CITY OF FALLS CHURCH

Dear Resident:

The purpose to this notice is to advise you that the City of Falls Church has contracted with AM-Liner East, Inc. to rehabilitate the City's sanitary sewer line that serves your property, by using the Cured In Place Process (CIPP), a trenchless technology for sanitary sewer reconstruction. The City utilizes this process, rather than excavation, to save money and the associated disruption of excavation and replacement.

This work is scheduled to start at 8:00 a.m. on ____________________ and be completed by 5:00 p.m. the same day. Access to your residence <u>will not</u> be required and it <u>is not</u> necessary for anyone to be home during the reconstruction process. Due to unforeseen circumstances, scheduling changes may occur. The current schedule is available on line at http://www.fallschurchva.gov/155/Public-Works

During this time, you <u>must</u> <u>discontinue</u> <u>all</u> <u>in-house</u> <u>water</u> <u>usage</u> until notified that you may resume such usage. <u>Do not use</u> showers, toilets, sinks, washing machines, dishwasher, etc. during this time. You should store water for your personal and cooking needs prior to 8:00 a.m.; however, you <u>must</u> <u>not</u> <u>discharge</u> <u>(flush</u> or <u>drain)</u> into the sewer system until the work is completed. Also, if you have a sump pump and think it is <u>connected</u> to the sanitary sewer system, please <u>notify</u> <u>Am-Liner East's</u> <u>Representative</u> <u>immediately</u> of its presence. Failure to comply with these instructions may result in a sewer back up into your property, and/or your water service may be temporarily shut off until the work is completed.

The resin used in the CIPP contains styrene, a chemical with an unpleasant odor that is detectable at very low concentration levels. This odor may enter your home through dry drain traps. Therefore, to eliminate any possibility of this odor entering your home, **please pour some water into all drains prior to the start of our work, including basement floor and air conditioner condensation drains**, to ensure that water is in the trap and a seal exists. This is also a good practice in the future to prevent unwanted gases from entering your home.

Thank you for your help, we apologize for any inconvenience that this may cause to you and your family. Should you have any questions or concerns, please direct your inquires to:

<u>Am-Liner East Rep.</u>	<u>OFFICE</u>	<u>MOBILE</u>
Olen All – Project Manager	540-955-9671	540-336-3968 (24 Hr)
Miguel Hernandez – Project Superintendent	540-955-9671	703-932-8487 (24 Hr)

601 Jack Enders Boulevard
Berryville, VA 22611

If you have any questions or concerns after regular working hours, please call one of Am-Liner's representatives at one of the 24 Hr contact numbers listed above. If you wish to contact the City staff responsible for this work, please call Mr. Darnell Pendleton at (571)238-5132 or Mr. Robert Goff at (703) 248-5013. For emergencies, after regular working hours, please call (703) 241-5050.

Sincerely,

Robert Goff

Robert Goff
Superintendent of Public Works

Department of Public Works, 7100 Gordon Rd., Falls Church, VA 22046

703-248-5081 • 703-534-5038 FAX • www.fallschurchva.gov

NASSCO Releases Guidelines On Styrenated Resins

by **Jeff Griffin** senior editor

NASSCO (National Association of Sewer Service Companies) has completed a state-of-the-art guideline for the use and handling of styrene based resins in the cured-in-place-pipe (CIPP) rehabilitation process.

The report, based on a study by the NASSCO CIPP Committee, is titled *Guideline for the Use and Handling of Styrenated Resins in Cured-In-Place-Pipe*, can be downloaded at no cost from the NASSCO web site, www.nassco.org.

Contents of the guideline includes:

- Facts about resin materials used for CIPP;
- Receiving, storing and handling of CIPP resins and initiation of chemicals;
- Transporting resin-saturated tubes;
- CIPP installation practices; and
- Water and steam curing.

"Until now, there has been no document providing a well-researched guideline for the proper handling and use of styrenated resins in CIPP linings," said Ed Kampbell, a member of the committee and principal author of the guideline. "NASSCO determined that such a guideline is needed due to the increasing number of CIPP projects, the expansion of CIPP into other areas such as

NASSCO CIPP Committee Members

Members of the NASSCO CIPP Committee that developed the guideline for using styrenated resins for cured-in-place-pipe applications are:

Chairman Lynn Osborn, Insituform Technologies; Ed Kampbell, Rehabilitation Resource Solutions; Marc Anctil, Logiball, Inc; Irv Gemora, NASSCO executive director; Steve Gearhart, CIPP Corp.; Geoff Yothers, Inliner Technologies; Greg Laszczynski, Mississippi Textiles; Gerry Muenchmeyer, Muenchmeyer & Associates; Kaleel Rahaim, Interplastic Corp; Jim Harris, City of Murfreesboro, TN; and Larry Kiest, LMK Enterprises.

storm sewers, and especially with some public concern about harm to the environment."

Addressing concerns

Concern over the potential of releasing styrene into the environment related to projects using styrenated resins during CIPP applications was a primary factor considered during the eight-month study by the committee.

"It is important to understand," said Kampbell, "that styrene use related to CIPP is a much different type of environmental risk than in other resin-using industries such as boat manufacturing which potentially can send large qualities of styrene into the air and their surface water discharges."

The guideline states that styrenated resin systems as they are currently used today in CIPP rehabilitation systems produce a safe and environmentally sound solution to the challenges of restoring the nation's failing infrastructure. The risk associated with styrene's use in CIPP is minimal and well within the Clean Water Act's original intent of keeping the environment as free as is practical of chemical pollutants. CIPP installation sites managed with "good housekeeping" will present little opportunity for human health risks and/or environmental risks.

The guideline sites a history of successful and safe usage of styrenated CIPP lining. In addition, it makes a strong case for styrenated resin CIPP usage.

Best material

"Styrene," says the guideline, "is the ideal monomer used for cross-linking polyester and vinyl ester resins. Although alternative monomers have been extensively investigated, none of those monomers have matched the overall performance of styrene. Polyester and vinyl ester resin systems have been used for more than 35 years in CIPP. During this time frame there have been no noted serious consequences to their usage in CIPP.

"Over the last 30 years, the increasing awareness of the need to limit the effects of styrene exposure has led the polyester resin processing industry to pursue strategies to reduce exposure in the manufacturing and processing plant environment. Most, if not all of the studies undertaken to date, have centered on these producer and user environments which are dramatically different than the work environment of the CIPP installation contractor."

The guideline continues that because no definitive document for these resin systems as used in this specific application existed, the unknown has lead to speculation as to their safety with respect to the work force involved, the general public when the odors enter the structures connected to the piping under rehabilitation, and to the greater downstream environment from where the work is taking place.

The report says that NASSCO created a styrene task force to review the technical information available from these studies and current CIPP installation practices to produce this CIPP specific guideline. In addition to this guideline, NASSCO has prepared an Inspector Training Course to properly equip the owner and the project engineer with the necessary knowledge to ensure that a proper installation is achieved which will minimize the potential for release of styrene to the environment.

NASSCO is a national organization composed of several hundred members representing rehabilitation industry manufacturers and suppliers, municipalities and utility districts, engineers and contracting firms.

FOR MORE INFORMATION:
NASSCO, (410) 486-3500, nassco.org

A Report on the Monitoring of Styrene in Toronto Homes During the Cured in Place Pipe (CIPP) Process for Sewer Pipe Rehabilitation by Insituform

PROJECT NO. 041-6742

Prepared for
Toronto Works & Emergency Services
2700 Eglinton Avenue West
Toronto, Ontario
M6M 1V1

Prepared by

AirZOne Inc.
2240 Speakman Dr.
Mississauga, Ontario
L5K 1A9

March, 2001

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EXECUTIVE SUMMARY

At the request of the Toronto Department of Works and Emergency Services, AirZOne Inc. conducted an investigation of airborne concentrations of styrene and 24 other volatile organic compounds (VOCs) in eight randomly selected residences during the rehabilitation of sewers with cured-in-place pipe (CIPP) installation. The study also measured ambient air quality, emissions from manholes, and occupational exposures for these compounds.

Air sampling was executed in three phases, before, during, and after, pipe installation. Sampling consisted primarily of area samples, but personal occupational exposures of several Insituform employees were also measured. Area samples were collected:

- in the basement and on the main floor living areas of selected test homes to determine the indoor airborne concentrations of styrene and a target list of 24 other compounds.
- outside of homes and upwind of manholes to determine the ambient air quality for styrene and the same 24 target compounds.
- above manhole openings to determine emissions from manholes for the same compounds during the CIPP process.

Personal samples were collected from the breathing zone of Insituform employees.

A total of 114 samples were collected during the study from September 20, 2000 to February 22, 2001. This included 75 indoor, 13 ambient, 11 manhole and 4 personal samples, as well as 11 quality control samples (10 % of the total). The bulk of the samples (89) were collected at six test homes during the first portion of the study (September 20 to December 16, 2000) when a pre-liner (10 mil thick polyethylene) was used during the CIPP installation process. An additional 25 samples were collected at two test homes during the last portion of the study (February 12 - 22, 2001) when no pre-liner was used for CIPP installation.

The results were compared to:

- permissible occupational exposure levels (for occupational samples) established by the Ontario Ministry of Labour Regulation respecting Control of Exposure to Biological and Chemical Agents (Ont. Reg. 833, as amended by 513/92; 597/94).
- ACGIH guidelines (for occupational samples).

- Ontario Environmental Protection Act, Regulation 346 ambient air quality standards based on ground level point-of-impingement standards (for ambient and indoor samples).
- typical indoor residential levels from various studies (for indoor samples).

In residential indoor air, styrene levels were typically below the detection limit (<0.00002 ppm) for most homes prior to CIPP installation. One home (Test Home #9) had styrene concentrations less than 0.00007 ppm prior to CIPP installation. In four of the eight test homes, the styrene levels remained below 0.0002 ppm during and after pipe installation. In two other test homes styrene levels increased during the CIPP process to 0.01 – 0.02 ppm and in two homes, levels reached 0.1 – 0.2 ppm. The latter two homes represented worst-case scenarios during the CIPP process. Both these homes were dry trap situations engineered for purposes of this study to simulate the greatest infiltration of CIPP process emissions into the home and thus to produce the highest concentrations. In one case (Test Home #2) the air sampling was conducted in close proximity to the clean-out drain access within the home and the lateral service line entered the manhole above the level of the main sewer line thus exposing the lateral service line to emissions from a larger surface area of curing pipe than is typical. In the other case (Test Home #9) there was no main clean-out trap leading to the lateral service connection and a PVC cap which normally blocked access to the lateral service line was removed by Toronto Works personnel during the CIPP installation phase. All elevated styrene levels were transient and returned to typical indoor levels within two days of completion of the CIPP installation. None of the homes had unusual indoor VOC levels.

Styrene emissions from manholes during the CIPP process ranged from 0.16 – 1.5 ppm when a pre-liner was utilized and reached 3.2 ppm when no pre-liner was used. These source emissions were not modelled to determine the impact downwind or the point of impingement concentrations but a rough rule of thumb would indicate a dilution ratio of about 500 times over a 100 m distance at 1 m/s wind speed in an urban area according to the US EPA SCREEN model. During the CIPP installation process, most of the ambient VOC levels were not significantly different from background upwind concentrations.

Personal exposures of styrene in the breathing zone of Insituform employees ranged from 0.08 to 0.5 ppm Styrene and all other VOC concentrations in the personal exposure samples were well below the permissible occupational limits.

While the CIPP process is a potential source of styrene, it does not appear to be a significant source of any of the other VOCs that are typically of concern in occupational or indoor air quality studies. Most of the levels of these VOCs were consistent with concentrations measured indoors in several studies in North America conducted over the last 20 years.

Styrene levels in homes were elevated significantly only in homes with dry sewer traps (engineered specifically for this study) during the CIPP installation. The levels, although elevated, were not of health concern.

