PROCESS SPECIFIC EMISSION FACTORS AT THREE OFFSET LITHOGRAPHY SHOPS

BY

CHARLES B. KEIL III
B.S. Wheaton College, 1987
M.S. University of Illinois at Chicago, 1991

THESIS

Submitted as partial fulfillment of the requirements
for the degree of Doctor of Philosophy in Public Health Sciences
in the Graduate College of the
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THE UNIVERSITY OF ILLINOIS AT CHICAGO
Graduate College
CERTIFICATE OF APPROVAL

May 20, 1994

I hereby recommend that the thesis prepared under my supervision by

Charles B. Keil, III.

entitled Process Specific Emission Factors at Three Offset Lithography Shops

be accepted in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

Adviser (Chairperson of Defense Committee)

I concur with this recommendation

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This thesis is dedicated to my daughter Chloe Elizabeth.

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TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

CHAPTER PAGE

LIST OF TABLES

LIST OF TABLES (CONTINUED)

LIST OF TABLES (CONTINUED)

LIST OF TABLES (CONTINUED)

LIST OF FIGURES

LIST OF ABBREVIATIONS

CMS	Completely Mixed Space Model
C_x	Organic Compound with X Carbon Atoms
EMB	Experimental Mass Balance Model
GC	Gas Chromatograph
m^3	Cubic Meter
mg/m^3	Milligrams per Cubic Meter
OSHA	Occupational Safety and Health Administration
PEL	Permissible Exposure Level
PM	Particulate Matter
ppm	Parts Per Million
SF_6	Sulfur Hexafluoride
TP	Total Particulate
VOC	Volatile Organic Compound
UIC	University of Illinois at Chicago
USEPA	United States Environmental Protection Agency

SUMMARY

Industrial hygiene survey teams made site tests at three offset lithography print shops. The sites were: a small shop, the in-house printing facilities for a manufacturer and a large scale operation that produced weekly national magazines. Data collected at each site included site layout and process information, air concentration of pollutants, ventilation measurements, and activity observations.

The solvents used at the sites were generally petroleum distillates containing a large number of different organic compounds. The concentrations of total volatile organic compounds at all sites were below what is considered a hazardous level for non-specific total organic exposure. However, some of the speciated components of the solvent mixture are known to be potential hazards at much lower levels. Benzene in particular was measured in concentrations that approached or exceeded the Occupational Safety and Health Administration action level.

Emission rates at the three sites ranged from 530 to 31,000 kg per year based on bulk solvent inventories or company estimates of emissions. The yearly emission rates based on the modelled emissions for the sampling periods ranged from 336 to 9,270 kg per year. Agreement was considered good since the modelled extrapolations were based on only two days of sampling at each site. The largest operation had the highest total yearly mass emissions, but the smallest shop had the highest emissions based on mass emitted per square foot printed. At the site where the data supported the use of two models, the hourly emission rates from each model were similar and highly correlated.

SUMMARY (continued)

The use of solvent to clean the presses was the greatest contributor to variation in the modelled emission rates. Emission factors were developed for each facility describing the mass emission of total VOC in terms of the number of solvent cleanings in the facility as a whole. The mass emissions from different cleaning processes, based on the type of press or qualitatively different procedures, was also determined for each site. The emission factors for the different types of press cleaning ranged from 24.95 to 65.95 g VOC per cleaning for manual cleaning processes. One site had an automated cleaning system which had an emission factor of 364 g VOC per cleaning. At one site a bulk solvent handling procedure was discriminated as a significant predictor of VOC emissions. Transferring bulk solvent between bottles at this site resulted in the emission of 699 grams of VOC in addition to the emissions from use of cleaning solvent at the presses.

The emission factors developed in this thesis can be used in offset printing operations to predict the mass emission of VOC for various operating conditions. These mass emissions, along with the ventilation characteristics of the operation, can be used to: predict indoor air concentrations, estimate emissions into the ambient environment, evaluate existing pollution control equipment, and prioritize control efforts.

1 INTRODUCTION

1.1 Rationale

Uncontrolled air pollution emissions, or "fugitive" emissions, from indoor sources have a double impact on public health. First, these indoor emissions are often the most significant determinant of indoor air quality and worker exposure to potentially hazardous pollutants. Second, the majority of indoor emissions exfiltrate to the atmosphere and impact ambient air quality and environmental health.

Engineering controls are often used to capture indoor emissions. In order to effectively implement engineering controls it is necessary to understand the nature of these emissions. One useful way to describe process emissions is with an emission factor. Emission factors describe pollutant mass emissions in terms of some process variable such as mass of pollutant emitted per number of parts produced. Emission factors have the advantage of describing pollutant emissions apart from the effects of the surrounding airspace. This fact makes emission factors a generalizable tool that is transferrable from one industrial setting to another and from one set of operation parameters to another.

Volatile organic compounds (VOC) are a broad class of organic compounds that can be found in the vapor phase under normal atmospheric conditions. As a class, VOCs are of environmental concern for a number of reasons. A number of VOCs are photochemically reactive and can contribute to tropospheric ozone production. Tropospheric ozone is a public health concern because of the increase in respiratory illness associated with high ozone exposure levels. Halogenated VOCs have been implicated in the reduction of stratospheric ozone. Reduced stratospheric ozone may increase the amount of ultraviolet radiation reaching the earth's surface which may create adverse health effects. Additionally, a number of VOCs are considered toxic and have specific health effects. The Occupational Safety and Health Administration (OSHA) has established Permissible Exposure Limits (PEL) for specific toxic VOCs found in work environments. The United States Environmental Protection Agency (USEPA) has also classified a number of VOCs as Hazardous Air Pollutants (HAP) that require control.

In 1993 the Illinois emission inventory for the Chicago area listed graphic arts as the largest stationary source category of VOC emissions accounting for 11% of the total (Illinois Environmental Protection Agency, 1993). This indicates that the graphic arts industry is a significant contributor to ambient VOC. The indoor concentrations of VOC at graphic arts operations are also potentially high since graphic arts processes often do not have local exhaust ventilation or air pollution control equipment.

Offset lithography accounts for 75% of all book and pamphlet printing and an increasing amount of newspaper printing (Bender et al., 1992). Fugitive emissions from offset printing are of concern in achieving OSHA compliance indoors and EPA compliance for atmospheric emissions. The organic materials used in offset lithography are often nonspecific petroleum distillates containing a variety of hydrocarbons from C_6 paraffins to C_{10} aromatics. The health effects standards for petroleum compound mixtures are generally high. There are PELs for Stoddard Solvent (500 ppm, 2,900 mg/m^3), gasoline (300 ppm, 900 mg/m^3), and VM & P naptha (300 ppm, 1350 mg/m^3)(Code of Federal Regulations, 1993). There are, however significantly lower PELs for a number of specific VOC compounds found in solvent mixtures and printing emissions. Some of the specific compounds found in printing solvents that are potential health hazards are benzene, toluene, ethylbenzene, and xylene.

Title V of the Clean Air Act Amendments of 1990 requires the establishment of an operating permit program for sources of air pollution. This legislation was modeled after the National Pollution Discharge Elimination System of the Clean Water Act (Lee, 1991). The new air pollution permitting program will require many VOC sources, including offset lithography, to establish a better characterization and inventory of their emissions and to reduce emissions as much as possible. Currently, processes that have a large portion of fugitive emissions are required to erect temporary total enclosures around the process to quantify air pollution control efficiency and emission rates (Edgerton et al., 1991, Edgerton, 1992).

1.2 Objective

The objective of this dissertation is to develop an emission factor model that will characterize the VOC emissions from offset printing operations and be able to discriminate the contribution of individual presses or specific processes within the facility to the total emissions. This model would predict emissions from printing facilities and be a useful tool in evaluations for air pollution permits, determining control requirements, and determining potential for worker exposure. The development of this model has three phases: 1) data collection at 3 offset printing shops under typical operating conditions without the use of enclosures, 2) development of emission rates for each site, and 3) correlating process and activity information with the emission rates in the form of emission factors.

1.3 Literature Review

1.3.1 Printing

Lithography is a planographic printing process. The image and non-image areas of the printing plate are on the same plane. The image area is chemically treated to accept ink and reject water while the non-image area is treated to reject ink and accept water. An aqueous fountain solution is applied to the plate by a series of rollers and adheres to the hydrophilic non-image areas. Ink is applied to the same plate by inking rollers and adheres to the image area while the fountain solution prevents ink transfer to the non-image area. The inked image is transferred to an intermediate rubber coated blanket cylinder which applies the ink to the substrate. Between jobs, at the end of the day, and sometimes during jobs, the inking rollers, plates, and blanket cylinders must be cleaned. This is usually done with an organic solvent.

Offset lithography can be done onto pre-cut sheets (sheet-fed) or onto continuous rolls of paper (web) which require mechanical manipulation such as cutting and folding to get the product in the final form. Sheet-fed printing is done by most small to mid-sized printing operations. Web printing is used for large volume printing jobs.

Web offset printing can be further characterized as being non-heatset or heatset. Non-heatset web printing has semi-fluid inks whose drying is a function of its absorption on the surface of the paper. Newsprint accounts for most non-heatset web printing. Heatset web offset lithography accounts for greater than 75% of the production of magazines, catalogs, books, and tabloids nationally. The inks in heatset printing require a drying unit, either hot air or direct fire, to dry the inks followed by chill rolls to cool the paper prior to cutting and folding.

Air emissions from offset printing can come from three sources: the ink, the fountain solution, and the cleaning solvents. Inks contain pigment, binders which lock the pigment onto the paper, and solvent which disperses the pigment and binders. Pigment is finely divided organic and inorganic particles. Some binders are organic resins, polymers, oils, or rosins. Solvents are usually petroleum derived organic compounds, but more inks are being produced with a water solvent. The amount of solvent in the ink varies with the application. Newspaper printing requires only 5% solvent while publication work inks have 40% solvent. In heatset printing 40% to 90% of the incoming solvent is evaporated in the drying unit, depending on the rate of ink use and the characteristics of the substrate. The fountain solution is mostly water and ions, but in some presses the fountain solution can contain 15% to 30% organics such as isopropanol or butyl cellusolve. The cleaning of the press rolls can be automated or manual. The nature of the emissions depends on the type of cleanup solvent used.

The 1977 estimation of total VOC emissions nation-wide from printing was 380,000 Mg (418,000 T)(USEPA, 1977). A more recent study found it difficult to estimate VOC emissions from the printing industry but estimated that 1.7 billion pounds of printing ink was used in 1987. The same study identified the five printing processes by market share size: lithography - 47%, gravure - 19%, flexography - 17%, letterpress - 11%, and screen printing - 3% (USEPA, 1992).

The USEPA suggests that printing emissions be estimated by a mass balance of solvent bought for a given facility. This assumes all VOCs are evaporated into the atmosphere and modifications are appropriate if there is a drying unit with some accompanying destruction of VOC. It is estimated that hot air driers destroy 40% of the VOC and direct fire driers destroy 60%. Quantifying emissions using a mass balance on solvent supplies requires accurate record keeping on the part of facility inventory and waste disposal personnel. This approach may provide a good long term emission rate, but short term emission rates in a plant may vary widely depending on process conditions. These short term emission rates are required for evaluation of control devices, estimation of indoor air concentrations, and identifying process conditions that most greatly contribute to air emissions.

