outdoor air would also reduce the levels of TVOC generally.



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Tom Beardall MHSc, CIH, ROH  
January 7, 2013



**Appendix**  
**Certificates of Analysis**

# CERTIFICATE OF ANALYSIS<sup>7</sup>



<b>Organization:</b>	Phoenix OHC Inc.	<b>Work Order No.:</b>	2504445
<b>Address:</b>	837 Princess St., Suite 401, Kingston, Ontario K7L 1G8	<b>Analysis Required:</b>	Benzene
<b>Client:</b>	Tom Beardall	<b>Sampling Media:</b>	Air Toxic TD Tube
<b>Project Name:</b>	QMS.2012.12.5	<b>CASSEN Method:</b>	M.2401. R0, M.2403.R3
<b>Date Sampled:</b>	December 05, 2012		
<b>Date Submitted:</b>	December 06, 2012		
<b>Date Analyzed:</b>	December 10, 2012		

## Benzene Results<sup>1,6</sup>

#	Sample	Sampling Volume (L)	Amount <sup>2</sup> (ng)	Concentration <sup>3</sup> (ug/m <sup>3</sup> )
1	B16346.Rm32	6.981	1.4	0.2
2	C01231.MechRm26	7.465	3.2	0.4
3	MI036596.Rm30	7.254	1.4	0.2
4	MI036725.Rm7	7.270	3.5	0.5
5	MI036779.Rm10	7.498	1.9	0.3
6	C07774.Blank	NA	<1	NA
7	B12886. Daycare	7.232	20.6	2.9
8	B12372.K.G.Rm 41	7.043	3.9	0.6
9	MI036709.Rm28	7.597	9.6	1.3
10	B17717.Outdoors	7.564	15.6	2.1

## Quality Control Data

#	Compound	Uncertainty <sup>4</sup> (%)	MRL <sup>5</sup> (ng)
1	Benzene	17	1

**Notes:**
**N.A.:** Not Available

- 1) The results obtained have been subtracted by the same lab blank. Samples 1-5 were run on GC/MS(SIM) mode while samples 6-10 were run on full scan GC/MS mode along with open characterization analysis.
- 2) **Amount** is the mass of target analyte in nanograms (ng) detected in the sample.
- 3) **Concentration** is the amount of target analyte in micrograms per cubic meter (ug/m<sup>3</sup>) of air. The air volumes used are the sampling volume supplied to CASSEN Testing Laboratories by the client.
- 4) **Uncertainty** is expressed as a percentage over the calibration range. It is a result of the evaluation aimed at characterizing the range within which the true value of a test result is estimated at the 95% confidence interval.
- 5) **MRL** is the minimum reporting limit in nanograms (ng). MRL is the lowest mass of analyte in a sample that can be reported with a defined reproducible level of certainty.
- 6) **CASSEN Testing Laboratories** has established a reporting policy that a maximum of three significant figures will be used for test results in compliance with the precision requirement of ISO 17025.
- 7) This **Certificate of Analysis** shall not be reproduced except in full, without written approval of the laboratory. These analytical results pertain only to the samples as received. No responsibility or liability is assumed for the manner in which the results are used.



Analyst: \_\_\_\_\_ Date: \_\_\_\_\_  
 Queenie Yip, B.Sc., C.Chem., Senior Chemist

# CERTIFICATE OF ANALYSIS<sup>9</sup>



<b>Organization:</b>	Phoenix OHC Inc.	<b>Work Order No.:</b>	2504445
<b>Address:</b>	837 Princess St., Suite 401, Kingston, Ontario K7L 1G8	<b>Analysis Required:</b>	Open Characterization
<b>Client:</b>	Tom Beardall	<b>CASSEN Method:</b>	M.2401.R0
<b>Project Name:</b>	QMS.2012.12.5	<b>GC/MS File:</b>	D39802.D
<b>Date Sampled:</b>	December 05, 2012	<b>Sample ID:</b>	B12372. KG. Rm 41
<b>Date Submitted:</b>	December 07, 2012	<b>Sample Volume:</b>	7.043 L
<b>Date Analyzed:</b>	December 08, 2012		