However, the styrene levels are significantly above the odour threshold which is rated as low as 0.005 ppm with a geometric median value of 0.14 ppm (From *Critiqued Values in Odour Thresholds for Chemicals with Established TLVs; ACGIH, 1989*). Some researchers set the odour threshold at the limit of concentration for the most sensitive observers, but the general approach has been to calculate an average threshold as the concentration to which 50 % of the observers report an odour. Odour thresholds are typically quoted as ranges because of the range of sensitivities (differences in people's ability to detect odours) in the human population.

To minimize odour problems during implementation of the CIPP process, residents should be advised to ensure that their sewer traps are in a proper state of repair. In cases of damaged, dry, or non-existent traps, the areas or rooms where floor drains or access holes to traps are located should be ventilated, if possible, by leaving doors or windows open to the outside during the CIPP installation process.

The use of a pre-liner during the CIPP process appears to reduce styrene emissions from manholes and would also reduce the risk of elevated styrene levels within homes with damaged, dry, or non-existent traps leading to lateral service lines.

SAMPLING HOMES

1. INTRODUCTION

At the request of the Toronto Department of Works and Emergency Services and one of its sewer rehabilitation contractors, Insituform, AirZOne Inc. conducted a study to measure the indoor air quality in eight randomly selected test homes, as well as ambient air quality, emissions from manholes, and typical occupational exposures of Insituform employees during the rehabilitation of damaged or deteriorated sewers using the cured-in-place pipe (CIPP) installation process. The principal compound of interest was styrene, but levels of 24 other volatile organic compounds (VOCs) were also monitored.

Briefly, the CIPP process involves:

- forcing a resin-impregnated felt tube liner through a section of damaged sewer pipe.
- circulating hot water (from an 800 BTU heater located in a large panel truck) through the tube, causing the thermosetting resin to harden and cure (at 50°C the resin becomes gel and at 80°C it begins to harden). This forms a new pipe within the damaged sewer pipe and typically requires 4 - 6 hours to cure, depending on the pipe length and diameter, and the amount of hardening catalyst.
- externally cutting open the manhole sections of the new pipe (via manhole access).
- internally cutting open access to lateral service lines, using closed circuit TV and a robotically-controlled cutting device.

In some instances, a pre-liner (10 mil thick polyethylene) is used along with the felt tube liner, but in other cases the CIPP process is used without the pre-liner.

During various sewer rehabilitation projects, some residents have expressed concerns about the distinctive plastic odour in their neighbourhood and within their homes. Typically, a home has a drain connection with a lateral service line to the municipal sewer system. A drain trap, designed to be wet at all times to trap unwanted sewer gases and prevent their entry into the home, is part of the connection to the lateral service line. It is possible that the trap may become dry or defective, permitting regular sewer gases as well as gases associated with pipe repair to enter into homes through basement floor drains.

SAMPLING HOMES

2. STUDY STRATEGY AND APPROACH

AirZOne Inc. conducted a monitoring program to measure airborne concentrations of styrene and other VOCs during Insituform's CIPP process of sewer rehabilitation on four Toronto streets during the periods of Sept. 20 - Oct. 5 and Dec. 13 - 16, 2000, and Feb. 12 - 22, 2001.

2.1 STUDY DESIGN

In consultation with Toronto Works, it was decided to execute a diagnostic study consisting of sampling airborne compounds at eight homes to investigate various influences on indoor concentrations including, background levels and outdoor levels of the target compounds, the presence of dry or wet traps in the lateral lines and the use or lack of a pre-liner during CIPP installation. The three phases of the study in each house were:

- Phase I (T1) – prior to pipe installation; 24-hour samples inside each of the homes to measure background levels of VOCs.
- Phase II (T2) – during the day of CIPP installation; 8 to 10-hour samples to measure the maximum levels of VOCs. Half the homes had dry traps and half had wet traps in the lateral lines.
- Phase III (T3) – two to three days after pipe installation; 24-hour samples to measure VOC levels during typical activities to determine residual concentrations.
- During monitoring at the first six test homes, the CIPP process included the use of a pre-liner, but no pre-liner was used during monitoring at the last two homes.

Table 2-1 shows the sampling schedule for the monitoring program. When a pre-liner was used in the CIPP process, Phase I monitoring was executed at the first six test homes during late September and early October, 2000. (Measurements were carried out in seven homes in this first phase – six homes plus one additional home which served as a back-up in the event of a cancellation or scheduling difficulties). Phase II and III sampling were also completed at four test homes during the late September/early October period. Phase II and Phase III sampling at the remaining two test homes where a pre-liner was used during the CIPP installation was originally scheduled for late October, but was completed in mid-December due to other commitments of the Insituform contractor and some weather-related delays.

Table 2-1 Sampling Schedule

Test Home #	Address	Trap	Phase I Pre-installation Testing (T1)	Phase II Installation Testing (T2)	Phase III Post-installation Testing (T3)
Year 2000 – pre-liner used					
1	27 Marigold Ave.	wet	Sept. 20-21	Sept. 27	Oct 4-5
2	161 Beech Ave.	dry	Sept. 20-21	Sept. 25	Sept. 27-28
3	14 Beech Ave.	wet	Sept. 20-21	Sept. 26	Sept. 28-29
4	12 Beech Ave.	dry	Sept. 20-21	Sept. 26	Sept. 28-29
5	284 Kenilworth Ave.	wet	Sept. 21-22	Dec. 13	Dec. 15-16
6	263 Kenilworth Ave.	-	Sept. 21-22	NA	NA
7	299 Kenilworth Ave.	dry	Oct. 5-6	Dec. 13	Dec. 15-16
Year 2001 – no pre-liner used					
8	73 Rivercourt Blvd.	wet	Feb. 12-13	Feb. 19	Feb. 21-22
9	71 Rivercourt Blvd.	dry	Feb. 12-13	Feb. 19	Feb. 21-22

NA = not applicable; no testing was done during or after pipe installation at test home #6

T1, T2, T3 were used for sample codes to designate the phase of the monitoring program

Home numbers were assigned according to the initial scheduling and execution of Phase I testing in each residence. Thus, although Phase I samples were collected in the residence originally designated as test home #6, no further samples were acquired at this residence due to wet trap/dry trap requirements and resident availability. Instead, samples were collected during all three phases of the study at test home #7.

Subsequent to the initial air sampling, when a pre-liner was used, two more test homes were added to the study in order to monitor styrene and other VOC concentrations when a pre-liner was not utilized in the CIPP process.

Samples were collected indoors and outdoors during each phase of the monitoring program. During pipe installation (Phase II), additional samples were collected above manholes where the pipe was curing, and in the breathing zone of selected Insituform employees. A summary of the monitoring sites is given in Table 2-2 while more detailed descriptions of the sampling locations and procedures are provided in Section 3.1.

Each sample was assigned a unique alpha-numeric code of the form Aa-Bb-Cc, where the letters refer to the program phase, sampling site, and sample location[1]. Details of the sampling codes are listed in Table 2-3. For example, the sample obtained during Phase I in test home #2 on the main floor was designated as T1-H2-M. For each sample in Phase II (T2), during the pipe installation, an additional 'W' or 'D' was added to the end of the sample code to identify the test home as having a wet or dry trap, respectively.

The sampling and analytical methods for the study are described in detail in Section 3 of the report. An account of the samples collected is provided in Table 3-1.

---

[1] Note, in the field, the initial four numbers of the sample code identified the AirZOne Inc. project number, 6742. To simplify the listings in the results tables, the 6742 designation is not included.

Table 2-2 Monitoring Sites

Sample Location	Home #	Comments About Sampling Location
Basements	1	in centre of recreation room, 1.4 m above floor; 3 - 4 m from floor drain in adjacent bathroom wet trap
	2	in furnace room, 1.7 m above floor; 2 m from floor drain in same room dry trap
	3	in laundry room, 1.4 m above floor; 5 m from floor drain in adjacent furnace room wet trap
	4	in centre of basement, 1.3 m above dirt floor (entire floor was torn up for remodeling) dry trap
	5	in recreation room, 1.4 m above floor; wet trap 6 m from laundry room floor drain, 1 m from rec room floor drain
	7	in laundry/furnace area, 1.1 m above floor 2 m from floor drain in same room dry trap
	8	in furnace room, 1.2 m above floor 1 m from floor drain in same room wet trap
	9	in recreation room, on window sill, 1.5 m above floor; 10 m from floor drain in storage room dry trap
Main Floors	all	living or dining room; approximately 1.2 to 1.5 metres above floor
Manholes • samples 1-3 were collected from manholes intermediate in the pipe installation/curing process length • manhole sample 4 was collected at the tail area of the pipe installation/curing process length • all samples were collected 10 cm above manhole-cover level (covers remained ajar during sampling)		
Manhole 1	2	400 minute sample; upwind sample 80 m SW of manhole sample
Manhole 2	3 & 4	471 minute sample; upwind sample 40 m WNW of manhole sample
Manhole 3	1	442 minute sample; upwind sample 100 m SW of manhole sample
Manhole 4	8 & 9	147 minute sample; upwind sample 300 m SW of manhole sample
Personal (Occupational) Samples		
Personal 1	2	Steve Mercer (440 minute sample)
Personal 2	3 & 4	Bill Krause (515 minute sample)
Personal 3	1	Bill Krause (440 minute sample)
Personal 4	5 & 7	Phil Marsden (287 minute sample)

wet / dry traps

Table 2-3 Sample Codes

Phase of project	Code	Sampling Site	Code	Sampling Location	Code	Trap (during T2)	Code
Phase I, prior to pipe installation	T1	Home	H (H1 to H9)	Basement	B1 and B2 (duplicates)	Wet	W
						Dry	D
Phase II, during pipe installation	T2			main floor	M		
Phase III, after pipe installation	T3			Outdoor	O		
		Manhole	M (M1 to M4)	in situ (actually, above manhole opening)	I1 and I2 (duplicates)		
				Upwind of manhole	U		
		Personal	P (P1 to P4)				
		Field Blank	Blk				

Examples:

T1-H2-M was collected on the main floor of Home #2 prior to pipe installation; T1-H3-B1 was collected in the basement of Home #3 prior to pipe installation.

T2-H5-M-W was collected on the main floor of Home #5 during the day of pipe installation, and the home had a wet trap.

T2-M1-I2 was the second of a duplicate set of samples (I2) collected on the first manhole test (M1) during the day of pipe installation (T2), while T2-M1-U was collected upwind of the manhole at the same time.

T2-P4 was the fourth personal sample (occupational exposure sample) which was collected during a day of pipe installation

2.2 SOLICITATION OF RESIDENTS

The solicitation of residents was undertaken by Toronto Works personnel. An introductory letter briefly outlining the study and describing some details of the in home measurements was distributed to randomly selected homes along various streets designated for sewer rehabilitation. Figure 2-1 shows a copy of the introductory letter. Residents who agreed to participate in the study received a follow-up visit from Toronto Works personnel and signed a release form. Copies of the release forms are in Appendix 1.

Figure 2-1 Introductory Letter Delivered to Selected Homes

TORONTO
Works & Emergency Services
Barry Gutteridge, Commissioner

Friday, September 15, 2000

Re: **Indoor & Ambient Air Quality Study**

Dear Sir or Madame:

My name is Sandra, and I am a 4th year student from University of Toronto working with the City of Toronto. As a requirement for my undergraduate degree in Civil Engineering Program, I am undertaking a thesis (research project) in collaboration with the Department of Works and Emergency Services under supervision of Professor Jeffrey Packer, Ph.D. P. Eng., University of Toronto, Department of Civil Engineering (416-978-4776). This project includes various studies and mainly focuses on the rehabilitation of gravity sewers.

As you should be aware by now, the sewers on your street will be rehabilitated in near future, and we are planning to use this opportunity to obtain some air quality information. The focus of the surveys on your street will involve the analysis of indoor and ambient air quality by Conor Pacific Environmental Technologies Inc. The study will require the preparation and gathering of stationary monitors for 3 trials in conjunction with the sewer rehabilitation work within a week.