The USEPA has developed an emission factor for graphic arts operations in large geographical areas. The emission factor is in terms of the area population and is of limited use for individual plants. The suggested value is 1 gram of VOC emissions from graphic arts per person per day.

In summary, the potential sources of air pollution from offset lithography are:

1. Ink fountains: solvents and particulate.
2. Dampening systems: isopropanol and organics depending on formulation.
3. Plates and blanket cylinder: solvents and particulate.
4. Drier: solvents and combustion products.
5. Product: offgassing of remaining solvent.
6. Press-cleaning operations: this is highly variable, based on the practices at different locations.

There are a limited number of published studies that report VOC concentrations and emissions from printing. One earlier study measured worker exposure to solvent levels in a printing shop. The study measured personal time-weighted average exposures to total

VOC. The study found that worker exposure to total solvent varied from 19 ppm to 45 ppm for a work day time-weighted average. This study also found that worker exposure was correlated with the number of plate changes the worker performed (Hansen and Whitehead, 1988). This study did not have enough information to estimate emission rates.

1.3.2 Emission Factors

Emission factors are defined by the USEPA in the introduction to AP-42, Compilation of Air Pollution Emission Factors. "An emission factor is an average value which relates the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. It is usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity that emits the pollutant"(USEPA, 1977).

Outdoor industrial emission factors have been developed and used for decades. USEPA has compiled emission factors in AP-42. These emission factors have been used for permitting, engineering control design, and atmospheric modelling.

The use of indoor emission factors is relatively new. They are useful in a number of ways. They provide a means of estimating indoor concentrations and exposures. They can be used to evaluate control priorities and in-place local exhaust ventilation (LEV). A powerful advantage of indoor emission factors is that in being expressed as mass emitted per activity they remove the effects of the surrounding airspace and thus are generalizable over a variety of operating conditions and from workspace to workspace.

Early indoor emission factors were primarily for domestic processes such as gas stoves and appliances, wood-burning stoves and fireplaces, tobacco smoke, building materials and consumer products. Wadden and Scheff provide a summary of these early emission factors (Wadden and Scheff, 1983).

More recently the emission factor approach has been applied to indoor industrial processes. Franke and Wadden developed emission factors for condensation nuclei, respirable particles, NO_2, and CO in a welding shop (Franke and Wadden, 1989). Emission factors from degreasing operations using a number of different solvents (trichloroethylene, freon, terpene, and methylchloroform) have been characterized (Wadden et al., 1989, Wadden et al., 1991, Scheff et al., 1992, Keil et al., 1993, Milz, 1994). Chrome and copper plating emission factors have been developed (Wadden et al., 1991, Milz, 1992). Emissions from candy glazing have also been studied (Wadden et al., 1994). An initial estimate of VOC emission factors has already been presented for one offset printing operation (Wadden et al., 1993).

1.3.3 Emission Rate Models

The studies mentioned above have used a number of different air pollution transport models to determine process pollutant emission rates. The determination of which model is appropriate is based on the physical setting of the process, the selection of air sampling locations, and other available data. In cases where more than one model may be appropriate, all models should be used and the results from the different models can be compared based on other knowledge about the process such as bulk material usage rates. For example, a model may initially seem appropriate, but the results may not reflect known periods of high activity and pollutant emission due to a poor selection of sampling locations. Additionally, all models will require a number of assumptions. When comparing two models of the same system, the strength of the assumptions must be judged when deciding upon the better model.

Two models, the experimental mass balance model and the completely mixed space model, are the most likely candidates for this study given the sites and data sets. These models have been used in previous studies and are supported by the data sets that were collected in this study.

1.3.3.1 Experimental Mass Balance

The experimental mass balance model (EMB) has been used for terpene degreasing, candy glazing, and printing emission rate determination. The EMB requires the measurement or a good estimate of the airflow and concentration of pollutant at all entry and exit points of the airspace. A mass balance requires that the mass flow into the room plus any mass generation in the room equals the mass flow out of the room plus any accumulation of mass in the room.

$$S + in = out + A \tag{1}$$

S = Source rate
A = Accumulation = 0 at steady state
in = mass flow rate into system
out = mass flow rate out of system

This equation can be written for a steady state system, defining mass flow as the product of volumetric flow and mass concentration giving equation 2.

$$S = \sum q_i C_i - \sum q_j C_j \tag{2}$$

Where q_i = volumetric flow through exits from system
C_i = Mass concentration at exits from system
q_j = volumetric flow through entrances to system
C_j = Mass concentration at entrances to system

1.3.3.2 Completely Mixed Space

A completely mixed space model (CMS) has been used for welding, chrome emissions and printing operations. In some cases it is convenient to consider the work-space as a volume approaching completely mixed conditions. This CMS model describes emissions into such a space without any reaction of pollutant. The air mass balance around a room is given in equation 3.

$$q_0 + q_2 = q_3 + q_4 \tag{3}$$

q_0: makeup air
q_2: infiltration air
q_3: exfiltration air
q_4: exhaust air

The mass balance around a room requires that the mass flow into the room (via makeup air, infiltration air, and recirculated air) plus mass generated from in-room sources equals the mass flow out of the room (via exhaust air, exfiltration air and recirculated air) plus any in-room sinks. This is described mathematically in equation 4.

$$kq_0C_o(1-F_0) + kq_1C_i(1-F_1) + kq_2C_o + S = kq_1C_i + kq_3C_i + kq_4C_i + R \tag{4}$$

q_0: makeup air
q_1: recirculation air
q_2: infiltration air
q_3: exfiltration air
q_4: exhaust air
F_0: filter efficiency on makeup air
F_1: filter efficiency on recirculation air
C_i: indoor concentration
C_o: outdoor concentration
S: indoor source emission rate
R: indoor sink removal rate
k: indoor mixing factor ($0 < k < 1$)

For a non-steady state system equation 4 can be written as equation 5.

$$V\frac{dC_i}{dt} = kq_0C_o\,(1-F_0) + kq_1C_i\,(1-F_1) + kq_2C_o - k(q_0 + q_1 + q_2)C_i + S - R \tag{5}$$

where V is the room volume. The solution for equation 4 for the instantaneous indoor concentration as a function of time, with other factors constant and boundary variables $C_i = C_s$ at $t=0$ is

$$C_i = \frac{k\,[q_0(1-F_0)+q_2]C_0+S-R}{k\,(q_0+q_1F_1+q_2)}\,[1-e^{-(k/V)(q_0+q_1F_1+q_2)t}] + C_se^{-(k/V)(q_0+q_1F_1+q_2)t} \tag{6}$$

In simpler cases where: infiltration and exfiltration air are essentially zero so $q_0 = q_4 = q$, outside air has a concentration of essentially zero, there is no filtration on make-up or recirculation air and there are no indoor sinks, equation 6 can be reduced to equation 7.

$$C_i = \frac{S}{kq}\,(1-e^{-\frac{kq}{V}t}) + C_se^{-\frac{kq}{V}t} \tag{7}$$

Concentration data is often only available as an average concentration (C_{av}) over a sampling time (t_{av}). Average concentration can be defined by equation 8. Solving equation 8 and isolating S, gives a useful form for calculating emission rates, equation 9.

$$C_{av} = \frac{\int_0^{t_{av}} C_i \, dt}{\int_0^{t_{av}} dt} \tag{8}$$

$$S = \frac{C_{av}\, kq - \left[C_s \frac{V}{t_{av}}\right] \left[1 - e^{-\frac{kq}{V} t_{av}}\right]}{1 + \left[\frac{V}{kq\, t_{av}} \left(e^{-\frac{kq}{V} t_{av}} - 1\right)\right]} \tag{9}$$

2 METHODS

2.1 Site Description

The layout of each study site was measured and recorded. Room dimensions were obtained from blueprints provided by the facility and verified by measurements with a tape measure. The location and dimensions of equipment in the room was also measured using a tape measure. All processes, raw materials, and products in the room were identified. Shift times, lengths and normal production rates were determined from employees. Air sampling took place during normal operations over a two day period. Each day was broken into six sampling periods or "runs" of approximately one hour.

2.2 Ventilation

The ventilation and airflow characteristics of each site were determined. Airflow through doors, other wall openings, low flow ducts, and some air diffusers and returns was determined by measuring the average air velocity at a cross sectional area by a multi-point traverse using a hot wire anemometer. The air velocity was multiplied by the cross sectional area to obtain the volumetric flow. High flow ducts were measured using a pitot tube and manometer to determine the average air velocity using a multi-point traverse. Again, the air velocity was multiplied by the cross sectional area to obtain the volumetric flow. The flow through most air diffusers and returns was measured with a direct reading balometer having a hood fitted for the diffuser or return size. In a few cases, the geometry of the diffuser location prohibited the use of the balometer and an anemometer was used. Advective flow at various points in the room was measured using an anemometer with a smoke tube to determine the direction of flow.

The effective airflow in the rooms and the mixing characteristics were measured by studying concentration decay when pollutant emissions were at or near zero. At site 1 sulfur hexafluoride (SF_6) tracer gas was released and concentration was measured using a portable gas chromatograph (GC). At site 2 the decay of VOC as measured by a continuous infrared monitor was measured at the end of the day. At site 3 the decay of carbon monoxide (CO) from fork lifts was measured when there were none operating in the area. Using the completely mixed space model assuming a source rate of zero and measuring the airflows and concentrations, the mixing factor, k, can be calculated.

2.3 Volatile Organic Compounds

2.3.1 Charcoal Tube - Gas Chromatography

VOC samples were collected on coconut charcoal sampling tubes (8 x 110 mm, 400 mg/200 mg). The air was sampled at 0.2 to 0.3 lpm for one hour. The sampling rate was lowered for longer samples. The sampling was done with personal sampling pumps. Flow rates were checked using calibrated rotameters. One hour sample flows were checked at the beginning and end of the sample and often approximately at the mid time of the sample. Longer samples were checked at the beginning and end and at a minimum of once per hour.

The charcoal tubes were analyzed by gas chromatography - flame ionization detection (GC-FID) at the University of Illinois at Chicago (UIC). For quality assurance, total VOC (n-hexane equivalent) was determined by a contract lab for sites 1 and 2 on samples taken side-by-side with all samples analyzed at UIC. Only a portion of the site 3 samples were sent to the contract lab for total VOC, based on good agreement between in-house results and contract lab results for sites 1 and 2. Total VOC was determined by applying the response factor for n-hexane to the total area under the chromatogram curve. Total VOC is therefore reported as n-hexane equivalent concentration.