## Major Volatile Organic Compounds Detected<sup>8</sup>

Rank <sup>1</sup>	CAS <sup>2</sup> Number	Tentative Identification <sup>3</sup>	R.T. <sup>4</sup> (min)	Amount <sup>5</sup> (ng)	Conc. <sup>6</sup> (ug/m <sup>3</sup> )
1	000541-02-6	Cyclopentasiloxane, decamethyl-	30.05	750	110
2	000064-17-5	Ethanol	5.06	310	43
3	005989-27-5	D-Limonene	27.50	190	27
4	000067-63-0	Isopropyl Alcohol	6.12	110	16
5	074367-34-3	Propanoic acid, 2-methyl-, 3-hydroxy-2,4,4-trimethylpentyl ester	36.51	92	13
6	000064-19-7	Acetic acid	13.15	87	12
7	000067-64-1	Acetone	5.82	84	12
8	000109-66-0	Pentane	4.91	83	12
9	006846-50-0	2,2,4-Trimethyl-1,3-pentanediol diisobutyrate	40.16	70	10
10	000540-97-6	Cyclohexasiloxane, dodecamethyl-	33.81	60	9
11	000071-23-8	1-Propanol	8.88	49	7
12	000556-67-2	Cyclotetrasiloxane, octamethyl-	25.16	46	7
13	000112-31-2	Decanal	32.66	38	5
14	000629-59-4	Tetradecane	35.42	35	5
15	000115-07-1	Propene + Propane	2.89	35	5
16	000075-71-8	Dichlorodifluoromethane	2.96	35	5
17	000078-79-5	1,3-Butadiene, 2-methyl-	5.39	32	5
18	000629-62-9	Pentadecane	37.07	30	4
19	000124-19-6	Nonanal	30.29	29	4
20	000056-23-5	Carbon Tetrachloride	11.32	28	4
21	003891-98-3	Dodecane, 2,6,10-trimethyl-	36.41	26	4
22	000066-25-1	Hexanal	19.03	26	4
23	000629-50-5	Tridecane	33.60	25	3
24	000084-66-2	Diethyl Phthalate	40.86	22	3
25	024251-86-3	Dodecane, 5,8-diethyl-	37.91	22	3
26	018435-22-8	Tetradecane, 3-methyl-	36.62	21	3
27	000075-69-4	Trichloromonofluoromethane	4.74	20	3
28	051284-29-8	Cyclohexane, (1,2-dimethylpropyl)-	34.11	19	3
29	061141-72-8	Dodecane, 4,6-dimethyl-	34.18	18	3
30	000078-84-2	Propanal, 2-methyl-	7.80	17	2
31	005444-75-7	2-Ethylhexylbenzoate	42.82	17	2
32	017312-59-3	Undecane, 4-ethyl-	32.95	16	2
33	081983-71-3	Cyclohexane, 1,1-dimethyl-2-propyl-	34.27	16	2
34	000111-76-2	Ethanol, 2-butoxy-	24.26	16	2
35	017301-23-4	Undecane, 2,6-dimethyl-	33.53	16	2