The sampling would involve the use of a small number of charcoal sampling tubes, placed strategically in the basement and other functional areas of your home. Each property has a drain connection with the City's sanitary and storm sewers as per attached diagram. To avoid sewer gases traveling to your home, a drain trap is constructed at the time of your drain installation (see attached diagram). This drain trap is designed to be wet at all times in order to trap unwanted sewer gaseous from entering into your homes. Seldom these traps could become dry or defective, and as a result, sewer gases could enter into homes through basement floor drains. This can occur without knowledge to the resident due to the odourless quality of some sewer gases.

In sewer rehabilitation industry throughout the world, new plastic materials are often used for rehabilitating sewers to prolong their service life. Most of the plastics used today carry a distinctive odour. Along with regular sewer gases, this odour can find it's way through dry/defective drain traps into residential homes during some sewer rehabilitation projects. It is of interest to this study to evaluate the extent to which these odours and gases can enter a home with a dry/defective drain trap.

Various streets in your neighbourhood have been selected for rehabilitation, and we have randomly approached your address for our study. We are looking for residents who would be interested in co-operating. If you agree to participate, a specialist from Conor Pacific will visit at a later time to provide further details and to obtain information about your home's characteristics and other factors that may affect the composition of your indoor air. All information will be kept confidential.

If you like to obtain further information or have concerns about this study, please do not hesitate to contact me at (416) 992-4092 or any of the representatives listed below during the hours of 8:30 am to 4:30 pm.

Sincerely,

Sandra Hantziagelis

City of Toronto: Kamran Sarrami, P. Eng., Supervisor, Installation & Rehabilitation, (416) 394-2659
Conor Pacific: Philip Fellin, M.Sc., Manager, Air Monitoring & Analysis, (905) 822-0331 Ext. 105

3. DESCRIPTION OF METHODS

Sampling and analysis methods are documented in this section.

3.1 SAMPLING

Deployment of air sampling equipment for indoor air quality testing, ambient testing, manhole testing, and personal samples were scheduled in consultation with, and were witnessed by, Toronto Department of Works and Emergency Services personnel for Installation and Rehabilitation, Districts 1 & 2, Larry Tyo (Project Coordinator) and/or Justin Boroneic (Inspector). The designation of a residence as a "dry" or "wet" trap test home was determined by Toronto Works personnel. For those homes designated as a dry trap test home, the drain trap was pumped dry by a local plumbing contractor (Mike Kolakovic of "Mr. Rooter" plumbing).

Typical procedures for pipe installation on streets where test homes 1 to 4 were located included the following (times are approximate, to within 5 - 10 minutes):

- Insituform personnel began pipe installation at 7:00 – 8:00 a.m.
- Pipe was cured from 8:30 a.m. – 1:30 p.m.
- Manhole sections were cut from the cured pipe from about 1:30 p.m. to 3:00 p.m. (depending on the number of manholes). Then openings for lateral service lines were cut.

The process was considerably faster during December (homes 5 and 7) since the section of pipe installed was shorter compared to sections on other streets, and, according to Insituform personnel, the amount of catalyst in the resin-embedded tubing had been reformulated to decrease the curing time. (Typically, the liners are fabricated at Insituform's Michigan facility and then transported to the rehabilitation location in refrigerated trucks).

- Insituform personnel commenced pipe installation at 7:00 a.m.
- Pipe was cured from 8:45 a.m. to 11:00 a.m.
- Manhole sections were cut from the cured pipe about noon and service laterals were opened from approximately 12:45 to 2:45 p.m.

During the February 2001 testing at homes 8 and 9, the process was similar to the December 2000 installation (relatively short pipe section (approximately 133 metres) and faster-curing catalyst formulation) except that no pre-liner was used.

- Insituform personnel commenced pipe installation at 9:30 a.m.
- Pipe was cured from 10:15 a.m. to 12:45 a.m.
- Service lateral lines were cut open from approximately 2:00 to 4:00 p.m.

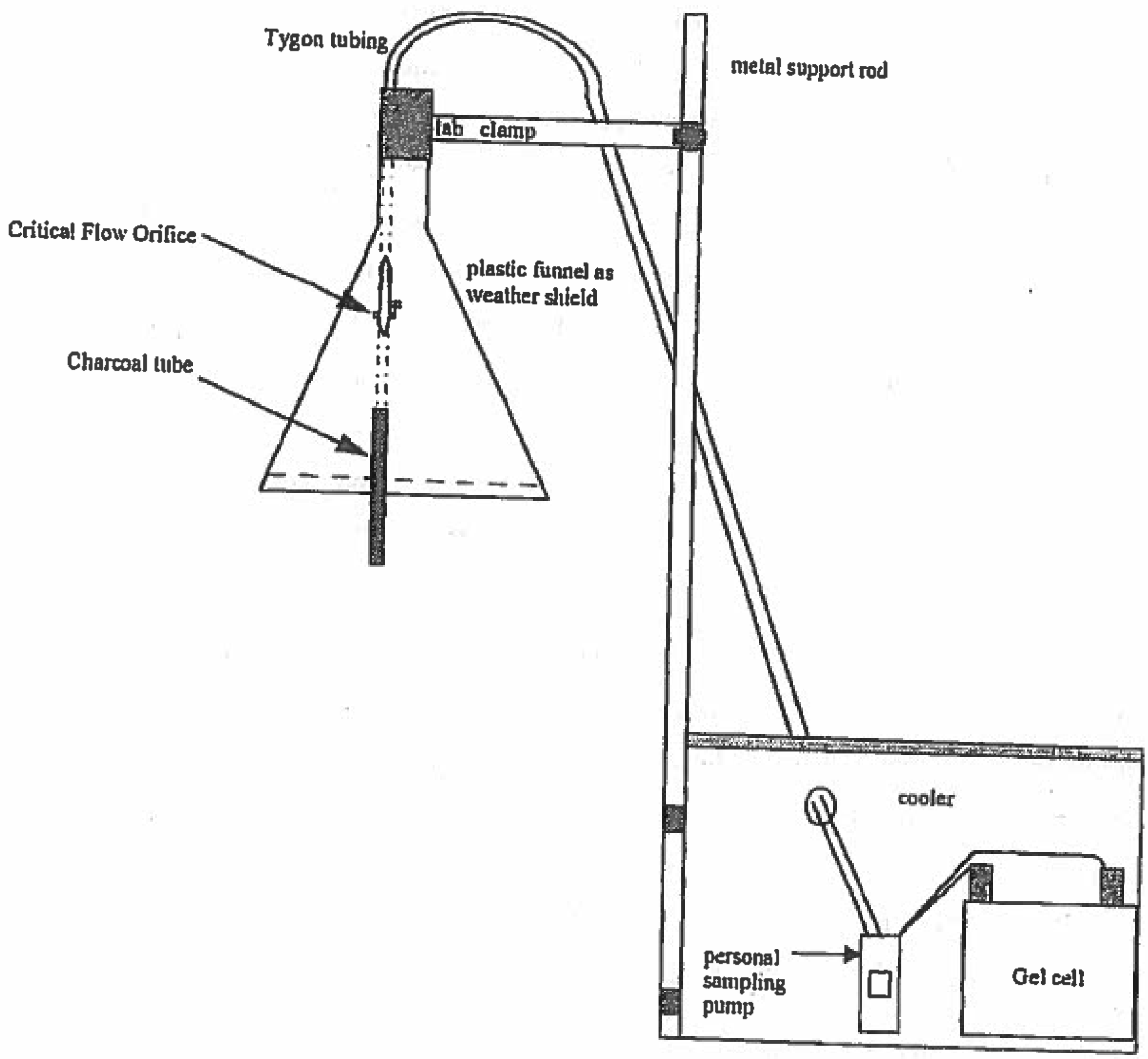
Since many of the residents of the test homes had employment obligations, samples were typically deployed between 7:00 and 8:30 a.m. and retrieved between 5:00 and 7:00 p.m.

All samples were collected by drawing air through 2-section (400 mg front section and 200 mg back section) charcoal sorbent tubes supplied by SKC Inc., Eighty Four, PA using intrinsically safe personal sampling pumps (SKC® Model 224). SKC battery packs and 6-volt gel cells, respectively, powered personal and area sampling pumps. Adjustable flow orifices (# 224-26-01, SKC Inc.) were used to set sampling flow rates to 100 mL/min. All pumps were calibrated with a gas flow standard (Mini-Buck Calibrator, Model M-5, A.P. Buck, Inc., Orlando, FL) before and after sampling. When sampling was completed, the samples were sealed and transported to the laboratory for analysis. Sample collection and analytical procedures were based on NIOSH Method 1501, *Aromatic Hydrocarbons*, except that gas chromatography coupled to mass spectrometry, operated in selected ion monitoring mode (GC/MS/SIM), was used to improve the specificity and sensitivity of analysis.

Indoor air quality samples in homes were collected at a height of about 1.5 metres above the floor, approximating the breathing zone of residents. Duplicate samples were collected in the basement area of each home within a 6 metre radius of the floor drain and another sample was collected in the living or dining room of the main floor. Samples were collected at the same locations within each home during each monitoring phase.

Ambient air samples (outdoor samples at homes, or upwind background samples during manhole monitoring) were collected at a height of approximately 1.5 metres above the ground using the set-up shown in Figure 3-1.

Figure 3-1 Sampling Set-Up for Ambient Air Monitoring



Manhole samples were collected at sites intermediate in the pipe installation process length (see site diagrams in Appendix 2) and were suspended 10 cm above manhole-cover level. During sampling, the cover remained ajar in order to provide an opening for measuring emissions from the manhole during the pipe curing process. These samples were exposed for as long as possible (i.e. 6 – 8 hours) until they interfered with contractor operations for cutting out the manhole sections of the cured pipe. However, during the CIPP installation at homes 8 and 9 (when no pre-liner was used), the sample was collected at the manhole where the "tail" of the curing pipe was located since there was no intermediate manhole and there was too much water and Insituform personnel activity at the "head" of the curing pipe to guarantee the security and validity of the sample. Moreover, this sample was only exposed for 2.5 hours since it would have interfered with contractor operations at the termination of the curing process. At the end of the process, the "tail" is punctured and water sprays vigorously from the manhole, compromising the integrity of the sample. Once the spray dissipates, personnel enter the manhole to remove the tail section. Then the cutting of the openings for the lateral lines begins.

To evaluate occupational exposures of Insituform employees, sampling media were suspended from the employees' collars to collect representative breathing zone exposures. The Insituform site foreman, Steve Mercer, selected an employee for personal exposure monitoring on each of the four pipe installation days. This employee remained on-site during the entire pipe installation and curing process, but not necessarily during the cutting of manholes and lateral lines. A summary of the samples collected is given in Table 3-1 and copies of the Sample Custody Form for each sample of the study are provided in Appendix 3.

Table 3-1 *Summary of Samples Collected*

Project Phase	Sample Type					Total
	Indoor	Ambient	QA/QC Field Blanks	Manhole	Personal	
T1 (pre-installation)	27	4	3			34
T2 (during CIPP Installation)	24	4	4	11	4	47
T3 (post-installation)	24	5	4			33
Total	75	13	11	11	4	114

3.2 EXTRACTION AND ANALYSIS

At the analytical laboratory the charcoal sorbent tubes were scored with a file, carefully broken open, and the front and back sections of charcoal were poured directly from the tube into individual 4 mL vials. The charcoal was extracted with carbon disulphide (CS_2) solvent which had been spiked with a deuterated internal reference compound to evaluate analytical method integrity.

All samples were analyzed with GC/MS/SIM. Complete details of the laboratory analysis including, the reagents and materials used, the preparation of standards, analytical instrumentation, and the chromatographic conditions are in Appendix 5.

Detailed data for the laboratory analyses are provided in Appendix 6. Exact sampling times and sampling rates (pump flow rates) were used to determine air volumes for each sample.