All samples analyzed at UIC for total VOC were also analyzed for speciated hydrocarbons. The initial analysis for the site 1 samples was for benzene, toluene, ethylbenzene, and xylene (BTEX) plus n-hexane. Other peaks in the chromatograms were later identified by determining the retention time (RT) of compounds suspected of being in the sample. The peaks determined by subsequent RT matching were quantified as n-hexane equivalent. A total of twelve compounds were identified at site 1. Compounds other than BTEX and n-hexane that were identified in the site 1 samples were: n-propylbenzene, o&p-ethyltoluene, all three trimethylbenzenes, and m-diethylbenzene. Benzene co-eluted with isopropanol, which was also present in the samples. The total VOC was determined by applying the n-hexane response factor to the total chromatogram area (minus the carbon disulfide (CS_2) solvent peak).

The speciated analysis for sites 2 and 3 used a slightly different temperature program and was calibrated for 19 compounds. The compounds that the GC was calibrated for were: n-hexane, isopropanol, benzene, toluene, p-xylene, m-xylene, isopropylbenzene, o-xylene, n-propylbenzene, m&p-ethyltoluene, isobutylbenzene, 1,3,5-trimethylbenzene, o-ethyltoluene, m-diethylbenzene, p-diethylbenzene, o-diethylbenzene, 1,2,3-trimethylbenzene and 1,2,4-trimethylbenzene. Total VOC was determined as for site 1.

The analytic systems used are presented in Table 1. Carbon disulfide was used for desorption of the charcoal tubes at room temperature.

TABLE 1. ANALYTIC PARAMETERS FOR VOC ANALYSIS.

Parameter	Site	UIC	Contract Lab
GC	all	HP 5890	HP 5890
Autosampler	all	none	HP 7673A
Integrator	all	HP Chemstation Software on HP Vectra PC	HP 3396A
Detector	all	FID	FID
Column	all	Supelcowax 10, 1 μm thickness 30 m x 0.53 mm	SPB-5 30 m x 0.53 m
Initial Temp	1 2 3	30 C 60 C 60 C	40 C 40 C 40 C
Initial Time	1 2 3	1.5 min. 8.0 min. 8.0 min.	3 min. 3 min. 3 min.
Level 1 Rate	1 2 3	5 degrees/min. 8 degrees/min. 8 degrees/min.	3 degrees/min. 8 degrees/min. 8 degrees/min.
Level 1 Temp	1 2 3	110 C 130 C 130 C	[a]
Level 2 Rate	1 2 3	10 degrees/min. 50 degrees/min. 50 degrees/min.	[a]
Final Temp	1 2 3	160 C 230 C 230 C	200 C 160 C 184 C
Injector Temp	1 2 3	205 C 205 C 205 C	225 C 225 C 200 C
Detector Temp	1 2 3	205 C 270 C 270 C	250 C 250 C 250 C
Desorption volume	1 2 3	2 ml front/1 ml back 2 ml front/1 ml back 2 ml front/1 ml back	3 ml 3 ml 3 ml
Injection volume	1 2 3	1 μl 1 μl 1 μl	1 μl 1 μl 1 μl

[a] only single level temperature program for contract lab analysis

2.3.2 Infrared Absorption

In addition to the charcoal tubes that give average concentrations over the sampling time, a Foxboro Miran 1A General Purpose Gas Analyzer was used to collect continuous concentration data. The instrument was operated at a wavelength of 13.9 μm which is the optimum wavelength for absorption of toluene. This wavelength was chosen because toluene was presumed to be a major component of the petroleum distillates used as ink solvents and clean-up solvents. Data was collected continuously on chart recorders and on Rustrak Ranger data loggers. Although infrared (IR) analysis is not compound specific, at a given wavelength it responds preferentially to an individual compound, while other similar compounds will give a lower response. The output from the Miran is a measure of total VOC concentration, but closed loop calibration isn't possible because the VOC mixture it will be measuring is not precisely known and will change over time. This problem was alleviated in the following manner. The Miran voltage output at each location was calibrated to total VOC using charcoal tube samples collected side-by side with the Miran. The average total VOC concentrations determined by the charcoal tubes and the average voltages from the Miran for the same sampling periods were used to generate total VOC calibration curves for the Miran.

2.3.3 Bulk Analysis

At each site bulk samples of the solvents were collected. Samples that were miscible in CS_2 were analyzed at UIC by GC-FID using the same method as for the charcoal tube samples. Selected samples were sent to a contract lab for analysis by GC - mass spectrometry.

2.4 Particulates

Particulate samples were collected on 25 mm open faced polycarbonate membrane filters, 0.4 μm pore size. They were collected at a rate of approximately 2 lpm. Personal sampling pumps were used and flow rates were checked as for VOC samples.

The filters were analyzed gravimetrically at UIC for TP. Following gravimetric analysis they were sent to a commercial lab for elemental analysis by proton induced x-ray emission spectrometry (PIXE).

2.5 Activity Measurement

Process variables and activities around the printing operations were recorded continuously during the sampling periods. Observations included: press running or not and speed, plate installation, removal or adjustment, paper installation, ink added, washing of plates and rollers, and maintenance activities.

Activity data were also obtained from the facilities. Jobs sheets and press logs were photocopied. Estimates of solvent bulk usage were obtained from employee estimates or inventory data.

2.6 Emission Rate Modelling

Emission rates were first determined using solvent inventory data. It was assumed that 100% of the clean-up solvent VOC evaporates into the airspace. This approach provided a reasonably accurate long term emission rate, but is of limited use in developing emission factors based on short term process variability.

Next the air concentration and ventilation data were used as input to the emission rate models described earlier. In each case there are a number of assumptions that were made. These assumptions are indicated with the results of the emission rate modelling. Assumptions were made based on physical information about the site. The results from the different models were compared with each other and with activity data to determine which emission rate model best reflected the variation in process activity and the approximate magnitude of emissions determined from inventory data.

2.7 Site Emission Factors

Once emission rates were developed, they were compared with activity data. Initially, the total room activity was tested for correlation with the emission rates. Activities that were initially considered to potentially correlate with emission rates were: paper throughput, number of jobs, job changes, plate changes, and frequency and type of press cleaning.

2.8 Individual Process Emission Factors

The next step in the analysis was to try to discriminate the contribution to the total emission rate from each press. The first approach was to use regression modelling on the activity for each press or press type instead of total room activity. For example, the emission rate was modelled as the dependent variable with multiple independent variables representing the activity at each individual press.

The second approach to discriminating individual source contributions was to do a component mass balance using speciated VOC and elemental data. The total VOC or particulate emissions can be further characterized by their specific component makeup or "fingerprint". The emission fingerprints from all sources must combine linearly to produce the speciated component pattern measured in the mixed air. The linear combination can be determined by multiple linear regression analysis. The resultant coefficients for the individual sources are their contributions to the total mixed concentration in the airspace.

3 SAMPLING RESULTS

3.1 Site 1 Sampling Results

3.1.1 Site 1 Description

Site 1 was one room of a medium sized printing facility. The room containing the presses was 1,030 m^3. The same general ventilation system serviced two adjacent rooms: a plate making room of 453 m^3, and a storage room of 159 m^3. The press room contained four offset presses and three spirit duplicators. Press #1 was a 1977 Miller TP-38A (two-color, stock size 25" x 29"). Press #2 was a 1964 Harris LXG-FR (one-color, stock size 23" x 29"). Press #3 was a 1975 Harris L-129 (one-color, stock size 24" x 29"). Press #4 was a 1969 Miller TP-38 (two-color, stock size 25" x 38"). Press #2 was not used during the test period. Also, only two of the spirit duplicators were used during the test. There was an operating six-color press in an adjacent room during the test. The layout of Site 1 is shown in Figure 1.

Site 1 was evaluated over a four day period. The first day was used for equipment set up, preliminary ventilation measurements, and process familiarization. The second and third days were the sample collection days. Each sample day consisted of six runs of approximately one hour each, three each morning and three each afternoon with no hourly samples collected during the lunch break. The fourth day was used for additional ventilation measurements and an SF_6 tracer gas study.

3.1.2 Site 1 Ventilation

The print room, the plate making room, and the storage room were served by the same general ventilation system. Air was supplied by ceiling diffusers and was returned via

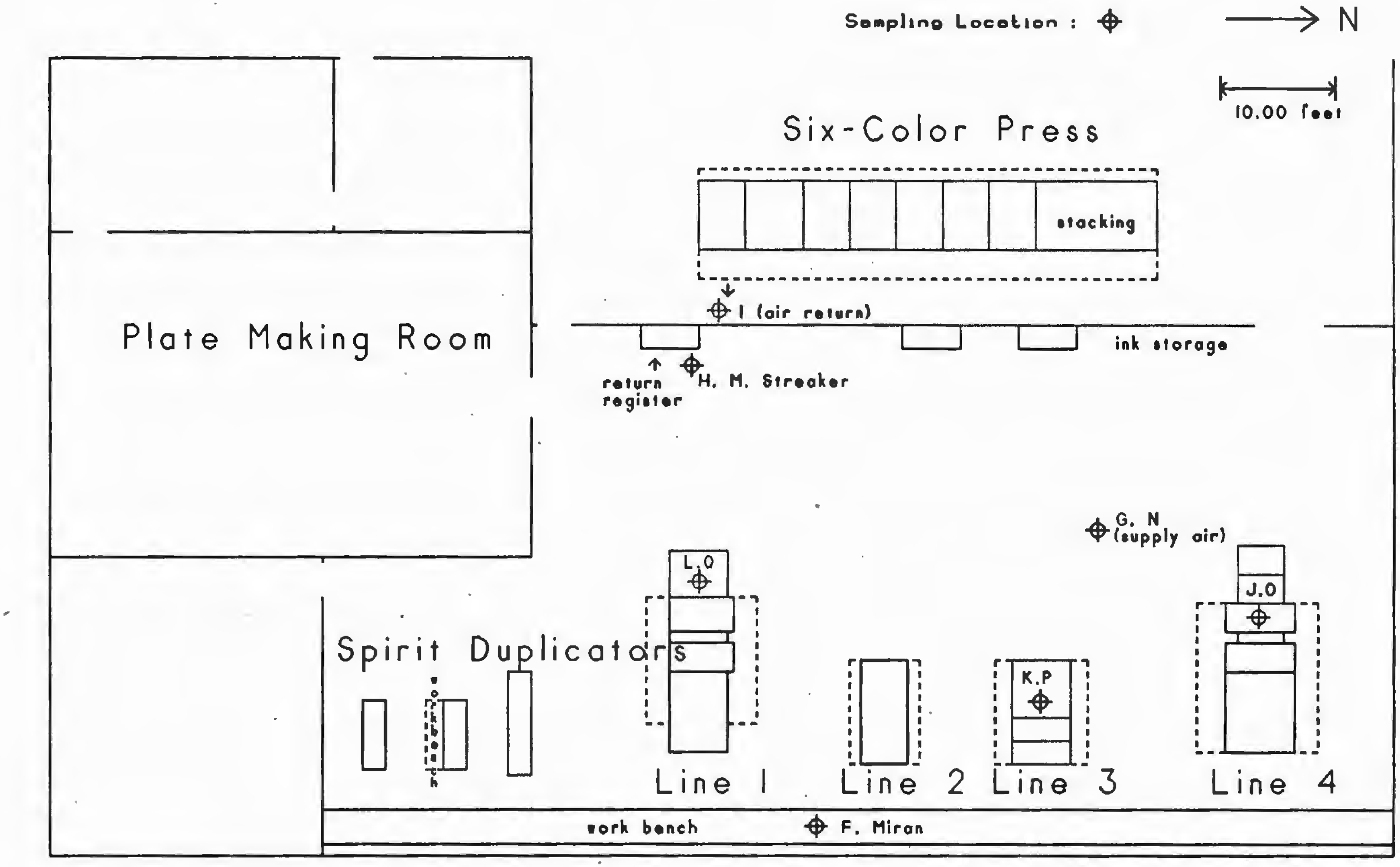

Figure 1. Site 1 Layout and Sample Locations

registers on the west wall of the press room. The air was 65% to 70% recirculated with makeup air from the roof accounting for the balance. There was no LEV and the non-recirculated air exfiltrated from the room via multiple routes including doors to an adjacent room. A summary of the airflow measurements is presented in Table 2. The sum of the airflows measured at the return register (244 m^3/min) and at the makeup air inlet (140 m^3/min) is within 10% of the value measured in the air-mover at the face of the filter (350 m^3/min). The sum of the diffuser measurements (255 m^3/min) does not agree as well. This may be due to leaks in the positive pressure duct work. The average of the return plus makeup flow and the air-mover flow was considered the gross airflow through the room (367 m^3/min). Even though the air exfiltration points were not all identified, the air balance for the room must be at steady state so the makeup airflow (140 m^3/min) was considered the net flow through the room.