## Total Volatile Organic Compounds (TVOCs)<sup>7,8</sup>

	Total Amount (ng)	Concentration (ug/m <sup>3</sup> )
TVOCs	4300	600

**Notes:**

- N.A.: Not Available
- 1) **Rank** is based on the descending order of concentration.
  - 2) **CAS Number** is the Chemical Abstracts Service registry number corresponding to the tentatively identified compound (first listed coeluting compound) listed beside it. The tentative identification and its corresponding CAS Number were obtained as the best possible match from the results of the NIST Mass Spectral Library search.
  - 3) **Tentative Identification** is based on the best match result of the mass spectral identification; results are not confirmed unless calibrated with reference standards.
  - 4) **Retention Time (R.T.)** is the time that the VOC eluted from the column in the chromatogram.
  - 5) **Amount** is the semi-quantitative estimate of the total mass of the VOC in nanograms (ng) detected in the sampling tube. The value depends on the VOC's response compared to selected reference compounds.
  - 6) **Concentration** is the total amount of the VOC in micrograms per cubic meter (ug/m<sup>3</sup>) of air. The air volumes used are those supplied to CASSEN Testing Laboratories.
  - 7) **TVOCs** result is a semi-quantitative total amount/concentration based on the summation of the estimated masses of the VOC peaks in the chromatogram. The result depends on the response of each VOC compared to selected reference compounds.
  - 8) **CASSEN Testing Laboratories** has established a reporting policy that a maximum of three significant figures will be used for test results in compliance with the precision requirement of ISO 17025.
  - 9) This **Certificate of Analysis** shall not be reproduced except in full, without written approval of the laboratory. These analytical results pertain only to the samples as received. No responsibility or liability is assumed for the manner in which the results are used.
  - 10) Please note that this report is strictly focused on VOCs or compounds that are detectable using this method with a mass scanning range from 34 amu to 400 amu. Unstable/reactive compounds as well as those outside this range can not be detected.



Analyst: \_\_\_\_\_ Date: \_\_\_\_\_  
Matthew Yao, M.Sc. Chemist

# CERTIFICATE OF ANALYSIS<sup>9</sup>



<b>Organization:</b>	Phoenix OHC Inc.	<b>Work Order No.:</b>	2504445
<b>Address:</b>	837 Princess St., Suite 401, Kingston, Ontario K7L 1G8	<b>Analysis Required:</b>	Open Characterization
<b>Client:</b>	Tom Beardall	<b>CASSEN Method:</b>	M.2401.R0
<b>Project Name:</b>	QMS.2012.12.5	<b>GC/MS File:</b>	D39801.D
<b>Date Sampled:</b>	December 05, 2012	<b>Sample ID:</b>	B12886. Daycare
<b>Date Submitted:</b>	December 07, 2012	<b>Sample Volume:</b>	7.232 L
<b>Date Analyzed:</b>	December 08, 2012		

## Major Volatile Organic Compounds Detected<sup>8</sup>

Rank <sup>1</sup>	CAS <sup>2</sup> Number	Tentative Identification <sup>3</sup>	R.T. <sup>4</sup> (min)	Amount <sup>5</sup> (ng)	Conc. <sup>6</sup> (ug/m <sup>3</sup> )
1	000541-02-6	Cyclopentasiloxane, decamethyl-	30.05	730	100
2	000064-17-5	Ethanol	5.06	540	75
3	000111-76-2	Ethanol, 2-butoxy-	23.93	270	38
4	000115-07-1	Propene	2.91	260	37
5	000109-66-0	Pentane	4.91	200	28
6	000064-19-7	Acetic acid	12.58	190	26
7	000067-64-1	Acetone	5.80	170	24
8	005989-27-5	D-Limonene	27.50	120	17
9	001717-00-6	1,1-Dichloro-1-fluoroethane	5.26	110	15
10	000071-23-8	1-Propanol	8.76	81	11
11	000075-71-8	Dichlorodifluoromethane	2.96	66	9
12	000115-11-7	1-Propene, 2-methyl- (Isobutylene)	3.39	54	7
13	005131-66-8	2-Propanol, 1-butoxy-	25.03	49	7
14	000075-07-0	Acetaldehyde	3.68	45	6
15	000067-63-0	Isopropyl Alcohol	6.15	44	6
16	000629-59-4	Tetradecane	35.42	41	6
17	000556-67-2	Cyclotetrasiloxane, octamethyl-	25.15	37	5
18	000124-19-6	Nonanal	30.29	36	5
19	000078-78-4	Butane, 2-methyl-	4.39	36	5
20	000075-69-4	Trichloromonofluoromethane	4.74	34	5
21	000540-97-6	Cyclohexasiloxane, dodecamethyl-	33.81	33	5
22	003891-98-3	Dodecane, 2,6,10-trimethyl-	36.48	33	5
23	000629-62-9	Pentadecane	37.07	32	4
24	006846-50-0	2,2,4-Trimethyl-1,3-pentanediol diisobutyrate	40.16	31	4
25	000066-25-1	Hexanal	19.01	29	4
26	005444-75-7	2-Ethylhexylbenzoate	42.83	27	4
27	000611-14-3	Benzene, 1-ethyl-2-methyl-	25.42	27	4
28	000078-79-5	1,3-Butadiene, 2-methyl-	5.38	26	4
29	000056-23-5	Carbon Tetrachloride	11.32	26	4
30	000071-36-3	1-Butanol	13.71	26	4
31	000095-63-6	Benzene, 1,2,4-trimethyl-	26.75	20	3
32	000141-78-6	Ethyl Acetate	9.94	17	2
33	000124-18-5	Decane	25.80	16	2
34	000544-76-3	Hexadecane	38.81	14	2
35	000075-09-2	Methylene Chloride	6.81	13	2