3.3 QUALITY ASSURANCE AND QUALITY CONTROL

Quality assurance and control (QA/QC) measures included:

- adherence to sampling protocols by field personnel
- collection of field blanks and duplicate samples. Field blanks were collected at three of the homes in each of the three phases of the study. Duplicate samples were collected in the basement of each home in all phases of the study, and duplicate samples were also collected at manhole openings during three of the four pipe installation days.
- analysis of unexposed charcoal sorbent tube extracts with each batch of extracts to verify blank levels.
- GC/MS/SIM analysis of all extracts.
- use of standard materials during analysis and a deuterated internal standard compounds in each extract.
- use of multi-point (6-point) calibration solutions and solvent blanks.

4. RESULTS

4.1 DATA COMPLETENESS

Table 3-1 gives a summary of the samples collected, 114 samples in total, including 3 or 4 field blanks in each phase of the study for a total of 11 QA/QC samples (10% of study total). Due to generally favourable weather conditions and good cooperation from residents and Insituform employees, all samples (indoor, ambient, manhole emissions, and personal exposures) were collected as planned. In some cases, outdoor samples served as the background for several of the homes when indoor sampling was executed simultaneously in several homes. Also, on two occasions during Phase II (during CIPP installation testing for homes 3 and 4, and for homes 8 and 9) the upwind sample for manhole emissions testing also served as the outdoor sample for the test homes.

4.2 DATA CHARACTERISTICS AND QUALITY

Indicators of analytical performance are discussed in this section, including blanks, method detection limits, internal standards, recovery efficiency, calibration and precision.

Blanks

Blank values were determined by analysis of unexposed sampling media kept in the laboratory and of field blank samples carried to test homes, momentarily exposed by handling in the same manner as samples, and then sealed and transported with exposed samplers to the laboratory. Styrene concentrations as well as all other VOC concentrations were below the analytical detection limit (0.02 µg (micrograms)/sample) in all field blanks, indicating that handling and transport of samplers did not contribute to the background levels on the sampling media.

Method Detection Limits

Detection limits are determined by the CFR 40 method whereby the reproducibility of seven low-level standard solutions is used to establish a statistically-based detection limit. This limit provides a 95% confidence level for determining false positives (i.e., a 5% chance of determining that a value below the detection limit will be listed as detected) and a similar level of confidence for false negatives (i.e. a 5% chance that a value above the detection limit will be listed as not detected). The detection limits for each sample are shown in the Analysis

Reports in Appendix 6. The calculated method detection limits for the target VOCs were all below 0.5 µg/m^3 (0.0001 ppm) and many were below 0.1 µg/m^3 (0.00002 ppm). Where a "less than" sign (<) appears in the laboratory reports and in summary tables, it indicates that the level measured was below the analytical detection limit, corrected for sample volume.

Internal Standards

A deuterated internal reference compound, toluene-d^8, was introduced into the extraction solvent prior to the extraction of samples. Data from this compound provides information to assess the stability of instrumental performance during analysis (retention time stability) and the reproducibility of analysis (at one concentration level). The samples were analyzed in five batches. Typically, the standard deviation of determination of the internal reference compound was less than 5% (relative standard deviation) RSD, indicating that analytical control was being maintained during each batch of analyses.

Recovery Efficiency

The recovery efficiencies were typically 90 - 95% for all compounds except naphthalene which was typically 33%.

Calibration

The correlation coefficient (r^2) for least squares linear regression analysis for calibration of the analysis instrument response was 0.999 or better for all the VOC target compounds and each analysis batch.

Precision

Results for duplicate samples from the basement of each home and the duplicate manhole samples in the detailed results (Appendix 6) give an indication of the measurement precision. Agreement between co-located samples was generally very good (i.e., typically within 10% RSD for compounds measured at more than ten times the detection limit).

4.3 AIRBORNE CONCENTRATIONS OF STYRENE AND OTHER VOCs

Airborne concentrations of styrene in the homes, in outdoor ambient air, in manhole emissions, and in personal exposures are summarized in Table 4-1. A summary of results for other VOCs measured inside and outside homes is shown in Table 4-2 while VOC concentrations at manholes and in personal exposures are in Table 4-3.

All concentrations from test samples are expressed in the report as parts per million (ppm). Where a "less than" sign (<) appears, it indicates that the level measured was below the analytical detection limit, corrected for sample volume. The original laboratory results (Appendix 6) are expressed in micrograms per cubic metre ($\mu g/m^3$) but, these have been converted to ppm in the main body of the report.

A listing of occupational limits (Ontario Reg. 833 TWAEV), ACGIH guidelines, indoor air quality guidelines and Ontario Ministry of Environment ambient air quality standards based on ground level point-of-impingement concentrations are provided in Table 4-4.

Table 4-5 gives a summary of the meteorological conditions during the days of CIPP installation. Meteorological records are also provided in Appendix 4.

4.3.1 VOC Levels in Residences - Styrene

Table 4-1 indicates that, in residential indoor air, styrene levels were typically below the detection limit (<0.00002 ppm) for most homes prior to CIPP installation. One home (Test Home #9) had styrene concentrations less than 0.00007 ppm prior to CIPP installation. In four of the eight test homes, the styrene levels remained below 0.0002 ppm during and after pipe installation In two test homes, Home #5 and #7, indoor styrene levels increased to about 0.01 and 0.025 ppm, respectively, for basement samples during the CIPP process and then fell to 0.0003 and 0.003 ppm, respectively, two days after pipe installation.

The highest recorded indoor styrene levels were in Homes #2 and #9, reaching 0.1 and 0.2 ppm, respectively, in the basement during pipe installation, but even in these cases, the indoor styrene concentrations diminished to 0.001 and 0.005 ppm, respectively, within two days of pipe installation. The highest residual styrene levels, two days after pipe installation were in dry trap homes (7 and 9) but these were only 0.003 – 0.005 ppm. Levels on the main floor living areas of all the test homes never exceeded 0.02 ppm.

Table 4-1 *Styrene Results (ppm)*

Sampling Site		Time of Sampling Relative to Pipe Installation		
Test Home	Location	Before (T1)	During (T2)	After (T3)
1 (wet)	basement 1	<0.00002	0.0002	<0.00002
	basement 2	<0.00002	<0.00007	<0.00002
	main floor	<0.00002	0.0001	<0.00002
	outdoor	<0.00002	0.0002	<0.00002
2 (dry)	basement 1	<0.00002	0.1	0.0006
	basement 2	<0.00002	0.1	0.0010
	main floor	<0.00002	0.005	0.0003
	outdoor	<0.00002	<0.00009	<0.00002
3 (wet)	basement 1	<0.00002	0.00009	0.00005
	basement 2	<0.00002	<0.00009	0.00005
	main floor	<0.00002	0.0003	0.0002
	outdoor	<0.00002	<0.00007	<0.00002
4 (dry)	basement 1	<0.00002	<0.00007	0.00002
	basement 2	<0.00002	<0.00009	0.00002
	main floor	<0.00002	<0.00007	0.0002
	outdoor	<0.00002	<0.00007	<0.00002
5 (wet)	basement 1	<0.00002	0.01	0.0003
	basement 2	<0.00002	0.01	0.0003
	main floor	<0.00002	0.003	0.0001
	outdoor	<0.00002	0.0004	0.00002
7 (dry)	basement 1	<0.00005	0.02	0.003
	basement 2	<0.00005	0.03	0.003
	main floor	<0.00005	<0.00012	0.004
	outdoor	<0.00005	0.0004	0.00002
8 (wet)	basement 1	<0.00002	0.0001	0.0003
	basement 2	<0.00002	0.0002	0.00005
	main floor	<0.00002	<0.00009	0.00005
	outdoor	<0.00002	0.0002	<0.00002
9 (dry)	basement 1	0.00007	0.2	0.004
	basement 2	0.00007	0.2	0.006
	main floor	0.0007	0.02	0.002
	outdoor	<0.00002	0.0002	<0.00002
manhole 1	in situ 1		0.98	
	in situ 2		0.73	
	upwind		0.00019	
manhole 2	in situ 1		0.16	
	in situ 2		0.16	
	upwind		<0.00007	
manhole 3	in situ 1		1.49	
	in situ 2		1.13	
	upwind		<0.00009	
manhole 4	in situ 1		3.19	
	in situ 2		3.05	
	upwind		0 00016	
personal 1			0.45	
personal 2			0.52	
personal 3			0.42	
personal 4			0.078	

Test Home 6: styrene concentrations were < 0.00002 ppm during T1
this home was not tested during T2 and T3

all field blanks were <0.000005 ppm during all phases of the study

Table 4-2 *VOC Average Indoor Concentrations, and Outdoor Concentrations at Test Homes (ppm)*

a) Home 1 and 2

Compound	HOME 1						HOME 2					
	Indoor			Outdoor			Indoor			Outdoor		
	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
DICHLOROMETHANE	0.01	0.003	0.006	<0.00003	<0.0001	<0.00003	<0.00003	0.0002	0.0002	<0.00003	0.0003	<0.00003
n-HEXANE	0.0003	0.0002	0.0003	<0.00003	<0.0001	0.0004	0.001	0.0004	<0.00003	<0.00003	0.0002	<0.00003
CHLOROFORM	0.001	0.0003	0.0001	<0.00002	0.0002	0.0001	0.0001	0.0002	0.0004	<0.00002	0.0001	0.00004
1,2-DICHLOROETHANE	<0.00002	<0.0001	0.00003	<0.00002	<0.0001	<0.00002	0.0001	<0.0001	0.00003	<0.00002	<0.0001	<0.00002
BENZENE	<0.00003	<0.0001	<0.00003	<0.00003	<0.0001	<0.00003	<0.00003	<0.0001	0.0001	<0.00003	<0.0001	<0.00003
TRICHLOROETHYLENE	<0.00002	<0.0001	<0.00002	<0.00002	<0.0001	<0.00002	<0.00002	<0.0001	<0.00002	<0.00002	<0.0001	<0.00002
TOLUENE	0.0008	0.001	0.003	0.0003	0.0008	0.003	0.02	0.005	0.01	0.0003	0.002	0.0005
TETRACHLOROETHYLENE	0.00002	0.00004	0.0001	<0.00001	0.0001	0.0001	0.0001	0.0001	0.0001	<0.00001	<0.0001	0.00004
ETHYLBENZENE	0.0001	0.0002	0.0003	0.0001	0.0001	0.0003	0.002	0.0008	0.002	0.0001	<0.0001	0.0001
XYLENES	0.0005	0.0008	0.001	0.0002	0.0006	0.002	0.007	0.003	0.007	0.0002	0.0001	0.0003
CUMENE	0.0003	0.0003	0.0006	0.00003	<0.0001	0.0002	0.002	0.001	0.002	0.00003	<0.0001	0.0001
α-PINENE	0.0002	0.0002	0.0002	<0.00002	<0.0001	0.00003	0.002	0.0008	0.002	<0.00002	<0.0001	0.00001
1,1,2,2-TETRACHLOROETHANE	<0.00001	<0.00004	<0.00001	<0.00001	<0.00004	<0.00003	<0.00001	<0.0001	<0.00001	<0.00001	<0.0001	<0.00001
n-DECANE	0.0001	0.0001	0.0001	<0.00002	0.0001	0.0002	0.0004	0.0001	0.0005	<0.00002	<0.0001	0.00004
1,3,5-TRIMETHYLBENZENE	0.00003	<0.0001	0.0001	0.00002	<0.0001	0.0001	0.0002	0.0001	0.0002	0.00002	<0.0001	0.00002
1,2,4-TRIMETHYLBENZENE	0.0001	0.0001	0.0002	0.00004	0.0001	0.0002	0.0005	0.0003	0.0005	0.00004	<0.0001	0.00004
PENTACHLOROETHANE	<0.00001	<0.00004	<0.00001	<0.00001	<0.00004	0.00003	<0.00001	<0.00005	0.00001	<0.00001	<0.00005	<0.00001
d-LIMONENE	0.0003	0.0002	0.0003	<0.00002	0.0001	0.0001	0.002	0.002	0.003	<0.00002	<0.0001	0.00001
p-CYMENE	0.00005	<0.0001	0.00003	<0.00002	<0.0001	<0.00002	0.0003	0.0001	0.0002	<0.00002	<0.0001	<0.00002
1,3-DICHLOROBENZENE	<0.00002	<0.00005	0.00003	<0.00002	<0.00005	<0.00003	<0.00002	<0.0001	<0.00002	<0.00002	<0.0001	<0.00002
1,4-DICHLOROBENZENE	<0.00002	<0.00005	0.0001	<0.00002	<0.00005	0.0001	<0.00002	<0.0001	<0.00002	<0.00002	<0.0001	<0.00002
HEXACHLOROETHANE	<0.00001	<0.00003	<0.00001	<0.00001	<0.00003	<0.00001	<0.00001	<0.00004	0.00001	<0.00001	<0.00004	<0.00001
1,2,4-TRICHLOROBENZENE	<0.00001	<0.00004	<0.00001	<0.00001	<0.00004	<0.00003	0.00002	<0.0001	<0.00001	<0.00001	<0.0001	<0.00001
NAPHTHALENE	0.00002	<0.0001	<0.00002	<0.00002	<0.0001	0.00002	0.00003	<0.0001	0.00003	<0.00002	<0.0001	<0.00002