The effective airflow and mixing factor for the room were determined by measuring the decay of SF_6 tracer gas. A short burst of SF_6 was released into the air return. The concentration of SF_6 at ten locations in and around the press room was determined by GC - ECD shortly afterwards and again 70 minutes later. Using the completely mixed space model where S is zero, C_s and C_i are measured, and t is known, the number of air changes per hour (kq/V) was determined for each location. The average was 2.16 air changes per hour. Using the volume of the air spaces serviced by the air system (1,631.2 m^3) and the measured makeup air flow of 140 m^3/min, the average mixing factor for the airspace is 0.42. The data for the tracer gas study is presented in Table 3.

TABLE 2. SITE 1 VENTILATION DATA.

Location	Flow Rate (cfm) at room T and P	(m^3/min)
Supply Air		
Diffuser Total	8998	254.8
At air mover	12358	350.0
Make up air	4938	139.8
Return Air	8629	244.4
Exfiltration Air	4938	139.8

TABLE 3. SITE 1 SF_6 TRACER GAS STUDY.

Location	Start Concentration (ppm)	End (t = 70 min) Concentration (ppm)	Air Changes per Hour (kq/V)
Supply Diffuser	24.8	2.07	2.13
Press #1	27.2	2.38	2.09
Plate Room	40.8	2.55	2.38
Press #4	38.6	2.56	2.33
Storage Room	38.8	2.54	2.34
North End Room	23.4	2.04	2.09
Return Register	25.3	2.25	2.07
Middle Room	24.3	2.10	2.10
Camera Room	35.8	2.92	2.15
Adjacent Room	18.1	1.93	1.92
Average			2.16
Mixing Factor (k)[a]			0.42

[a] k calculated based on a room volume of 1631 m^3 and a makeup air rate of 140 m^3/min

3.1.3 Site 1 Volatile Organic Compounds

Twelve one-hour charcoal tube samples were taken at seven locations. The Miran infrared analyzer was run continuously throughout the two sampling days. The sampling locations are shown in Figure 1.

The results of the GC-FID analysis for total VOC done at UIC are presented in Table 4. The average total VOC concentration in the room was 72.50 mg/m^3. The sample periods reported, reflect the average start and end times for the seven samples taken during each run. The results of the samples sent to the contract lab for quality control were in good agreement with the UIC results. The side-by-side sample comparisons are shown graphically in Figure 2. The speciated VOC averages are presented in Table 5. Complete speciated VOC data is included in Appendix A.

The average voltage from the Miran during a sampling period was calibrated to total VOC equivalent using the GC results from the charcoal tube sample taken immediately adjacent to the analyzer. The adjacent charcoal tube sample concentration was correlated to the average room using all the in-room samples. This correlation was used to convert the Miran output to a continuous measure of average room concentration. Table 6 presents the data used in these calculations. The continuous two day infrared analyzer trace is presented in Figure 3.

Samples of the solvents used on the presses were collected and analyzed. The results of the bulk sample analysis are presented in Table 7.

TABLE 4. SITE 1 TOTAL VOC CONCENTRATIONS (MG/M^3).

Time	Run	Bench (F)	Supply (G)	Return (H)	Adj Rm (I)	Press 4 (J)	Press 3 (K)	Press 1 (L)	Rm Avg	Avg (F,G,H)
09:08–10:07	1	69.86	42.71	47.64	36.08	119.10	95.31	57.87	72.08	53.40
10:08–11:09	2	48.48	30.79	34.51	44.46	73.37	42.56	57.21	47.82	37.93
11:11–12:02	3	51.39	29.54	30.55	26.98	34.09	34.45	33.81	35.64	37.16
13:13–14:11	4	50.38	29.52	32.43	35.61	41.88	39.57	38.10	38.65	37.44
14:12–15:14	5	62.38	33.17	52.80	80.13	109.41	71.22	46.47	62.58	49.45
15:15–16:13	6	152.61	98.98	127.26	107.59	267.37	178.40	105.88	155.08	126.28
09:11–10:04	7	22.83	18.64	19.59	25.64	24.48	19.88	25.71	21.86	20.35
10:05–11:01	8	27.74	18.22	21.87	31.91	58.07	34.64	27.05	31.27	22.61
11:02–12:00	9	35.95	30.44	35.59	81.64	61.97	42.00	43.49	41.57	33.99
13:21–14:21	10	73.39	51.43	51.72	62.19	70.93	62.29	82.33	65.35	58.85
14:22–15:18	11	135.51	101.51	104.95	84.26	295.10	147.13	118.38	150.43	113.99
15:18–16:19	12	175.51	116.73	108.59	167.54	159.05	157.17	169.40	147.74	133.61
Average		75.50	50.14	55.63	65.34	109.57	77.05	67.14	72.50	60.42

TABLE 5. SITE 1 TWO–DAY AVERAGE SPECIATED VOC CONCENTRATIONS (MG/M^3).

Compound	Bench (F)	Supply (G)	Return (H)	Adj Rm (I)	Press 4 (J)	Press 3 (K)	Press 1 (L)
n–Hexane	2.06	0.90	1.31	0.14	0.82	1.07	1.37
Benzene	5.09	3.30	3.71	3.88	8.17	4.77	4.21
Toluene	23.14	16.54	18.04	24.14	28.84	22.60	22.10
Ethylbenzene	0.44	0.27	0.30	0.39	0.84	0.50	0.38
p–Xylene	0.22	0.16	0.16	0.17	0.34	0.23	0.21
m–Xylene	0.45	0.27	0.32	0.24	0.59	0.39	0.42
o–Xylene	0.61	0.41	0.46	0.43	0.85	0.73	0.62
n–Propylbenzene	1.59	1.14	1.23	1.36	2.52	1.88	1.68
p–Ethyltoluene	6.53	4.77	5.09	5.63	10.35	7.72	6.98
1,3,5–Trimethylbenzene	2.29	1.63	1.79	1.98	3.68	2.75	2.53
o–Ethyltoluene	1.50	0.92	1.15	1.32	2.39	2.02	1.73
1,2,4–Trimethylbenzene	3.15	2.27	2.44	2.75	5.07	3.75	3.43
m–Diethylbenzene	0.37	0.25	0.28	0.29	0.58	0.45	0.43
1,2,3–Trimethylbenzene	0.32	0.22	0.25	0.30	0.53	0.39	0.35
Total VOC	75.50	50.14	55.62	65.34	109.57	77.05	67.14

TABLE 6. SITE 1 MIRAN DATA EVALUATION.

Run	Adjacent Sample (mg/m^3)	Miran Average (volt)	Miran Total VOC (mg/m^3)[a]	Room Avg (mg/m^3)	Miran Room Avg Total VOC (mg/m^3)[b]
1	69.86	0.7173	94.93	72.08	91.01
2	48.48	0.4629	59.72	47.82	57.47
3	51.39	0.4232	54.23	35.64	52.24
4	50.38	0.3242	40.53	38.65	39.18
5	62.38	0.4539	58.48	62.58	56.28
6	152.61	0.6548	86.28	155.08	82.77
7	22.83	0.2637	32.15	21.86	31.20
8	27.74	0.2196	26.05	31.27	25.39
9	35.95	0.3438	43.24	41.57	41.77
10	73.39	0.7187	95.12	65.35	91.20
11	135.51	1.069	143.60	150.43	137.39
12	175.51	1.272	171.69	147.74	164.16

[a] Bench (mg/m^3) = volt x 138.39 − 4.34 $r^2 = .79$

[b] Room (mg/m^3) = Bench (mg/m^3) x 0.9528 + 0.5682 r2 = .95

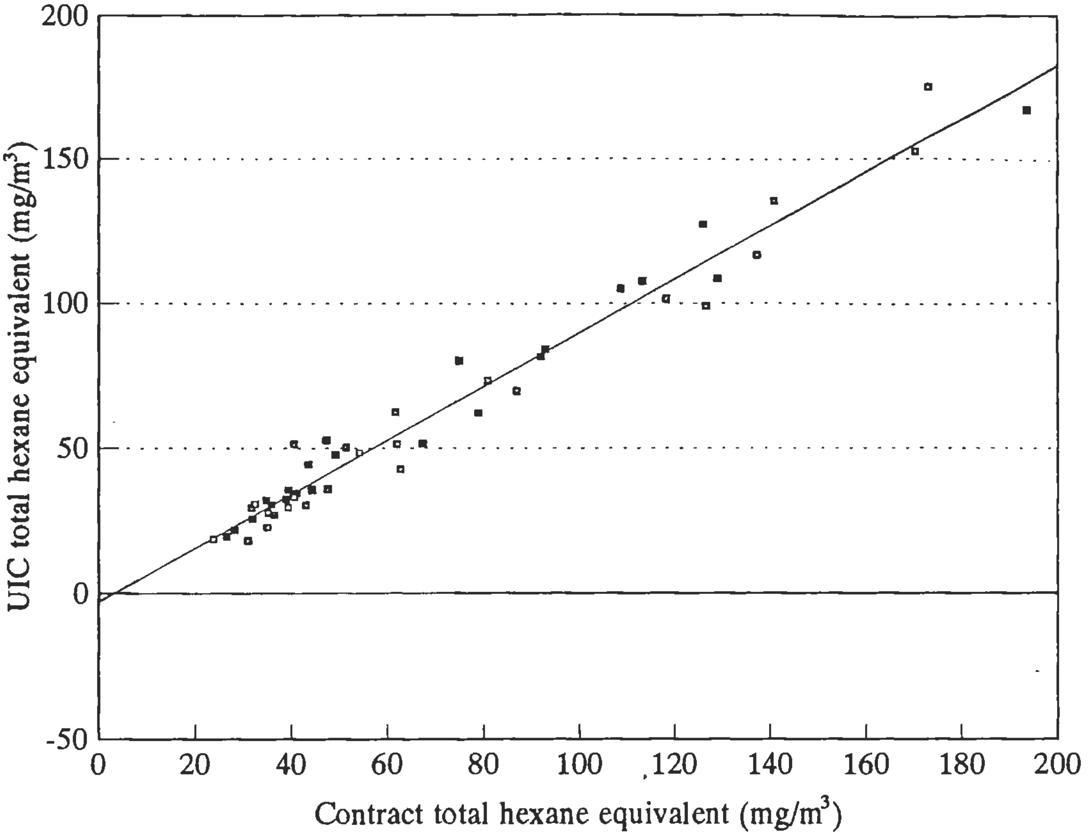

Figure 2. Site 1 Comparison of Hexane Equivalent Concentrations, Contract Lab vs. UIC.