## Total Volatile Organic Compounds (TVOCs)<sup>7,8</sup>

	Total Amount (ng)	Concentration (ug/m <sup>3</sup> )
TVOCs	4200	570

**Notes:**

- N.A.: Not Available
- 1) **Rank** is based on the descending order of concentration.
  - 2) **CAS Number** is the Chemical Abstracts Service registry number corresponding to the tentatively identified compound (first listed coeluting compound) listed beside it. The tentative identification and its corresponding CAS Number were obtained as the best possible match from the results of the NIST Mass Spectral Library search.
  - 3) **Tentative Identification** is based on the best match result of the mass spectral identification; results are not confirmed unless calibrated with reference standards.
  - 4) **Retention Time (R.T.)** is the time that the VOC eluted from the column in the chromatogram.
  - 5) **Amount** is the semi-quantitative estimate of the total mass of the VOC in nanograms (ng) detected in the sampling tube. The value depends on the VOC's response compared to selected reference compounds.
  - 6) **Concentration** is the total amount of the VOC in micrograms per cubic meter (ug/m<sup>3</sup>) of air. The air volumes used are those supplied to CASSEN Testing Laboratories.
  - 7) **TVOCs** result is a semi-quantitative total amount/concentration based on the summation of the estimated masses of the VOC peaks in the chromatogram. The result depends on the response of each VOC compared to selected reference compounds.
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  - 10) Please note that this report is strictly focused on VOCs or compounds that are detectable using this method with a mass scanning range from 34 amu to 400 amu. Unstable/reactive compounds as well as those outside this range can not be detected.



Analyst: \_\_\_\_\_ Date: \_\_\_\_\_  
Matthew Yao, M.Sc. Chemist

# CERTIFICATE OF ANALYSIS<sup>9</sup>



<b>Organization:</b> Phoenix OHC Inc.	<b>Work Order No.:</b> 2504445
<b>Address:</b> 837 Princess St., Suite 401, Kingston, Ontario K7L 1G8	<b>Analysis Required:</b> Open Characterization
<b>Client:</b> Tom Beardall	<b>CASSEN Method:</b> M.2401.R0
<b>Project Name:</b> QMS.2012.12.5	<b>GC/MS File:</b> D39803.D
<b>Date Sampled:</b> December 05, 2012	<b>Sample ID:</b> MI036709. Rm 28
<b>Date Submitted:</b> December 07, 2012	<b>Sample Volume:</b> 7.597 L
<b>Date Analyzed:</b> December 08, 2012	