Table 4-2 VOC Average Indoor Concentrations, and Outdoor Concentrations at Test Homes (ppm) (continued)

b) Home 3 and 4

Compound	HOME 3						HOME 4					
	Indoor			Outdoor			Indoor			Outdoor		
	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
DICHLOROMETHANE	0.0002	0.001	0.00004	<0.00003	0.0007	<0.00003	0.002	0.003	0.002	<0.00003	0.0007	<0.00003
n-HEXANE	0.002	0.002	<0.00003	<0.00003	0.0005	<0.00003	0.0005	0.0007	<0.00003	<0.00003	0.0005	<0.00003
CHLOROFORM	0.0001	0.0002	0.0001	<0.00002	<0.0001	0.00001	0.00003	<0.0001	0.00004	<0.00002	<0.0001	0.00001
1,2-DICHLOROETHANE	<0.00002	<0.0001	0.00003	<0.00002	<0.0001	0.00002	<0.00002	<0.0001	0.00003	<0.00002	<0.0001	0.00002
BENZENE	<0.00003	0.0005	<0.00003	<0.00003	0.0007	<0.00003	<0.00003	0.001	<0.00003	<0.00003	0.0007	<0.00003
TRICHLOROETHYLENE	<0.00002	<0.0001	<0.00002	<0.00002	<0.0001	<0.00002	<0.00002	<0.0001	<0.00002	<0.00002	<0.0001	<0.00002
TOLUENE	0.005	0.005	0.002	0.0003	0.003	0.001	0.0006	0.003	0.001	0.0003	0.003	0.001
TETRACHLOROETHYLENE	0.01	0.004	0.002	<0.00001	0.0001	0.0001	0.00004	0.0001	0.0001	<0.00001	0.0001	0.0001
ETHYLBENZENE	0.0008	0.0006	0.0003	0.0001	0.0003	0.0002	0.0001	0.0003	0.0002	0.0001	0.0003	0.0002
XYLENES	0.005	0.003	0.002	0.0002	0.001	0.0008	0.0004	0.001	0.0009	0.0002	0.001	0.0008
CUMENE	0.01	0.006	0.004	0.00003	0.0002	0.0001	0.0002	0.0003	0.0002	0.00003	0.0002	0.0001
α-PINENE	0.01	0.005	0.003	<0.00002	<0.0001	0.00002	0.0001	0.0001	0.0001	<0.00002	<0.0001	0.00002
1,1,2,2-TETRACHLOROETHANE	0.00002	<0.0001	0.00001	<0.00001	<0.00004	<0.00001	<0.00001	<0.0001	<0.00001	<0.00001	<0.00004	<0.00001
n-DECANE	0.001	0.001	0.0006	<0.00002	0.0001	0.0001	0.0002	0.0001	0.0002	<0.00002	0.0001	0.0001
1,3,5-TRIMETHYLBENZENE	0.0002	0.0002	0.0001	0.00002	0.0001	0.00004	0.00004	0.0001	0.0001	0.00002	0.0001	0.00004
1,2,4-TRIMETHYLBENZENE	0.0009	0.0007	0.0004	0.00004	0.0002	0.0001	0.0001	0.0002	0.0001	0.00004	0.0002	0.0001
PENTACHLOROETHANE	<0.00001	<0.00005	0.00001	<0.00001	<0.00004	<0.00001	<0.00001	<0.00005	<0.00001	<0.00001	<0.00004	<0.00001
d-LIMONENE	0.003	0.002	0.002	<0.00002	0.0001	0.00005	0.0001	0.0002	0.0001	<0.00002	0.0001	0.00005
p-CYMENE	0.001	0.0005	0.0004	<0.00002	<0.0001	<0.00002	0.00002	<0.0001	0.00001	<0.00002	<0.0001	<0.00002
1,3-DICHLOROBENZENE	<0.00002	<0.0001	<0.00002	<0.00002	<0.00005	<0.00002	<0.00002	<0.0001	0.00002	<0.00002	<0.00005	<0.00002
1,4-DICHLOROBENZENE	0.00002	<0.0001	<0.00002	<0.00002	<0.00005	<0.00002	<0.00002	<0.0001	<0.00002	<0.00002	<0.00005	<0.00002
HEXACHLOROETHANE	<0.00001	<0.00004	0.00001	<0.00001	<0.00003	<0.00001	<0.00001	<0.00004	<0.00001	<0.00001	<0.00003	<0.00001
1,2,4-TRICHLOROBENZENE	<0.00001	<0.0001	0.00001	<0.00001	<0.00004	<0.00001	<0.00001	<0.0001	<0.00001	<0.00001	<0.00004	<0.00001
NAPHTHALENE	0.0001	0.0001	0.0001	<0.00001	<0.0001	<0.00002	<0.00002	<0.0001	<0.00002	<0.00002	<0.0001	<0.00002

Table 4-2 VOC Average Indoor Concentrations, and Outdoor Concentrations at Test Homes (ppm) (continued)

c) Home 5 and 7

Compound	HOME 5						HOME 7					
	Indoor			Outdoor			Indoor			Outdoor		
	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
DICHLOROMETHANE	0.0004	0.0003	0.0004	0.0006	<0.0001	0.0004	0.001	0.003	0.005	<0.00006	<0.0001	0.0004
n-HEXANE	0.002	0.0006	0.0002	0.0008	0.0005	0.0007	0.0005	0.0002	0.0004	<0.00006	0.0005	0.0007
CHLOROFORM	0.0002	0.0001	0.0001	0.0001	0.0001	0.00005	0.0003	<0.0001	0.0003	0.0001	0.0001	0.00005
1,2-DICHLOROETHANE	0.00003	0.0001	0.00003	0.00003	<0.0001	<0.00002	<0.00005	<0.0001	<0.00002	<0.00005	<0.0001	<0.00002
BENZENE	0.0008	0.001	0.0003	0.001	0.001	0.001	<0.00006	0.0004	0.0005	<0.00006	0.001	0.001
TRICHLOROETHYLENE	0.00003	0.00004	0.00004	0.0001	<0.0001	0.0001	<0.00004	<0.0001	0.0001	<0.00004	<0.0001	0.0001
TOLUENE	0.002	0.002	0.002	0.004	0.002	0.002	0.008	0.0009	0.002	0.003	0.002	0.002
TETRACHLOROETHYLENE	0.0001	0.0001	0.0001	0.0002	<0.00004	0.0001	0.001	0.0003	0.0005	0.0001	<0.00004	0.0001
ETHYLBENZENE	0.0003	0.0003	0.0002	0.0004	0.0003	0.0003	0.0006	0.0002	0.0003	0.0003	0.0003	0.0003
XYLENES	0.001	0.001	0.0008	0.002	0.001	0.001	0.003	0.0007	0.001	0.001	0.001	0.001
CUMENE	0.0009	0.0004	0.0002	0.0007	0.0001	0.0002	0.001	0.0007	0.0009	<0.00004	0.0001	0.0002
α-PINENE	0.0003	0.0001	0.0001	0.0002	<0.0001	<0.00002	0.0007	0.0001	0.0004	<0.00004	<0.0001	<0.00002
1,1,2,2-TETRACHLOROETHANE	0.00002	0.00003	<0.00001	<0.00001	<0.00004	<0.00001	<0.00003	<0.0001	<0.00001	<0.00003	<0.00004	<0.00001
n-DECANE	0.002	0.0002	0.0001	0.0001	0.0001	0.0001	0.005	0.0004	0.0009	0.0001	0.0001	0.0001
1,3,5-TRIMETHYLBENZENE	0.0004	0.0001	0.0001	0.0001	0.0001	0.0001	0.0006	0.0002	0.0002	0.0001	0.0001	0.0001
1,2,4-TRIMETHYLBENZENE	0.001	0.0001	0.0001	0.0002	0.0002	0.0002	0.002	0.0003	0.0005	0.0002	0.0002	0.0002
PENTACHLOROETHANE	<0.00001	0.00003	<0.00001	<0.00001	<0.00004	<0.00001	<0.00002	<0.00005	<0.00001	<0.00002	<0.00004	<0.00001
d-LIMONENE	0.0006	0.0002	0.0009	0.002	0.00005	0.00004	0.02	0.0001	0.0009	<0.00004	0.00005	0.00004
p-CYMENE	0.0001	0.00004	0.00003	0.00004	<0.0001	<0.00002	0.0002	<0.0001	0.0001	<0.00004	<0.0001	<0.00002
1,3-DICHLOROBENZENE	0.00002	0.00004	0.00002	0.00002	<0.00005	<0.00002	<0.00003	<0.0001	<0.00002	<0.00003	<0.00005	<0.00002
1,4-DICHLOROBENZENE	0.00002	0.00004	<0.00002	<0.00002	<0.00005	<0.00002	0.0001	<0.0001	0.00002	<0.00003	<0.00005	<0.00002
HEXACHLOROETHANE	0.00001	0.00002	<0.00001	<0.00001	<0.00003	<0.00001	<0.00002	<0.00004	<0.00001	<0.00002	<0.00003	<0.00001
1,2,4-TRICHLOROBENZENE	0.00002	0.00003	<0.00001	<0.00001	<0.00004	<0.00001	<0.00003	<0.0001	<0.00001	<0.00003	<0.00004	<0.00001
NAPHTHALENE	0.0002	0.00004	<0.00002	<0.00002	<0.0001	<0.00002	0.0002	<0.0001	<0.00002	<0.00004	<0.0001	<0.00002