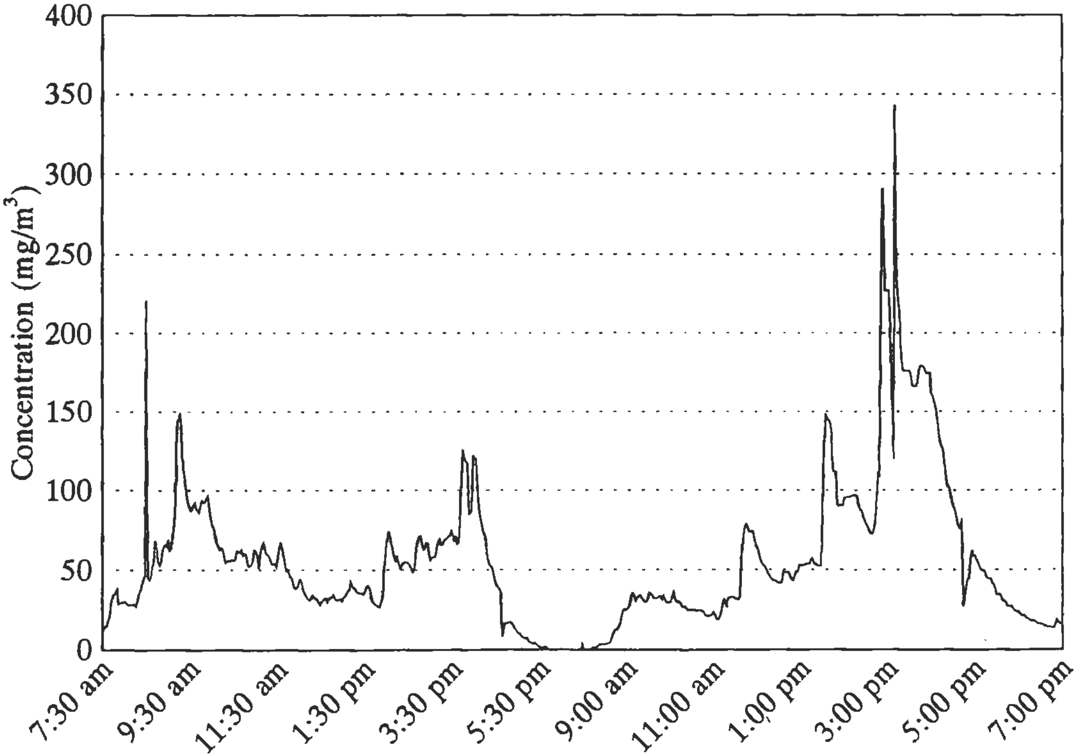

Figure 3. Site 1 Continuous Total VOC Concentration at Workbench Determined by Miran

TABLE 7. SITE 1 BULK SAMPLE ANALYSIS OF SOLVENTS (MG/ML).

Solvent Press used	Clean Quick Line #1	Step #1 Line #1	Step #1 Line #3	Step #1 Line #4	Step #2 Line #3	Step #2 Line #4	Blanket Wash Line #4	Plate Wash Line #4	Gasoline Duplicator
Compound									
n-Hexane	bdl[a]	bdl	bdl	bdl	bdl	bdl	bdl	bdl	156.58
Benzene[b]	44.84	22.19	32.58	bdl	34.38	54.26	91.99	bdl	16.45
Toluene	189.46	5.38	26.22	17.59	15.28	27.42	78.55	bdl	44.52
Ethylbenzene	0.34	9.94	42.57	77.06	5.98	6.48	8.61	23.56	10.85
p-Xylene	1.13	bdl	bdl	bdl	4.36	3.03	bdl	bdl	11.51
m-Xylene	2.74	9.78	10.75	19.38	10.69	3.96	4.24	bdl	26.6
o-Xylene	11.03	8.45	40.59	23.12	14.73	9.21	bdl	bdl	15.88
n-Propylbenzene	27.77	2.55	13.15	14.24	35.61	31.39	bdl	0.61	4.08
p-Ethyltoluene	119.66	6.64	22.64	bdl	151.48	142.31	bdl	bdl	19.91
1,3,5-Trimethylbenzene	101.89	2.15	9.73	bdl	47.28	54.03	bdl	bdl	8.09
o-Ethyltoluene	26.77	2	5.16	bdl	29.11	42.65	bdl	bdl	4.66
1,2,4-Trimethylbenzene	65.4	4.89	17.71	bdl	103.37	82.22	bdl	bdl	22.71
m-Diethylbenzene	17.32	0.88	5.05	1.77	19.61	9.6	bdl	bdl	6.45
1,2,3-Trimethylbenzene	6.28	1.35	5.28	1.98	13.54	9.38	bdl	bdl	6.28
Total VOC	671.36	183.25	763.3	440.26	763.3	819.12	676.38	88.41	682.34
Contract Lab Benzene	0.0165	bdl	bdl	0.0055	bdl	bdl	bdl	bdl	1.623

[a] bdl: below detection limit

[b] Includes isopropanol; only gasoline composition was likely to have been completely benzene

3.1.5 Site 1 Activity Measurement

The principle activity that was considered a probable candidate for correlation with VOC emissions was the number of times solvent was used to clean the press. The number of solvent uses was defined as the number of times an activity type involving the use of solvent was observed during a sample period (sample period being defined as the average start and stop time of all samples). In some cases, solvent cleaning occurred within four minutes of the end of the period. These cleanings took place during sample changes and the emissions from these cleanings were probably measured on two sets of charcoal tubes. In these cases the activity was counted as one-half in the sample period ending, and one-half in the sample period beginning. The summary of the solvent cleaning events are presented by sample period in Table 8.

The choice of process variable to explore for correlation with VOC emissions was not based on a systematic evaluation of all process variables tracked and recorded. Solvent cleaning was chosen based on observations at the site. Solvent odor was strongest during and immediately after cleaning. Also, the Miran trace (Figure 3) reflected high concentrations of VOC during periods of solvent cleaning.

In addition to the number of solvent cleanings, the number of sheets printed over the two sampling days was determined for each press. Press 1 printed 14,030 sheets (92,600 ft^2). Press 3 printed 16,430 sheets (79,400 ft^2). Press 4 printed 9,694 sheets (63,950 ft^2). The letterhead duplicator printed 36,242 sheets (23,500 ft^2). The envelope duplicator printed 11,000 envelopes (2,750 ft^2).

An estimate of weekly bulk solvent use was obtained from the press operators. This data is presented on Table 9.

TABLE 8. SITE 1 SOLVENT CLEANING ACTIVITY SUMMARY (NUMBER OF PRESS CLEANINGS).

	Start	End	Press #1	Press #3	Press #4	Duplicator #1	Duplicator #3	Total
Day 1	08:00	09:08	4	5	2	1	3	15
	09:08	10:07	0	2	7	2	0	11
	10:08	11:09	2	0	4	1	2	9
	11:11	12:02	0	0	0	0	2	2
	12:02	13:13	0	0	0	0	0	0
	13:13	14:11	0	0	2	1	4	7
	14:12	15:14	0	3	5	2.5	3.5	14
	15:15	16:13	2	6	4	3.5	1.5	17
	16:13	16:45	0	0	0	0	0	0
Day 2	08:30	09:11	2	1	0	0	0.5	3.5
	09:11	10:04	0	1	0	1	2.5	4.5
	10:05	11:01	0	2	3	0	0	5
	11:02	12:00	0	2	1	5	0	8
	12:00	13:20	0	0	0	0	1	1
	13:21	14:21	2	0	0	0	7	9
	14:22	15:18	0	8	5	0	5	18
	15:18	16:19	0	2	0	0	0	2
	16:19	17:20	0	0	0	0	0	0

TABLE 9. SITE 1 BULK SOLVENT USE RATE ESTIMATED BY PRINTERS (GALLONS/WEEK).

	Press			
Solvent	Line #1	Line #3	Line #4	Letterhead Duplicator
Clean Quick	2	0	2	0.5
V–120	2	0	2	0
Step #1	2	1	2	0
Step #2	0.5	1	2	0
Blanket Wash	0	0	2	0
Gasoline	0	0	0	0.5
Press Total	6.5	2	10	1

3.2 Site 2 Sampling Results

3.2.1 Site 2 Description

Site 2 was an in-house printing facility for a production company. The room volume was 6,598 m^3 and was served by general ventilation that also served 1,180 m^3 of office space. The only LEV was the cyclone exhaust at the punch on press #1. The room contained five offset presses and two spirit duplicators. Press #1 was a Didde Conserver (web-fed, non-heatset, one-color, two-sides, with hole puncher and cyclone exhaust, web width 11"). Press #2 was a Didde Webcom (web-fed, non-heatset, four-color, web width 17.25"). Press #3 was a Heidelburg Sorm (sheet-fed, one-color, stock size 20.25" x 24"). Press #4 was a Heidelburg Kors (sheet-fed, one-color, stock size 17.25" x 22.5"). Press #5 was a Ryobi (sheet-fed, two-color, stock size 11" x 17"). The spirit duplicators printed on sheet size of 8.5" x 11". The printing activities were concentrated in the western section of the room. The eastern section was used for publication storage and publication shipping operations. North of the main room was the office area for the print shop. The office area was on the same general ventilation system as the main room. The layout of Site 2 is shown in Figure 4.

Site 2 was studied over a three day period. The initial day was for equipment set-up, initial ventilation measurements, and process familiarization. The next two days consisted of air sampling, process observation, and complete ventilation measurements. Each sampling day consisted of six consecutive runs of approximately one hour each.