## Major Volatile Organic Compounds Detected<sup>8</sup>

Rank <sup>1</sup>	CAS <sup>2</sup> Number	Tentative Identification <sup>3</sup>	R.T. <sup>4</sup> (min)	Amount <sup>5</sup> (ng)	Conc. <sup>6</sup> (ug/m <sup>3</sup> )
1	000541-02-6	Cyclopentasiloxane, decamethyl-	30.04	97	13
2	005989-27-5	D-Limonene	27.50	65	9
3	000075-71-8	Dichlorodifluoromethane	2.94	56	7
4	000067-64-1	Acetone	5.83	43	6
5	000064-17-5	Ethanol	5.09	40	5
6	000112-40-3	Dodecane	31.51	37	5
7	000075-69-4	Trichloromonofluoromethane	4.72	24	3
8	000078-79-5	1,3-Butadiene, 2-methyl-	5.38	22	3
9	000109-66-0	Pentane	4.89	20	3
10	000104-76-7	1-Hexanol, 2-ethyl-	28.37	20	3
11	000064-19-7	Acetic acid	13.77	18	2
12	000127-18-4	Tetrachloroethylene	18.42	18	2
13	000056-23-5	Carbon Tetrachloride	11.32	17	2
14	000066-25-1	Hexanal	19.04	17	2
15	000075-07-0	Acetaldehyde	3.64	16	2
16	000076-13-1	Ethane, 1,1,2-trichloro-1,2,2-trifluoro-	5.76	11	1
17	000124-19-6	Nonanal	30.30	9	1
18	000556-67-2	Cyclotetrasiloxane, octamethyl-	25.16	9	1
19	000123-72-8	Butanal	9.41	8	1
20	000629-59-4	Tetradecane	35.42	7	1
21	000540-97-6	Cyclohexasiloxane, dodecamethyl-	33.81	6	1
22	000078-78-4	Butane, 2-methyl-	4.37	6	1
23	001717-00-6	1,1-Dichloro-1-fluoroethane	5.25	6	1
24	000108-88-3	Toluene	16.91	6	1
25	000110-82-7	Cyclohexane	11.05	6	1
26	074367-34-3	Propanoic acid, 2-methyl-, 3-hydroxy-2,4,4-trimethylpentyl ester	36.51	6	1
27	000067-63-0	Isopropyl Alcohol	6.25	6	1
28	000124-13-0	Octanal	27.35	5	1
29	000110-62-3	Pentanal	14.27	5	1
30	000108-95-2	Phenol	29.24	4	1
31	000111-66-0	1-Octene	17.05	4	1
32	000108-94-1	Cyclohexanone	24.10	4	< 1
33	000092-52-4	Biphenyl	36.61	4	< 1
34	000141-78-6	Ethyl Acetate	10.07	4	< 1
35	001195-32-0	.alpha.-p-Dimethylstyrene (p-Cymene)	29.75	3	< 1

## Total Volatile Organic Compounds (TVOCs)<sup>7,8</sup>

	Total Amount (ng)	Concentration (ug/m <sup>3</sup> )
TVOCs	750	99

**Notes:**

- N.A.: Not Available
- 1) **Rank** is based on the descending order of concentration.
  - 2) **CAS Number** is the Chemical Abstracts Service registry number corresponding to the tentatively identified compound (first listed coeluting compound) listed beside it. The tentative identification and its corresponding CAS Number were obtained as the best possible match from the results of the NIST Mass Spectral Library search.
  - 3) **Tentative Identification** is based on the best match result of the mass spectral identification; results are not confirmed unless calibrated with reference standards.
  - 4) **Retention Time (R.T.)** is the time that the VOC eluted from the column in the chromatogram.
  - 5) **Amount** is the semi-quantitative estimate of the total mass of the VOC in nanograms (ng) detected in the sampling tube. The value depends on the VOC's response compared to selected reference compounds.
  - 6) **Concentration** is the total amount of the VOC in micrograms per cubic meter (ug/m<sup>3</sup>) of air. The air volumes used are those supplied to CASSEN Testing Laboratories.
  - 7) **TVOCs** result is a semi-quantitative total amount/concentration based on the summation of the estimated masses of the VOC peaks in the chromatogram. The result depends on the response of each VOC compared to selected reference compounds.
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  - 10) Please note that this report is strictly focused on VOCs or compounds that are detectable using this method with a mass scanning range from 34 amu to 400 amu. Unstable/reactive compounds as well as those outside this range can not be detected.