Table 4-2 *VOC Average Indoor Concentrations, and Outdoor Concentrations at Test Homes (ppm) (continued)*

d) Home 8 and 9

Compound	HOME 8						HOME 9					
	Indoor			Outdoor			Indoor			Outdoor		
	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
DICHLOROMETHANE	0.0002	0.0005	<0.00003	<0.00003	<0.0001	<0.00003	0.0001	0.02	0.01	<0.00003	<0.0001	<0.00003
n-HEXANE	0.001	0.0008	0.002	0.0005	<0.0001	0.0004	0.01	0.01	0.009	0.0005	<0.0001	0.0004
CHLOROFORM	0.00003	0.00004	<0.00002	<0.00002	<0.0001	<0.00002	0.0001	0.0001	0.0001	<0.00002	<0.0001	<0.00002
1,2-DICHLOROETHANE	0.00003	0.00005	0.00003	<0.00002	<0.0001	<0.00002	0.00002	0.00005	0.00003	<0.00002	<0.0001	<0.00002
BENZENE	0.0004	0.0003	0.0005	0.0003	0.0008	0.0007	0.0004	0.0004	0.0006	0.0003	0.0008	0.0007
TRICHLOROETHYLENE	0.00002	0.00004	<0.00002	<0.00002	<0.0001	<0.00002	<0.00002	0.00004	<0.00002	<0.00002	<0.0001	<0.00002
TOLUENE	0.02	0.02	0.003	0.001	0.0003	0.004	0.004	0.007	0.002	0.001	0.0003	0.004
TETRACHLOROETHYLENE	0.00003	0.00004	0.00003	0.00002	<0.0001	0.00004	0.00004	0.00004	0.00003	0.00002	<0.0001	0.00004
ETHYLBENZENE	0.0002	0.0001	0.001	0.0001	<0.0001	0.0001	0.009	0.002	0.0005	0.0001	<0.0001	0.0001
XYLENES	0.0009	0.0004	0.006	0.0003	<0.0001	0.0005	0.04	0.01	0.003	0.0003	<0.0001	0.0005
CUMENE	0.0001	0.0001	0.0001	<0.00002	<0.0001	<0.00002	0.001	0.001	0.0004	<0.00002	<0.0001	<0.00002
α-PINENE	0.0004	0.0003	0.0005	<0.00002	<0.0001	<0.00002	0.002	0.002	0.002	<0.00002	<0.0001	<0.00002
1,1,2,2-TETRACHLOROETHANE	<0.00001	0.00003	<0.00001	<0.00001	<0.0001	<0.00001	0.0002	0.0005	0.00001	<0.00001	<0.0001	<0.00001
n-DECANE	0.0002	0.0002	0.0004	0.00002	<0.0001	0.0001	0.02	0.08	0.002	0.00002	<0.0001	0.0001
1,3,5-TRIMETHYLBENZENE	0.0001	0.0001	0.0003	0.00003	<0.0001	0.00002	0.002	0.002	0.0006	0.00003	<0.0001	0.00002
1,2,4-TRIMETHYLBENZENE	0.0002	0.0002	0.0003	0.00005	<0.0001	0.0001	0.004	0.005	0.0006	0.00005	<0.0001	0.0001
PENTACHLOROETHANE	<0.00001	<0.00005	0.00002	<0.00001	<0.00005	<0.00001	0.00002	0.00004	<0.00001	<0.00001	<0.00005	<0.00001
d-LIMONENE	0.002	0.0002	0.0009	<0.00002	0.0001	<0.00002	0.004	0.002	0.001	<0.00002	0.0001	<0.00002
p-CYMENE	0.0001	0.00004	0.00002	<0.00002	<0.0001	<0.00002	0.0003	0.0002	0.0001	<0.00002	<0.0001	<0.00002
1,3-DICHLOROBENZENE	<0.00002	<0.0001	<0.00002	<0.00002	<0.0001	<0.00002	<0.00002	0.00003	<0.00002	<0.00002	<0.0001	<0.00002
1,4-DICHLOROBENZENE	0.00005	<0.0001	0.0001	<0.00002	<0.0001	<0.00002	<0.00002	0.00003	<0.00002	<0.00002	<0.0001	<0.00002
HEXACHLOROETHANE	<0.00001	<0.00004	<0.00001	<0.00001	<0.00004	<0.00001	<0.00001	0.00002	<0.00001	<0.00001	<0.00004	<0.00001
1,2,4-TRICHLOROBENZENE	<0.00001	<0.0001	<0.00001	<0.00001	<0.0001	<0.00001	<0.00001	0.00003	<0.00001	<0.00001	<0.0001	<0.00001
NAPHTHALENE	<0.00002	<0.0001	0.00002	<0.00002	<0.0001	<0.00002	0.00004	0.00004	<0.00002	<0.00002	<0.0001	<0.00002

Table 4-3 *VOC Concentrations in Manhole Emissions and Personal Exposure Samples (ppm)*

Compounds	Manholes								Personal (Occupational) Exposures			
	M1		M2		M3		M4		P1	P2	P3	P4
	manhole	upwind	manhole	upwind	manhole	upwind	manhole	upwind	Sept. 25	Sept. 26	Sept. 27	Dec. 13
DICHLOROMETHANE	0.0003	<0.0001	0.0003	0.0007	<0.0001	<0.0001	<0.0003	<0.0001	0.001	0.001	<0.0001	<0.0002
n-HEXANE	0.0004	0.0004	0.0008	0.0005	0.0004	<0.0001	<0.0003	<0.0001	0.001	0.004	0.001	0.001
CHLOROFORM	0.0002	0.0002	<0.0001	<0.0001	0.0005	0.0004	<0.0002	<0.0001	<0.0001	<0.0001	0.0003	<0.0001
1,2-DICHLOROETHANE	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0002	<0.0001	<0.0001	<0.0001	<0.0001	0.0002
BENZENE	0.0003	<0.0002	0.001	0.0006	<0.0002	<0.0001	0.003	0.0007	0.002	0.003	<0.0001	0.002
TRICHLOROETHYLENE	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
TOLUENE	0.002	0.001	0.004	0.003	0.002	0.001	0.006	0.0003	0.005	0.01	0.007	0.01
TETRACHLOROETHYLENE	<0.0001	<0.0001	0.0002	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001
ETHYLBENZENE	0.001	<0.0001	0.0007	0.0004	0.002	0.0001	0.004	<0.0001	0.001	0.002	0.001	0.001
XYLENES	0.005	0.0003	0.003	0.002	0.009	0.0005	0.02	<0.0001	0.005	0.01	0.007	0.007
CUMENE	0.002	<0.0001	0.0008	0.0002	0.004	0.0002	0.002	<0.0001	0.002	0.004	0.003	0.006
α-PINENE	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
1,1,2,2-TETRACHLOROETHANE	<0.0001	<0.0001	<0.0001	<0.00004	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002
n-DECANE	0.0003	<0.0001	0.0002	0.0001	0.001	<0.0001	0.001	<0.0001	<0.0001	0.002	0.001	0.009
1,3,5-TRIMETHYLBENZENE	0.001	<0.0001	0.0002	0.0001	0.002	<0.0001	0.004	<0.0001	0.001	0.002	0.001	0.001
1,2,4-TRIMETHYLBENZENE	0.003	<0.0001	0.0006	0.0002	0.005	<0.0001	0.007	<0.0001	0.001	0.004	0.003	0.003
PENTACHLOROETHANE	<0.0001	<0.0001	<0.0001	<0.00004	<0.0001	<0.00005	<0.0001	<0.00005	<0.00005	<0.00005	<0.00005	<0.0001
d-LIMONENE	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	0.0004	0.0001	0.001	0.001	0.001	0.0002
p-CYMENE	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0002	<0.0001	<0.0001	0.0001	<0.0001	0.0003
1,3-DICHLOROBENZENE	<0.0001	<0.0001	<0.0001	<0.00005	<0.0001	<0.0001	<0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
1,4-DICHLOROBENZENE	<0.0001	<0.0001	<0.0001	<0.00005	<0.0001	<0.0001	<0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
HEXACHLOROETHANE	<0.0001	<0.0001	<0.0001	<0.00003	<0.0001	<0.00004	<0.0001	<0.00004	<0.00004	<0.00004	<0.00004	<0.0001
1,2,4-TRICHLOROBENZENE	<0.0001	<0.0001	<0.0001	<0.00004	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
NAPHTHALENE	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Table 4-4 *Occupational Limits and Guidelines, Typical Residential Indoor Levels, and Outdoor Regulation Levels (ppm)*

Compound	INDOOR			OUTDOOR
	Occupational		Residential	
	Ont Reg 833 TWAEV ppm	ACGIH TWA ppm	Typical Indoor Residential Range of Means** ppm	POI half-hour ppm
Styrene	50[*]	20[b]	0.0001 - 0.0007	0.094
Dichloromethane	50	50	0.005	UD
n-Hexane	50	50	0.0003 - 0.003	9.9
Chloroform	10	10	0.0001 - 0.001	0.31
1,2-Dichloroethane	10	10	<0.00002	0.15[f]
Benzene	1.0	0.5	0.0008 - 0.01	ne[g]
Trichloroethylene	50	50	0.0001 - 0.002	0.65
Toluene	50	50[b]	0.003 - 0.02	0.53
Tetrachloroethylene	25	25	0.0002 - 0.002	UD
Ethylbenzene	100	100	0.0001 - 0.003	0.92
Xylenes	100[a]	100[a]	0.0001 - 0.005	0.53[c]
Cumene	50[b]	50[b]	-	ne
α-Pinene	ne	ne	0.0008 - 0.002	ne
1,1,2,2-Tetrachloroethane	1[b]	1[b]	<0.00001 - 0.00001	ne
n-Decane	ne	ne	0.0004 - 0.005	UD
1,3,5-Trimethylbenzene	25[c]	25[c]	0.0005 - 0.0008	ne
1,2,4-Trimethylbenzene	25[c]	25[c]	0.0009 - 0.002	0.10
Pentachloroethane	ne	ne	<0.00001	ne
d-Limonene	ne	25[d]	0.002 - 0.005	ne
p-Cymene	50[a]	25[d]	~0.0002	ne
1,3-Dichlorobenzene	ne	25	<0.00002	6.2
1,4-Dichlorobenzene	10	10	0.0001 - 0.004	0.047
Hexachloroethane	1	1[b]	<0.00001	ne
1,2,4-Trichlorobenzene	ne	5 (C)	0.00001 - 0.0001	0.013
Naphthalene	10	10	0.0004 - 0.0008	0.0069

Ont. Reg. 833 is the Ontario Ministry of Labour Regulation respecting Control of Exposure to Biological and Chemical Agents (O. Reg. 833, as amended by 513/92; 597/94) and includes the new Ontario regulations which became effective Sept. 30, 2000

TWAEV = Time Weighted Average Exposure Value

ACGIH = American Conference of Governmental Industrial Hygienists; TWA = Time Weighted Average

** data from 6 studies, in Canada, U.S. and Europe, 1986 - 1997

POI = Point of Impingement standards from Ont. MOE Nov. 1999

[*] Ont. proposed regulations to lower the styrene standard to 20 ppm, but it is still under consultation and review as of Feb. 2001

[a] sum of o-,m-, and p- isomers

[b] skin: may be significant absorption of the agent through the skin, mucous membranes or eyes, preventative action should be taken against this

[c] sum of all isomers

[d] no ACGIH guideline; data is from CCOHS RTECS database, Scandinavian occupational exposure limit (OEL)

[f] data for 1,1-dichloroethane

ne = not established "<" indicates the detection limit C = ceiling limit

UD = Under Development; the Ministry is seeking additional information from stakeholders prior to recommending a revised point-of-impingement standard (formerly, guideline was not established for n-decane or tetrachloroethylene, but was 1.53 ppm (or 5,300 μg/m³) for dichloromethane (also known as methylene chloride))

[g] there is no assigned standard for benzene. Emissions to environment are to be prevented or limited to greatest extent possible