3.2.2 Site 2 Ventilation

The main room and offices were served by three dedicated air moving systems. The air returns were between the drop ceiling and the roof on the south wall. The airflow was

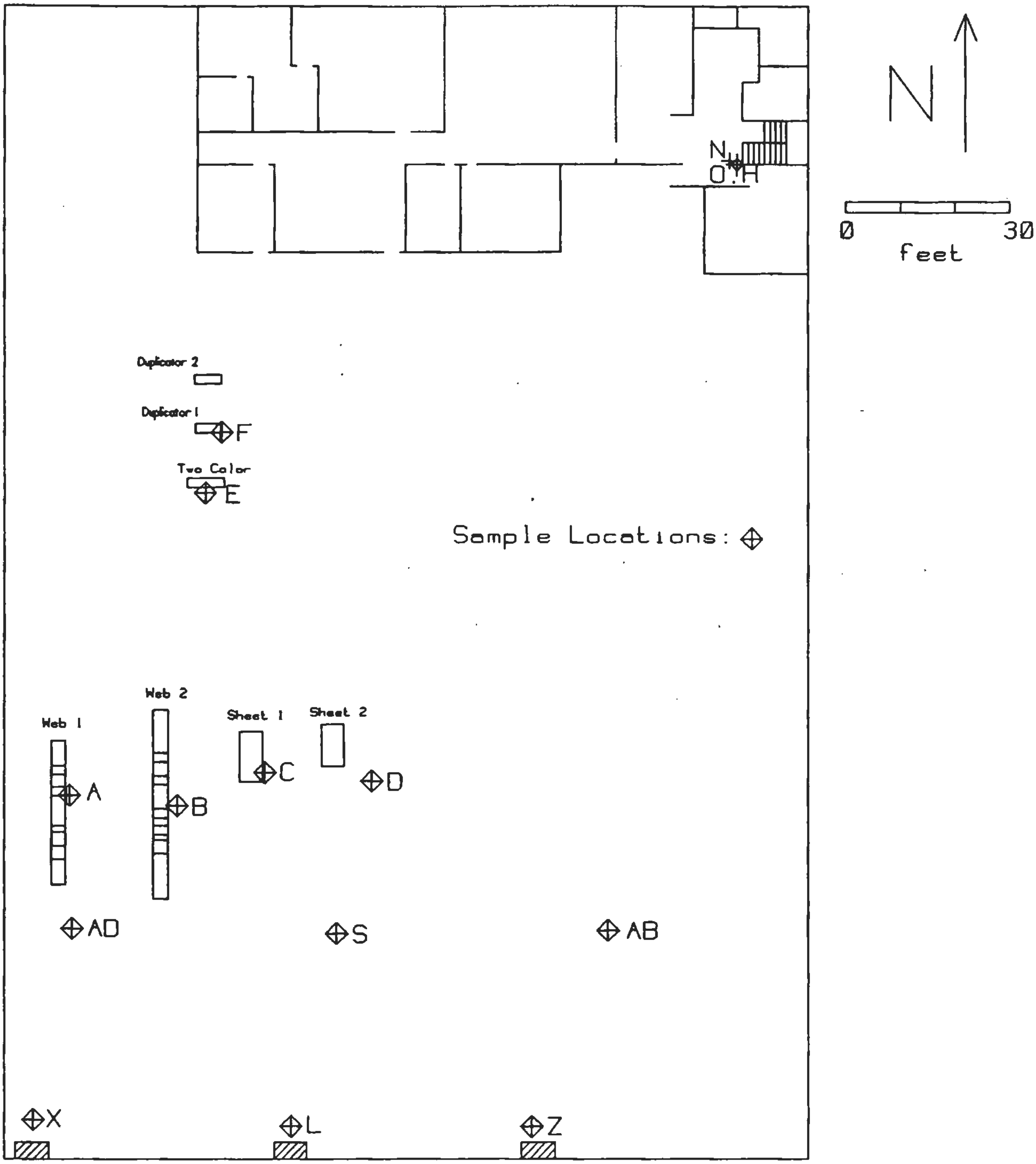

Figure 4. Site 2 Layout and Sample Locations.

measured using a thermoanemometer (537.7 m^3/min). There was no sign of make-up air intake on the roof when tested with smoke tubes. A facility engineer stated that the make-up air rate is constantly set at about 5% of the total air flow. Air was supplied to the room via ceiling diffusers and was measured using a balometer (386.7 m^3/min). The only location of airflow out of the room was down the stairs at the northeast corner of the room. Airflow was measured using a thermoanemometer (120.3 m^3/min). Table 10 summarizes the air flow measurements. The difference between the airflow into the returns and out the diffusers is probably due to the positive pressure duct leakage and the different measurement techniques. Based on the data available, the probable air balance around the room is illustrated in Figure 5.

The decay of the Miran output at the end of the day was too gradual to use to determine the effective airflow through the room. This was because the source emission rate was probably not zero. VOC off-gassing continued for some time after the end of operations. Mixing factors for large spaces commonly range from 0.1 to 0.3 (Wadden and Scheff, 1987) and a value of 0.3 was chosen for this space.

TABLE 10. SITE 2 VENTILATION MEASUREMENTS.

Direction	Location	Airflow (m^3/min)
Into Room		
	Ceiling Diffuser Total	387.7
Out of Room		
	Down NE Stairs	120.3
	West Return	193.4
	Middle Return	188.5
	East Return	155.8
	Total Out	658.0

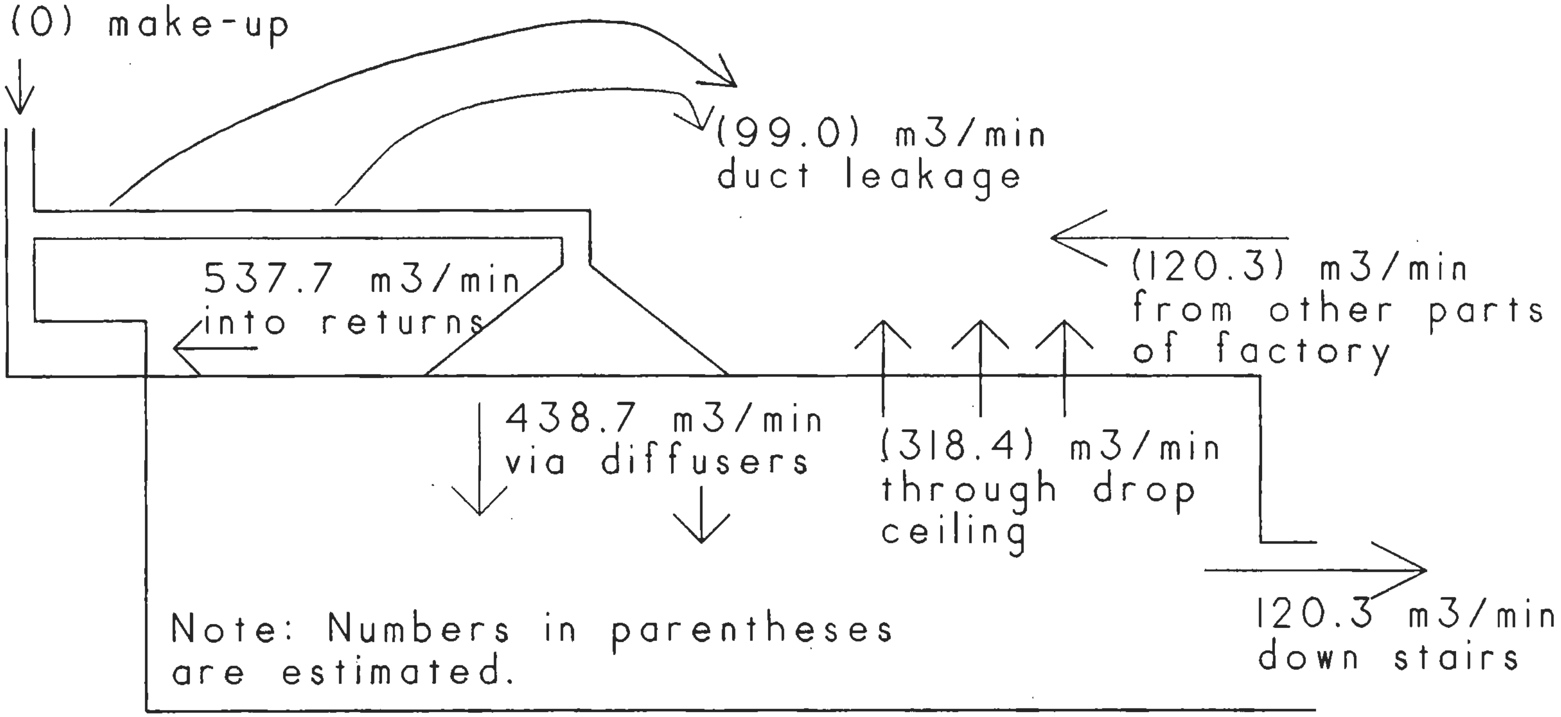

Figure 5. Site 2 Estimated Air Balance.

3.2.3 Site 2 Volatile Organic Compounds

The charcoal tube sampling locations are shown in Figure 4. The samples at the middle air return, the stairway, the roof, and the middle supply (L,N,P,S) were one hour samples collected for six consecutive hours each sampling day. The samples at the west and east air returns (X,Z) and the west and east supply air (AD, AB) were six hour samples, one sample taken each sample day. Additionally, each press had two one hour samples taken near it each day. Two Mirans were run, one at each web press, continuously throughout the two sampling days.

The total VOC results for samples taken at the air returns, the stairway, the roof and the air supplies are presented in Table 11. All charcoal tube samples had a side-by-side sample sent to a contract lab for analysis. The UIC total VOC results agreed well with contract lab results ($r^2=0.87$). The average speciated VOC compositions at all sample locations for each day are shown in Table 12. The complete speciated VOC analysis is included in Appendix B.

The two infrared analyzers continuously collected data. There were one hour samples collected at the same locations as the Mirans. These side by side samples were used to calibrate each Miran output to total VOC. The origin (0,0) was included as a data point since the Mirans were zeroed using a charcoal cartridge to remove VOC. The data and calibration equations are shown in Table 13. The magnitude of the coefficients are similar, which would be expected since the organic vapor mixture measured at each location has generally the same composition. The small difference in calibration equations is from slight differences between the instruments and because the mixtures and concentration measured by the Mirans were not exactly the same. The two day total VOC traces from the Mirans are shown in Figure 6.