Analyst: \_\_\_\_\_ Date: \_\_\_\_\_  
Matthew Yao, M.Sc. Chemist

# CERTIFICATE OF ANALYSIS<sup>9</sup>



<b>Organization:</b> Phoenix OHC Inc.	<b>Work Order No.:</b> 2504445
<b>Address:</b> 837 Princess St., Suite 401, Kingston, Ontario K7L 1G8	<b>Analysis Required:</b> Open Characterization
<b>Client:</b> Tom Beardall	<b>CASSEN Method:</b> M.2401.R0
<b>Project Name:</b> QMS.2012.12.5	<b>GC/MS File:</b> D39813.D
<b>Date Sampled:</b> December 05, 2012	<b>Sample ID:</b> B17717. Outdoors
<b>Date Submitted:</b> December 07, 2012	<b>Sample Volume:</b> 7.564 L
<b>Date Analyzed:</b> December 10, 2012	

## Major Volatile Organic Compounds Detected<sup>8</sup>

Rank <sup>1</sup>	CAS <sup>2</sup> Number	Tentative Identification <sup>3</sup>	R.T. <sup>4</sup> (min)	Amount <sup>5</sup> (ng)	Conc. <sup>6</sup> (ug/m <sup>3</sup> )
1	000075-71-8	Dichlorodifluoromethane	2.92	77	10
2	000075-69-4	Trichloromonofluoromethane	4.75	50	7
3	000056-23-5	Carbon Tetrachloride	11.35	33	4
4	000076-13-1	Ethane, 1,1,2-trichloro-1,2,2-trifluoro-	5.78	26	3
5	000109-66-0	Pentane	4.93	23	3
6	000078-78-4	Butane, 2-methyl-	4.40	15	2
7	000629-62-9	Pentadecane	37.10	14	2
8	000629-59-4	Tetradecane	35.45	9	1
9	000067-64-1	Acetone	5.91	9	1
10	000075-07-0	Acetaldehyde	3.62	9	1
11	000629-50-5	Tridecane	33.63	9	1
12	000075-09-2	Methylene Chloride	6.81	8	1
13	001717-00-6	1,1-Dichloro-1-fluoroethane	5.28	8	1
14	000544-76-3	Hexadecane	38.84	8	1
15	000354-33-6	Ethane, pentafluoro-	4.14	7	1
16	000064-17-5	Ethanol	5.28	6	1
17	026741-18-4	9-methylheptadecane	40.80	5	1
18	000124-19-6	Nonanal	30.32	4	1
19	000108-88-3	Toluene	16.94	3	< 1
20	000124-13-0	Octanal	27.37	3	< 1
21	000556-67-2	Cyclotetrasiloxane, octamethyl-	25.19	3	< 1
22	000107-02-8	Acrolein	5.77	3	< 1
23	000112-31-2	Decanal	32.70	2	< 1
24	000110-54-3	Hexane	8.09	2	< 1
25	000108-95-2	Phenol	29.25	2	< 1
26	000149-57-5	Hexanoic acid, 2-ethyl-	31.27	1	< 1
27	000079-92-5	Camphene	24.70	1	< 1
28	000096-37-7	Cyclopentane, methyl-	9.48	1	< 1
29	000100-42-5	Styrene	22.92	1	< 1
30	000110-82-7	Cyclohexane	11.07	1	< 1
31	000100-52-7	Benzaldehyde	27.00	1	< 1
32	000589-34-4	Hexane, 3-methyl-	11.46	< 1	< 1
33	000108-38-3	m-Xylene + p-Xylene	21.65	< 1	< 1
34	000080-56-8	.alpha.-Pinene	23.85	< 1	< 1
35	000100-41-4	Ethylbenzene	21.30	< 1	< 1

## Total Volatile Organic Compounds (TVOCs)<sup>7,8</sup>

	Total Amount (ng)	Concentration (ug/m <sup>3</sup> )
TVOCs	360	48

**Notes:**

- N.A.: Not Available
- 1) **Rank** is based on the descending order of concentration.
  - 2) **CAS Number** is the Chemical Abstracts Service registry number corresponding to the tentatively identified compound (first listed coeluting compound) listed beside it. The tentative identification and its corresponding CAS Number were obtained as the best possible match from the results of the NIST Mass Spectral Library search.
  - 3) **Tentative Identification** is based on the best match result of the mass spectral identification; results are not confirmed unless calibrated with reference standards.
  - 4) **Retention Time (R.T.)** is the time that the VOC eluted from the column in the chromatogram.
  - 5) **Amount** is the semi-quantitative estimate of the total mass of the VOC in nanograms (ng) detected in the sampling tube. The value depends on the VOC's response compared to selected reference compounds.
  - 6) **Concentration** is the total amount of the VOC in micrograms per cubic meter (ug/m<sup>3</sup>) of air. The air volumes used are those supplied to CASSEN Testing Laboratories.
  - 7) **TVOCs** result is a semi-quantitative total amount/concentration based on the summation of the estimated masses of the VOC peaks in the chromatogram. The result depends on the response of each VOC compared to selected reference compounds.
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Analyst: \_\_\_\_\_ Date: \_\_\_\_\_  
Matthew Yao, M.Sc. Chemist