Table 4-5 Summary of Meteorological Conditions During CIPP Installation

Date	Time	Temperature (°C)	Relative Humidity (%)	Wind Direction	Wind Speed (km/h)	Weather Comments
Sept. 25/00	2 a.m	5.4	79	NNW	12	mostly cloudy
	5 a.m.	5.2	79	WNW	6	clear
	8 a.m.	6.1	82	NW	10	mostly cloudy
	* 9 a.m.	8	69	N	6	partly cloudy
	11 a.m.	10.4	57	NE	6	mainly sunny
	2 p.m.	12.1	48	ESE	6	mostly cloudy
	5 p.m.	11.2	55	S	10	cloudy
	8 p.m.	10.2	61	S	4	cloudy
	11 p.m.	8.6	71	WNW	6	mostly cloudy
Sept. 26/00	2 a.m	7.3	85	N	12	mostly cloudy
	5 a.m.	5.8	89	N	8	mainly clear
	8 a.m.	6.7	84	NW	4	mainly sunny
	11 a.m.	13.0	53	NW	6	sunny
	2 p.m.	15.4	42	WSW	6	sunny
	5 p.m.	17.0	48	WSW	8	sunny
	8 p.m.	13.9	59	W	19	clear
	11 p.m.	11.6	72	WSW	19	clear
Sept. 27/00	2 a.m	10.2	78	WSW	10	clear
	5 a.m.	9.5	85	S	10	clear
	* 6 a.m.	9	90	ESE	7	clear
	8 a.m.	9.9	85	ESE	4	sunny
	* 9 a.m.	12	75	SE	6	sunny
	11 a.m.	16.6	63	WSW	17	sunny
	2 p.m.	20.4	53	WNW	29	mainly sunny
	5 p.m.	16.6	69	N	29	mostly cloudy
Dec. 13/00	2 a.m	-10.5	83	SSW	4	cloudy
	* 4 a.m	-11	87	SW	6	cloudy
	5 a.m.	-10.7	82	WSW	6	mostly cloudy
	* 6 a.m.	-10	80	WSW	6	cloudy
	8 a.m.	-10.3	75	E	8	mainly sunny
	11 a.m.	-6.6	77	SW	8	mostly cloudy
	2 p.m.	-5.2	67	SW	8	cloudy
	5 p.m.	-4.3	67	SSE	8	cloudy
Feb. 19/01	2 a.m	-4.8	59	SW	27	cloudy
	5 a.m.	-4.4	63	WSW	27	cloudy
	* 6 a.m.	-5	65	SW	20	clear
	8 a.m.	-4.0	66	SSW	27	mostly cloudy
	11 a.m.	-0.8	55	SW	31	mostly cloudy
	2 p.m.	1.4	51	SW	33	mostly cloudy
	5 p.m.	2.2	55	SW	23	cloudy

CIPP Installation Dates	Test Home
Sept. 25/00	2
Sept. 26/00	3 & 4
Sept. 27/00	1
Dec. 13/00	5 & 7
Feb. 19/01	8 & 9

all met data from Pearson International Airport
- most from newspaper listings
- except * which is by telephone from Toronto weather information line (416-661-0123)

Comparison with Table 4-4 suggests that styrene levels in all test homes in the periods before and after CIPP installation were within the range of typical indoor residential levels (0.0001 – 0.0007 ppm) and well below any occupational standards (20 – 50 ppm). These standards are generally not applied to indoor residential situations as they are meant to protect workers in process-related occupations. Results from Homes #2 and #9, in the basement area during the 10-hour monitoring period during CIPP installation, exceed the MOE point-of-impingement regulation of 0.094 ppm for 0.5 and 24 hours, established on the basis of nuisance odours.

The sampling situations for Homes #2 and #9 were selected in consultation with Toronto Department of Works personnel, Larry Tyo and Justin Boroneic, to represent worst-case scenarios during the CIPP process, with and without a pre-liner, respectively. Both homes were designated as dry trap conditions.

In the case of Home #2, the trap was dried, to permit gases to enter more easily. Also, the street end of the lateral service line for this home entered the manhole slightly above the level of the main sewer line. Thus, the lateral line was not obstructed by any portion of the curing pipe or pre-liner during the CIPP process, as is typically the case. Instead, this unobstructed lateral line was exposed to emissions from a larger surface area of curing pipe within the manhole during the entire curing process. In addition, the basement sampling location was within a small furnace room and it was decided that the door, although it had louvered slots, should remain closed during the sampling period. Finally, the sampling site was close to the floor drain (see Table 2-2). In the case of Test Home #9, a clean-out trap leading to the lateral service connection did not exist. Instead, a PVC cap was normally completely screwed into the floor drain to block access to the lateral line. This cap was removed by Toronto Works personnel during the CIPP installation phase to provide a worst-case scenario for access of sewer gases to a residence when no pre-liner is used. However, even in these worst-case scenarios, as noted above for all test homes, elevated styrene concentrations were transient and returned to typical indoor levels during Phase III monitoring (approximately 40 hours after the CIPP process was completed).

Results from Home 8 (wet trap, no pre-liner), when compared to Homes 1, 3, and 5 (wet traps, pre-liner used) show no significant difference in styrene concentrations within wet trap homes when a pre-liner is not used. However, comparison of results of dry trap homes

(Home 9 versus Homes 2, 4, and 7) indicate styrene levels at least twice as high when no pre-liner is used.

The outdoor concentrations of styrene (Table 4-1) at all test homes were at or below detection limit levels (0.00002 ppm) during pre- and post-installation phases and remained less than 0.0005 ppm during the CIPP process.

Other VOCs

Table 4-2 shows that outdoor concentrations for most VOCs were low at all homes during all phases of the study. None of the homes had unusual indoor VOC levels. Most VOC concentrations were less than 0.0003 ppm and rarely exceeded 0.0015 ppm. The highest levels were usually for toluene and xylenes, but even these are generally within the typical indoor range (see Table 4-4). In Home #3, high levels of terpenes (α-pinene and d-limonene) were found. These are usually indicative of the use of cleaning products since these compounds are commonly included as deodorizers.

The results suggest that VOC levels are independent of styrene generated as a result of the CIPP process. For example, in Home #3, there were low and constant levels of styrene (Table 4-1), but VOC levels were highest during Phase I, decreased during the CIPP installation of Phase II, and decreased further during Phase III (see Table 4-2b). Similarly, although Home #9 showed the highest indoor levels of styrene for the study during Phase II CIPP installation, many other VOCs were highest during Phase I, decreased during Phase II, and decreased further during Phase III (see Table 4-2d). Also, although the second highest levels of styrene were recorded in Home #2 during the pipe installation phase (Phase II), there was no related increase in other VOCs during this phase (Table 4-2a) In fact, in this home, many of the VOC levels were high prior to pipe installation (Phase I), decreased in concentration during Phase II, and then increased again in Phase III to levels approaching those of Phase I. This suggests consumer products and activities of residents such as hobbies, use of cleaning materials etc. are the likely contributors of these VOCs. However, even in these instances, the VOC levels were within the range measured in several other studies (Table 4-4).

4.3.2 Manhole Measurement Results - Styrene

The highest concentrations of any substance measured in the study were those for styrene measured at manhole openings (Table 4-1). These ranged from 0.16 – 3.2 ppm. The measurements were made at a height of approximately 10 centimetres above the ground-level manhole opening. It appears that the lack of a pre-liner (Manhole 4) allows styrene emissions that are two to three times higher than in situations where a pre-liner is used. These emissions are typically dispersed by natural dilution such as diffusion and advection by wind action and thus would be lower at downwind locations. No modeling was conducted to determine the point of impingement concentrations as this was not included in the scope of work. However, as a general rule of thumb, emissions from a ground level source such as this decrease about 500 times at a distance of 100 m from the source (at 1 m/s wind speed in an urban area, according to the US EPA SCREEN model).

Other VOCs

Table 4-3 indicates that most of the other VOC levels at manholes were not significantly different from background upwind levels, except for those of toluene, ethylbenzene, xylenes, and trimethylbenzenes. These substances are typically associated with automotive emissions and their presence is likely due to the proximity of several of Insituform's vehicles that operated continuously during the CIPP process as well as contributions from other nearby traffic sources.

4.3.3 Personal Samples (Occupational Exposures)

Permissible exposure values for the target compounds are outlined in Table 4-4. Ontario data are from Regulations 833, respecting *Control of Exposures to Biological or Chemical Agents.* As part of these regulations, employers are typically required to take measures to reduce airborne concentrations to levels less than the Time-Weighted Average Exposure Value (TWAEV). Time-Weighted Average Exposure Values refer to airborne concentrations of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed to, day after day, without adverse health effects. TWAEV are concentrations which should not be exceeded based on an 8-hour day, and 40-hour week.

Styrene

Personal exposures for styrene (Table 4-1) ranged from 0.08 – 0.5 ppm which are well within the permissible occupational TWAEV limit of 50 ppm given in Table 4-4. The measured occupational exposures are also below the proposed revised Ontario limit of 20 ppm which is currently under consultation and review.

Other VOCs

Concentrations in occupational samples were below detection limits (0.0001 ppm) for about half of the other VOCs. The highest levels were those for toluene, ethylbenzene, xylenes, and trimethylbenzenes, likely due to the employee's proximity to on-site running vehicles. The highest level was 0.01 ppm for toluene, which is well below the permissible occupational limit (Table 4-4). Other VOC concentrations in the personal exposure samples were also well below the permissible occupational limits of Table 4-4.

5. CONCLUSIONS

While the CIPP process is a potential source of styrene, it does not appear that it is a significant source of any of the other VOCs that are typically of concern in occupational or indoor air quality studies. Most of the levels of these VOCs were consistent with concentrations measured indoors in several studies in North America conducted over the last 20 years.

Styrene levels in homes were elevated significantly only in homes with dry sewer traps (engineered specifically for this study) during the CIPP installation. The levels, although elevated, were not of health concern.

However, the styrene levels are significantly above the odour threshold which is rated as low as 0.005 ppm with a geometric median value of 0.14 ppm (From *Critiqued Values in Odour Thresholds for Chemicals with Established TLVs; ACGIH, 1989*). Some researchers set the odour threshold at the limit of concentration for the most sensitive observers, but the general approach has been to calculate an average threshold where 50% of the observers report an odour. Odour thresholds are typically quoted as ranges because of the range of sensitivities (differences in people's ability to detect odours) in the human population.

To minimize odour problems during implementation of the CIPP process, residents should be advised to ensure that their sewer traps are in a proper state of repair. In cases of damaged, dry, or non-existent traps, the areas or rooms where floor drains or access holes to traps are located should be ventilated, if possible, by leaving doors or windows open to the outside during the CIPP installation process.

The use of a pre-liner during the CIPP process appears to reduce styrene emissions from manholes and to reduce styrene concentration in homes with dry traps. Thus, the use of a pre-liner would reduce the risk of elevated styrene levels within homes in the event that some residences may have damaged, dry, or non-existent traps leading to lateral service lines.

Occupational levels of styrene were not of concern since they were well below both current and newly proposed TWAEVs. All other VOC concentrations in the personal exposure samples were well below the permissible occupational limits.

References

1999 Pocket Ontario Occupational Health and Safety Act & Regulations, Consolidated Edition, Carswell Publishing, Toronto, 1999.

Threshold Limit Values for Chemical Substances in the Work Environment, adopted by ACGIH for 2000, with intended changes, In *2000 TLVs and BEIs*, American Conference of Governmental Industrial Hygienists, 2000.

NIOSH RTECs (Registry of Toxic Effects *of Chemical Substances)*, CD-ROM 2000/2001 version, provided by Canadian Centre for Occupational Health and Safety, Hamilton, update expiry Mar. 2001.

Critiqued Values in *Odor Thresholds* for *Chemicals with Established Occupational Health Standards*, American Industrial Hygiene Association, Akron, Ohio, 1989.

Molhave, L., Bach, B., & Pedersen, O.F. "Human Reactions to Low Concentrations of Volatile Organic Compounds". Environ. Int'L 1986, Vol 12, pp. 167-175.

MATERIAL SAFETY DATA SHEET

SECTION I - IDENTIFICATION

TRADE NAME: STYPOL 040-3148
DESCRIPTION: UNSATURATED POLYESTER RESIN
PRODUCT CODE IDENTITY: 0403148B2
NPCA HMIS RATING: H 2* F 3 R 1

REVISION: 06
LAST REVISED : 04/20/2007
DATE OF ISSUE: 05/17/2007

COMPANY NAME: COOK COMPOSITES AND POLYMERS CO.
ADDRESS: 820 E. 14th AVENUE
NORTH KANSAS CITY, MO 64116
CUSTOMER:

PREPARED BY:
HAZARD COMMUNICATION DEPT.
INFORMATION TELEPHONE:
COMPOSITES: 1-800-821-3590
POLYMERS: 1-800-488-5541

ATTENTION:

24 HOUR RESPONSE NUMBER (CHEMTREC): 1-800-424-9300 (NORTH AMERICA)
703-527-3887 (INTERNATIONAL)

CCP certifies that its products comply with all the provisions of the Toxic Substances Control Act (TSCA), unless otherwise stated by ingredient in Section II.