TABLE 11. SITE 2 TOTAL VOC RESULTS (MG/M^3)

Time	Middle Supply (S)	Middle Return (L)	Stairway (N)	Roof (P)	West Supply (AD)	West Return (X)	East Supply (AB)	East Return (Z)	Web 1	Web 2	Sheet 1	Sheet 2	Dupli–cator	2–color sheet
12 May														
09:16–10:07	8.03	6.73	6.56	bdl[a]					22.83			18.24		
10:07–11:04	9.37	6.77	6.01	bdl						11.42			22.87	
11:04–12:02	11.30	5.65	6.61	bdl							15.48			33.16
12:02–13:07	9.32	5.81	6.95	0.40					13.17			12.45		
13:07–13:59	10.00	6.20	7.19	bdl						13.34			14.73	
13:59–15:16	22.10	7.43	8.56	bdl							23.62			58.06
Average	11.69	6.43	6.98	0.08	18.02[b]	17.99[b]	8.12[b]	3.98[b]	18.00[c]	12.38[c]	19.55[c]	15.34[c]	18.80[c]	45.61[c]
13 May														
09:07–10:14	9.62	7.36	5.42	0.14							15.99	9.71		
10:14–11:02	11.00	9.24	3.58	bdl						19.69			34.2	
11:02–12:02	12.70	10.50	8.49	bdl					24.36					16.42
12:02–13:03	14.60	9.92	9.80	0.16							18.11	15.08		
13:03–13:59	16.00	9.97	6.56	0.13						48.87			16.21	
13:59–15:07	24.20	17.00	9.92	0.10					55.09					31.02
Average	14.69	10.66	7.30	0.09	17.74[b]	20.90[b]	13.12[b]	6.57[b]	39.72[c]	34.28[c]	17.05[c]	12.40[c]	25.20[c]	23.72[c]

[a] bdl: below detection limit

[b] Six hour sample, sampling period average only

[c] Only two one–hour samples taken during day and used for average

TABLE 12. SITE 2 AVERAGE SPECIATED VOC CONCENTRATIONS (MG/M^3)

	Web 1	Web 2	Sheet 1	Sheet 2	2 Color Press	Duplicator	Middle Supply	Middle Return	Stairway	Roof	West Supply	West Return	East Supply	East Return
n-Hexane	0.18	0.17	0.13	0.27	0.16	0.11	0.11	0.12	0.07	0.11	0.13	0.13	0.08	0.06
Isopropanol	2.25	1.12	3.28	2.01	1.53	2.37	1.82	1.24	0.77	0.00	1.99	1.65	0.72	0.51
Benzene	0.69	0.33	0.28	0.42	0.70	0.74	0.27	0.39	0.10	0.01	bdl	0.57	0.33	0.17
Toluene	0.68	0.46	0.48	0.42	0.38	0.82	0.34	0.42	0.26	0.01	0.59	0.57	0.57	0.32
Ethylbenzene	0.24	0.19	0.18	0.10	0.14	0.31	0.10	0.10	0.06	bdl	0.32	0.28	0.12	0.06
p-Xylene	0.02	0.15	0.15	0.12	0.06	0.12	0.07	0.06	0.03	bdl	0.14	0.12	0.06	0.04
m-Xylene	0.44	0.20	0.17	0.13	0.17	0.30	0.16	0.15	0.09	bdl	0.45	0.32	0.14	0.09
Isopropylbenzene	0.27	0.25	0.16	0.12	0.21	0.28	0.12	0.11	0.07	bdl	0.20	0.17	0.09	0.04
o-Xylene	0.30	0.28	0.20	0.16	0.22	0.31	0.16	0.16	0.09	bdl	0.26	0.22	0.13	0.07
n-Propylbenzene	0.69	0.60	0.38	0.29	0.54	0.76	0.29	0.23	0.14	bdl	0.47	0.41	0.20	0.08
m&p Ethyltoluene	3.06	2.63	1.71	1.29	2.42	3.33	1.29	1.06	0.63	0.03	2.07	1.81	0.90	0.36
Isobutylbenzene	0.13	0.15	0.34	[a]bdl	bdl	bdl	0.27	bdl	bdl	bdl	bdl	bdl	bdl	bdl
1,3,5-Trimethylbenzene	0.99	0.80	0.30	0.45	0.84	1.17	0.22	0.36	0.21	0.01	0.76	0.65	0.32	0.12
o-Ethyltoluene	0.75	0.64	0.42	0.31	0.58	0.81	0.26	0.24	0.14	0.01	0.51	0.44	0.22	0.08
1,2,4-Trimethylbenzene	2.46	2.08	1.37	1.07	2.03	2.77	1.05	0.85	0.50	0.02	1.72	1.49	0.75	0.30
m-Diethylbenzene	0.22	0.18	0.12	0.09	0.18	0.25	0.09	0.07	0.04	bdl	0.15	0.13	0.07	0.03
p-Diethylbenzene	0.11	0.08	0.05	0.04	0.07	0.11	0.04	0.01	0.01	bdl	0.07	0.06	0.03	0.01
o-Diethylbenzene	0.14	0.12	0.10	0.05	0.08	0.11	0.06	0.04	0.03	bdl	0.07	0.06	0.04	0.01
1,2,3-Trimethylbenzene	0.31	0.24	0.14	0.16	0.26	0.34	0.14	0.13	0.07	bdl	0.25	0.20	0.12	0.05
Total VOC	28.86	23.33	18.30	13.87	22.00	46.15	13.19	8.55	7.14	0.09	17.88	19.45	10.62	5.28

[a] bdl: below detection limit

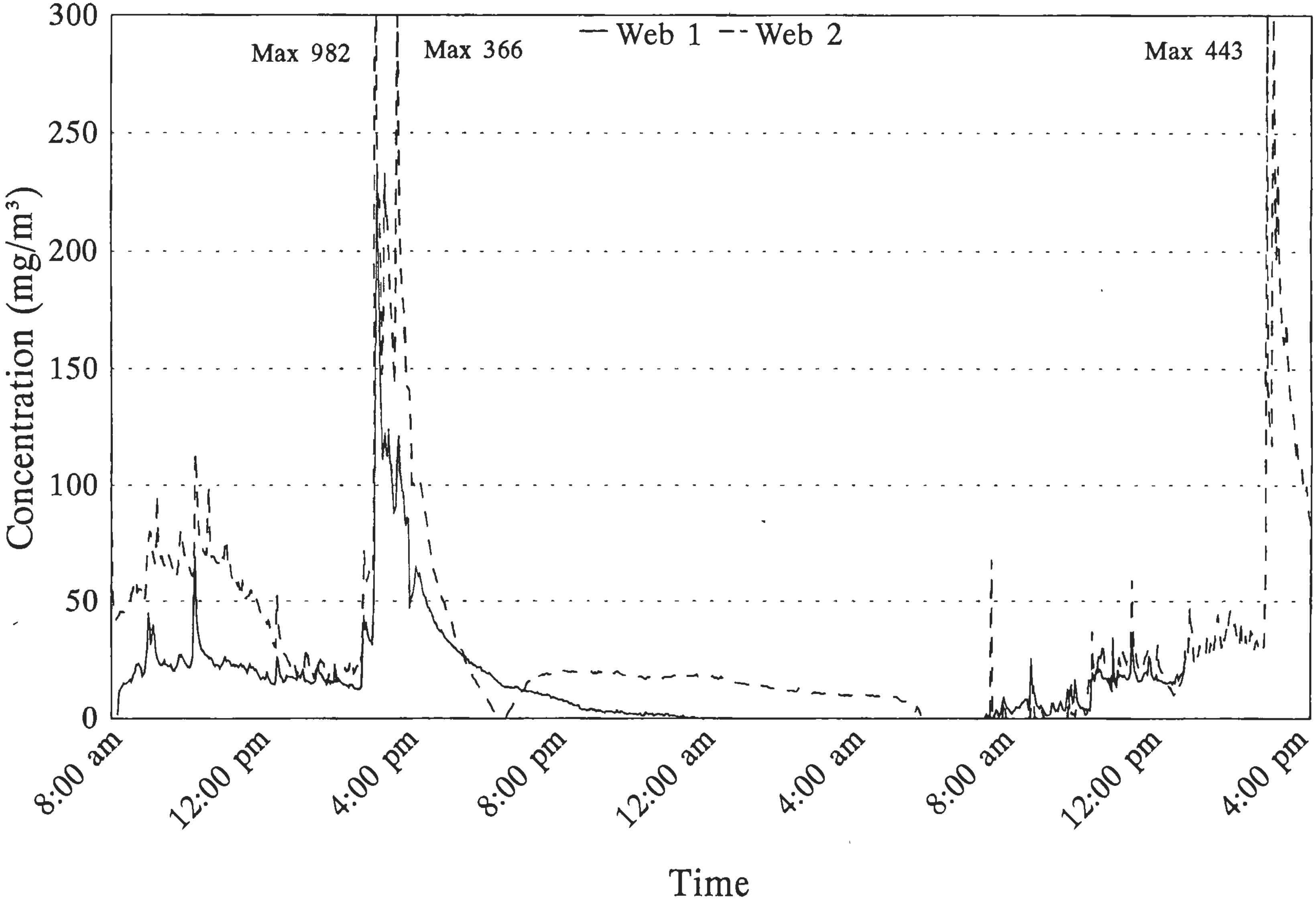

Figure 6. Site 2 Continuous Total VOC Concentration as Determined by Miran.

TABLE 13. SITE 2 MIRAN CALIBRATION TO TOTAL VOC.

Location	Date	Time	Miran (volt)	Total VOC (mg/m^3)	Miran (mg/m^3)^{a,b}
Web 1	Day 1	9:07-10:12	0.1056	22.99	24.66
	Day 1	12:10-13:10	0.0756	15.15	17.72
	Day 1	10:57-11:55	0.0830	23.88	19.43
Web 2	Day 1	13:10-14:02	0.0434	14.30	20.76
	Day 2	10:21-10:54	0.0461	16.92	22.26
	Day 2	12:59-14:03	0.0641	39.20	32.25

[a] Web 1 Total VOC = Miran (volt) x 231.4 + 0.224 $r^2 = 0.92$
[b] Web 2 Total VOC = Miran (volt) x 554.9 - 3.318 $r^2 = 0.84$

Samples of the bulk solvents used in the press operations were collected and analyzed. The results are presented in Table 14.

3.2.5 Site 2 Activity Measurement

As at Site 1, the solvent usage for cleaning presses was considered a likely activity related to the variability in VOC emission rates. The number of solvent usages during a period was defined as the number of times the activity code for wiping or spraying solvent occurred during the sampling period. If an event occurred within the last five minutes of a sample period it was considered half in the previous and half in the following sample period. The summary of solvent cleaning events are presented in Table 15.

Bulk solvent inventory data was obtained from the supply room at the plant. This data is presented in Table 16.

A total of 315,130 sheets (698,580 ft^2) were printed at site 2 during the two sampling days. Web 1 produced 56,548 sheets (73,430 ft^2). Web 2 produced 124,560 sheets (328,270 ft^2). Sheet press 1 printed 55,536 sheets (187,430 ft^2). Sheet press 2 printed 23,290 sheets (62,770 ft^2). The two-color sheet press printed 16,678 sheets (21,660 ft^2). The duplicator printed 38,518 sheets (25,010 ft^2).