# CERTIFICATE OF ANALYSIS<sup>9</sup>



<b>Organization:</b>	Phoenix OHC Inc.	<b>Work Order No.:</b>	2504445
<b>Address:</b>	837 Princess St., Suite 401, Kingston, Ontario K7L 1G8	<b>Analysis Required:</b>	Open Characterization
<b>Client:</b>	Tom Beardall	<b>CASSEN Method:</b>	M.2401.R0
<b>Project Name:</b>	QMS.2012.12.5	<b>GC/MS File:</b>	D39805.D
<b>Date Sampled:</b>	December 05, 2012	<b>Sample ID:</b>	C07774. Blank
<b>Date Submitted:</b>	December 07, 2012	<b>Sample Volume:</b>	N.A.
<b>Date Analyzed:</b>	December 08, 2012		

## Major Volatile Organic Compounds Detected<sup>8</sup>

Rank <sup>1</sup>	CAS <sup>2</sup> Number	Tentative Identification <sup>3</sup>	R.T. <sup>4</sup> (min)	Amount <sup>5</sup> (ng)	Conc. <sup>6</sup> (ug/m <sup>3</sup> )
1	005444-75-7	2-Ethylhexylbenzoate	42.84	4	N.A.
2	000067-64-1	Acetone	5.91	4	N.A.
3	000124-19-6	Nonanal	30.29	4	N.A.
4	000064-17-5	Ethanol	5.27	3	N.A.
5	000110-54-3	Hexane	8.07	3	N.A.

\* Only five compounds are reported for blank samples.

## Total Volatile Organic Compounds (TVOCs)<sup>7,8</sup>

	Total Amount (ng)	Concentration (ug/m <sup>3</sup> )
TVOCs	44	N.A.

**Notes:**

N.A.: Not Available

- 1) **Rank** is based on the descending order of concentration.
- 2) **CAS Number** is the Chemical Abstracts Service registry number corresponding to the tentatively identified compound (first listed coeluting compound) listed beside it. The tentative identification and its corresponding CAS Number were obtained as the best possible match from the results of the NIST Mass Spectral Library search.
- 3) **Tentative Identification** is based on the best match result of the mass spectral identification; results are not confirmed unless calibrated with reference standards.
- 4) **Retention Time (R.T.)** is the time that the VOC eluted from the column in the chromatogram.
- 5) **Amount** is the semi-quantitative estimate of the total mass of the VOC in nanograms (ng) detected in the sampling tube. The value depends on the VOC's response compared to selected reference compounds.
- 6) **Concentration** is the total amount of the VOC in micrograms per cubic meter (ug/m<sup>3</sup>) of air. The air volumes used are those supplied to CASSEN Testing Laboratories.
- 7) **TVOCs** result is a semi-quantitative total amount/concentration based on the summation of the estimated masses of the VOC peaks in the chromatogram. The result depends on the response of each VOC compared to selected reference compounds.
- 8) **CASSEN Testing Laboratories** has established a reporting policy that a maximum of three significant figures will be used for test results in compliance with the precision requirement of ISO 17025.
- 9) This **Certificate of Analysis** shall not be reproduced except in full, without written approval of the laboratory. These analytical results pertain only to the samples as received. No responsibility or liability is assumed for the manner in which the results are used.
- 10) Please note that this report is strictly focused on VOCs or compounds that are detectable using this method with a mass scanning range from 34 amu to 400 amu. Unstable/reactive compounds as well as those outside this range can not be detected.

Analyst: \_\_\_\_\_ Date: \_\_\_\_\_  
Matthew Yao, M.Sc. Chemist