*** The percent by weight composition data given in Sections II and X are NOT SPECIFICATIONS, but are based on 'target' formula values for each ingredient in the product. The data are presented as ranges for low hazard ingredients and single point values for ingredients of regulatory concern. Actual batch concentrations will vary within limits consistent with separately established product specifications. ***

SECTION II INGREDIENTS

1
CAS# 000100-42-5
STYRENE MONOMER
PCT BY WT: 31.9040 VAPOR PRESSURE: 4.500 MMHG @ 68F
EXPOSURE LIMIT:

ACGIH TLV/TWA:	20 PPM (85 MG/CU.M.)
ACGIH TLV/STEL:	40 PPM (170 MG/CU.M.)
OSHA PEL/TWA:	100 PPM (8 HR TWA)
OSHA PEL/CEILING:	ACCEPTABLE MAX. PEAK: 600 PPM (5 MIN IN ANY 3 HRS)
OSHA PEL/STEL:	ACCEPTABLE CONCENTRATION: 200 PPM (15 MIN TWA)
LD50, Oral:	4.37 G/KG (RAT)
LD50, Dermal:	>5 G/KG (RABBIT)
OTHER:	LCLo: 5000 PPM/8H (RAT)
OTHER (cont.):	NIOSH TWA: 50 PPM (215 MG/M3)

OTHER LIMITS:
IARC - Group 2B See Section V

2
UNSATURATED POLYESTER RESIN
ON TSCA INVENTORY/ON CANADIAN DSL CAS# PROPRIETARY
PCT BY WT: 40 - 50
EXPOSURE LIMIT:

ACGIH TLV/TWA:	NONE ESTABLISHED
OSHA PEL/TWA:	NONE ESTABLISHED

This product contains one or more reported carcinogens or suspected

carcinogens which are noted by NTP, IARC, or OSHA-Z in the appropriate subsection above under OTHER LIMITS.
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******************************************************************************
* STYPOL 040-3148                                                            *
*                         MATERIAL SAFETY DATA SHEET                         *
* 0403148B2                                                                  *
******************************************************************************
******************************************************************************
     This substance is classified as a hazardous air pollutant.
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SECTION III PHYSICAL DATA

Boiling Range: High- -N/A F Low- 293.0 F
Vapor Pressure: See Section II
Theoretical Weight per Gallon, Calculated: 10.4401 LB/GL
Theoretical Specific Gravity, Calculated: 1.254
Theoretical VOC, Calculated: 3.343 LB/GL
--If applicable , see Section X for further VOC information--
Physical State: LIQUID
Appearance: LIGHT AMBER
Odor: STYRENE
Odor Threshold: -N/A
pH: -N/A
Freezing Point: -N/A
Water Solubility: INSOLUBLE
Coefficient of Water/Oil Distribution: -N/A
Mechanical Impact Explosion: NO KNOWN HAZARD
Static Electricity Explosion: AVOID STATIC CHARGE
% HAP BY WEIGHT 31.927
% MONOMER BY WEIGHT 31.903

SECTION IV FIRE AND EXPLOSION HAZARD DATA

FLAMMABILITY CHARACTERISTICS:
Lowest Closed Cup Flashpoint: 88.0 degrees F
For Flash Points less than 73 deg. F.
OSHA Flammability Classification: Class IB
DOT Flammability Classification: Flammable Liquid
Lower Flammable Limit in Air: Lower- 1.1 % by volume
For Flash Points 73 to 100 deg. F.
OSHA Flammability Classification: Class IC
DOT Flammability Classification: Flammable Liquid
DOT Shipping Name:
DOT Shipping Name:
Flash Points less than 73 deg. F. = RESIN SOLUTION, 3, UN1866, PG II
Flash Points 73 to 100 deg. F. = RESIN SOLUTION, 3, UN1866, PG III
EXTINGUISHING MEDIA:
Foam, carbon dioxide, dry chemical, water fog.
UNUSUAL FIRE AND EXPLOSION HAZARDS:
If polymerization takes place in a container, there is possibility of violent rupture of the container. Vapors are uninhibited and may form polymers in vents or flame arrestors of storage tanks resulting in stoppage of vents. Vapors may cause flash fire. Keep containers tightly closed and isolate from heat, electrical equipment, sparks and

flame. Never use welding or cutting torch on or near drum (even empty) because product (even just residue) can ignite explosively.

SPECIAL FIRE FIGHTING PROCEDURES:

Full protective equipment including self-contained breathing apparatus should be used. Water spray may be ineffective. If water is used, fog nozzles are preferable. Water may be used to cool closed containers to prevent pressure build-up and possible auto-ignition or explosion when exposed to extreme heat.

ADDITIONAL TRANSPORTATION INFORMATION:

Freight Classification:

NMFC: 149980/SUB 2 RESIN COMPOUNDS, LIQUID LTL CLASS 55

SECTION V HEALTH HAZARD DATA

EFFECTS OF EXCESSIVE OVEREXPOSURE. PRIMARY ROUTES OF ENTRY ARE:

EYE CONTACT:

Irritation. Symptoms are tearing, redness and discomfort.

SKIN CONTACT:

Irritation. Can cause defatting of skin which may lead to dermatitis.

INHALATION:

Irritation to nose and throat. Extended or repeated exposure to concentrations above the recommended exposure limits may cause brain or nervous system depression, with symptoms such as dizziness, headache or nausea and if continued indefinitely, loss of consciousness, liver and kidney damage.

Reports have associated repeated and prolonged occupational overexposure to solvents with permanent brain and nervous system damage.

INGESTION:

May cause mouth, throat, esophagus and stomach irritation, nausea, vomiting and diarrhea. Aspiration into lungs can cause pneumonitis which can be fatal.

MEDICAL CONDITIONS THAT MAY BE AGGRAVATED BY EXPOSURE TO THIS PRODUCT.

Preexisting eye, skin, liver, kidney and respiratory disorders.

EMERGENCY AND FIRST AID PROCEDURES:

In case of eye contact, flush immediately with plenty of water for at least 15 minutes and get medical attention; for skin, wash thoroughly with soap and water. If affected by inhalation of vapors or spray mist, remove to fresh air. If swallowed, get medical attention immediately.

CALIFORNIA PROPOSITION 65 INFORMATION:

WARNING - This product contains a chemical(s) known to the State of California to cause cancer.

OTHER HEALTH HAZARDS:

STYRENE MONOMER

The International Agency for Research on Cancer (IARC) has reclassified styrene as Group 2B "possibly carcinogenic to humans". This new classification is not based on new health data relating to either humans or animals, but on a change in the IARC classification system. The Styrene Information and Research Center does not agree with the reclassification and has published the following statement. "Recently published studies tracing 50,000 workers exposed to high occupational levels of styrene over a period of 45 years showed no association between styrene and cancer, no increase in cancer among styrene workers (as opposed to the average among all workers), and no increase in mortality related to styrene."

An increased incidence of lung tumors was observed in mice from a recent inhalation study. The relevance of this finding is uncertain. Data from other long-term animal studies and from epidemiology studies of workers exposed to styrene do not provide a basis to conclude that styrene is carcinogenic.

Lung effects have been observed in the mouse following repeated exposure to styrene.

SECTION VI REACTIVITY DATA

STABILITY: Stable HAZARDOUS POLYMERIZATION: May occur.

CONDITIONS TO AVOID:
Elevated temperatures.

INCOMPATABILITY (MATERIALS TO AVOID):
Oxidizers, reducing agents, peroxides, strong acids, bases, UV light, or any source of free radicals and mild steel.

HAZARDOUS DECOMPOSITION PRODUCTS:
Thermal decomposition or combustion can produce fumes containing organic acids, carbon dioxide and carbon monoxide.

SECTION VII SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED:
Remove all sources of ignition (flames, hot surfaces, and electrical, static, or frictional sparks). Avoid breathing vapors. Ventilate area. Contain and remove with inert absorbent and non-sparking tools.

WASTE DISPOSAL METHOD:
Dispose of in accordance with local, state and federal regulations. Do not incinerate closed containers. Incinerate in approved facility.

SECTION VIII SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION:
Do not breathe vapors. Wear an appropriate, properly fitted respirator (NIOSH/MSHA approved) during use of this product until vapors are exhausted, unless air monitoring demonstrates vapor levels are below applicable limits. Follow respirator manufacturer's directions for respirator use. Observe OSHA Standard 29CFR 1910.134.

VENTILATION:
Provide general clean air dilution or local exhaust ventilation in volume and pattern to keep the air contaminant concentration below the lower explosion limit and below current applicable exposure limits. Refer to OSHA Standard 1910.94.

NOTE: Heavy solvent vapors should be removed from lower levels of the work area and all ignition sources (nonexplosion-proof motors, etc.) should be eliminated.

PROTECTIVE GLOVES:
Use solvent impermeable gloves to avoid contact with product.

EYE PROTECTION:
Do not get in eyes. Use safety eyewear with splash guards or side shields, chemical goggles, face shields.

OTHER PROTECTIVE EQUIPMENT:
Avoid contact with skin. Use protective clothing. Prevent contact with contaminated clothing. Wash contaminated clothing, including shoes, before reuse.

SECTION IX SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING:
Do not store above 100 deg. F. Store large quantities in buildings

designed to comply with OSHA 1910.106. Keep away from heat, sparks and flame. Keep containers closed when not in use and upright to prevent leakage.

OTHER PRECAUTIONS:

Containers should be grounded when pouring. Do not take internally. Wash hands after using and before smoking or eating. Emptied containers may retain hazardous residue and explosive vapors. Keep away from heat, sparks and flames. Do not cut, puncture or weld on or near emptied containers. Follow all hazard precautions given in this data sheet until container is thoroughly cleaned or destroyed.

KEEP OUT OF REACH OF CHILDREN   FOR INDUSTRIAL USE ONLY

SECTION X Sara Title III Information

SARA 313 INFORMATION:

This product contains the following substances subject to the reporting requirements of Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372:

STYRENE MONOMER

CAS# 000100-42-5   PCT BY WT: 31.9040

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DISCLAIMER AND LIMITATION OF LIABILITY

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The products sold hereunder shall meet Seller's applicable specifications at the time of shipment. Seller's specifications may be subject to change at any time without notice to Buyer. Buyer must give Seller notice in writing of any alleged defect covered by this warranty (together with all identifying details, including the Product Code(s), description and date of purchase) within thirty (30) days of the date of shipment of the product or prior to the expiration of the shipment's quality life, whichever occurs first. THE WARRANTY DESCRIBED HEREIN SHALL BE IN LIEU OF ANY OTHER WARRANTY, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OF MERCHANTABILITY OF FITNESS FOR A PARTICULAR PURPOSE. THERE ARE NO WARRANTIES THAT EXTEND BEYOND THE DESCRIPTION OF THE FACE HEREOF. The Buyer's sole and exclusive remedy against Seller shall be for the replacement of the product or refund of the purchase price in the event that a defective condition of the product should be found to exist by Seller. NO OTHER REMEDY (INCLUDING, BUT NOT LIMITED TO, INCIDENTAL OR CONSEQUENTIAL DAMAGES FOR LOST PROFITS, LOST SALES, INJURY TO PERSON OR PROPERTY, OR ANY OTHER INCIDENTAL OR CONSEQUENTIAL LOSS) SHALL BE AVAILABLE TO THE BUYER.

The sole purpose of this exclusive remedy shall be to provide Buyer with replacement of the product or refund of the purchase price of the product if any defect in material or workmanship is found to exist. This exclusive remedy shall not be deemed to have failed its essential purpose so long as Seller is willing and able to replace the defective products or refund the purchase price.