TABLE 14. SITE 2 BULK SAMPLE ANALYSIS OF SOLVENTS (G/ML)

	V–120	Pronto	Rycoline	Stay–open	Rubber rejuvenator	PR500	Gum Arabic	Jet Wet
n–Hexane	bdl[a]	bdl	0.00195	bdl	bdl	bdl	bdl	bdl
Isopropanol	1.274 [b]	bdl	0.03965	0.11551	bdl	bdl	bdl	bdl
Benzene	bdl	bdl	0.02537	bdl	0.00571	0.00262	0.00216	0.00236
Toluene	bdl	bdl	bdl	0.00111	bdl	0.00247	bdl	bdl
Ethylbenzene	bdl	bdl	0.00785	0.08374	bdl	0.03801	bdl	bdl
p–Xylene	bdl	bdl	0.00237	0.05518	0.00024	0.02708	bdl	bdl
m–Xylene	bdl	bdl	0.00284	0.12530	bdl	bdl	bdl	bdl
Isopropylbenzene	bdl	0.00034	0.01207	bdl	bdl	0.01614	bdl	bdl
o–Xylene	bdl	0.00034	0.01078	0.02251	bdl	0.01668	bdl	bdl
n–Propylbenzene	bdl	0.00095	0.02718	bdl	bdl	0.00538	bdl	bdl
m&p Ethyltoluene	bdl	0.00436	0.11632	bdl	bdl	0.00322	bdl	bdl
Isobutylbenzene	bdl	0.00182	0.05736	bdl	bdl	bdl	bdl	bdl
1,3,5–Trimethylbenzene	bdl	bdl	bdl	bdl	bdl	0.00218	bdl	bdl
o–Ethyltoluene	bdl	0.00103	0.03829	bdl	bdl	0.00192	bdl	bdl
1,2,4–Trimethylbenzene	bdl	0.00379	0.07937	bdl	bdl	bdl	bdl	bdl
m–Diethylbenzene	bdl	0.00024	0.00634	bdl	bdl	bdl	bdl	bdl
p–Diethylbenzene	bdl	bdl	0.00452	bdl	bdl	0.00055	bdl	bdl
o–Diethylbenzene	bdl	0.00009	0.00170	bdl	bdl	0.01254	bdl	bdl
1,2,3–Trimethylbenzene	bdl	0.00043	0.01020	bdl	bdl	bdl	bdl	bdl
Total VOC	0.835 [c]	0.72500	0.31500	0.54500	0.40900	0.42000	0.08300	1.20800

[a] bdl:Below detection limit (<0.00001 g/ml)

[b] Although V–120 was nearly 100% isopropanol, the reported value differs from isopropanol density (0.785) due to the response being outside the range for which the instrument was calibrated

[c] VOC as hexane equivalent will not be the same as the compound density.

TABLE 15. SITE 2 SOLVENT CLEANING ACTIVITY SUMMARY (NUMBER OF CLEANINGS).

Time	Web #1	Web #2	Sheet #1	Sheet #2	Duplicator	Two-color	Total
Day 1							
08:13–09:16	0	3	0	2	1	2	8
09:16–10:07	0	3	0	0	3	0	6
10:07–11:04	0.5	1	0	0	4	0	5.5
11:04–12:02	2.5	2	0	0	2	5	11.5
12:02–13:07	0.5	0	0	0	4.5	3	8
13:07–13:59	2.5	2	0	0	0.5	2	7
13:59–15:16	3.5	10	1.5	0	6	12.5	33.5
15:16–15:45	2.5	0	2.5	3	2	1.5	11.5
Day 2							
08:00–09:07	1	6	0	0	0.5	6	13.5
09:07–10:14	2	0	0	3.5	3.5	16	25
10:14–11:02	1	2	0	3	1	15	22
11:02–12:02	1	2	2	1.5	5	0	11.5
12:02–13:03	1	2	0	1	2	0	6
13:03–13:59	4	1	0	0	5	0	10
13:59–15:07	2	6	0	3	0	0	11
15:07–15:58	10	2	5	7	1	0	25

TABLE 16. SITE 2 ONE–YEAR BULK SOLVENT INVENTORY DATA

Solvent	Units	Size/unit	MSDS VOC data	kg
Varn V–120	24	5 gal can	6.36 lb VOC/gal	346.91
PR–410 rubber rejuvenator	3	1 gal can	0.634 lb VOC/gal	0.86
Varn Revitol	5	1 gal can	0.97 lb VOC/gal	2.20
Ammonia	0	not listed	–	0.00
Varn Pronto	0	5 gal can	6.78 lb VOC/gal	0.00
Isopropanol	2	5 gal can	100% VOC, s.g.=0.78	29.52
Rycoline	11	1 gal can	100% VOC, s.g.=0.80	33.31
Stay open spray	324	17.5 oz can	min. 50% VOC (60%)	96.65
Super rubber rejuvenator	0	5 gal can	8.49 lb VOC/gal	0.00
Chrome cleaner	3	1 qt can	>60% VOC (70%) s.g.=0.96	1.91
Plate conditioner	3	1 qt can	>85% VOC (90%) s.g.=1.017	2.60
Gum arabic	1	1 gal can	0% VOC	0.00
Varn fountain solution	1	5 gal can	0.53 lb VOC/gal	1.20
Varn Jet Wet	4	1 gal can	7.49 lb VOC/gal	13.62
Ryobi fountain solution	2	2.5 gal can	5wt% VOC, 8.4 lb/gal	0.95
Total				529.74

3.3 Site 3 Sampling Results

3.3.1 Site 3 Description

Site 3 was one room of a large volume printing operation capable of producing national weekly magazines, running three shifts, 24 hours a day. The room contained three large multi-color web-heatset presses with cutting and folding equipment. All three had natural gas fired driers followed by catalytic afterburner pollution control devices. The presses printed on 38" wide web and were equipped with automatic blanket washing systems. The room was 16,431 m^3 and was served by general ventilation. The layout of site 3 is shown in Figure 7.

Site 3 was studied over a three day period. The first day was for equipment set-up and initial ventilation measurements. The following two days were the sampling days. Each sampling day consisted of six consecutive runs of approximately one-hour sample periods.

3.3.2 Site 3 Ventilation

Site 3 was served by general ventilation. The only mechanically supplied air to the room was through spot coolers positioned at the press control stations. The spot cooler intake was on the roof of the building and provided a total of 285.5 m^3/min of outside air. Other airflow into the room came through the loading dock doors (626.8 m^3/min), the south east door into the room (605.2 m^3/min), and the south west door (361.6 m^3/min). Also, there were two screen doors on the north wall of the room through which the direction of airflow was predominately inward (392.3 and 468.0 m^3/min). Airflow out of the room was through the doorways on the western wall (389.8 and 283.4 m^3/min), through two ceiling exhaust fans (847.2 and 846.4 m^3/min), and through the drying units on the print lines (133.1, 113.4, and 113.0 m^3/min). These measurements resulted in a good air mass balance around the room:

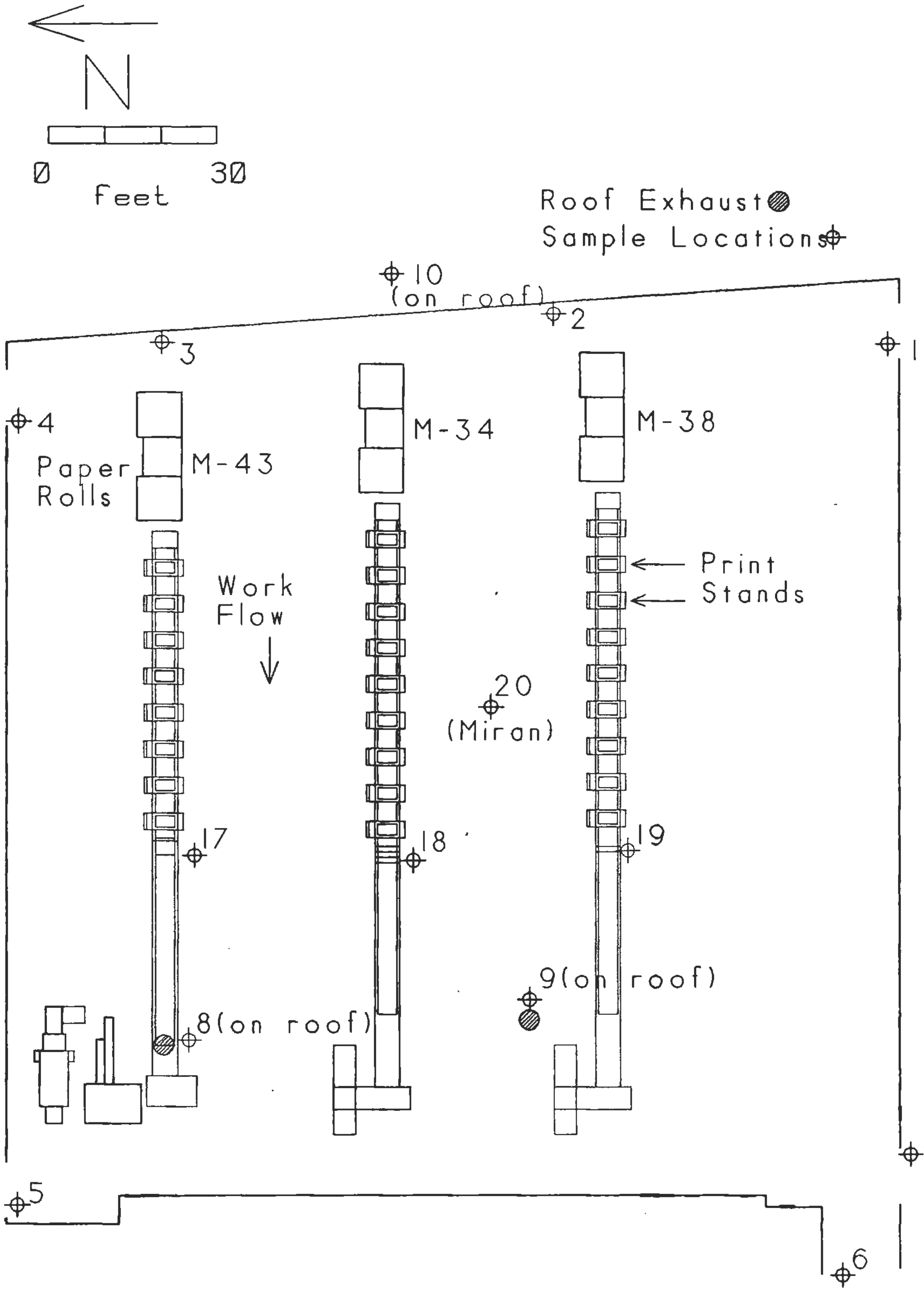

Figure 7. Site 3 Layout and Sampling Locations.

total in, 2,739.4 m³/min, total out, 2.727.9 m³/min). A schematic diagram of the airflow is presented in Figure 8 and the airflow measurements are summarized in Table 17.

TABLE 17. SITE 3 VENTILATION MEASUREMENTS

Direction	Location	No. of Measurements	Flow (m³/min)
Into Room	Southeast Door	3	605.2
	South Screen Door	3	468.0
	North Screen Door	3	392.3
	Southwest Door	3	361.6
	Loading Dock	3	626.8
	Roof Intake	1	285.5
	Total In		2,739.4
Out of Room	Northeast Door	3	389.8
	Northwest Door	3	283.4
	North Ceiling Exhaust	2	847.2
	South Ceiling Exhaust	2	846.4
	M-38 Exhaust	2	113.0
	M-34 Exhaust	2	113.4
	M-43 Exhaust	2	131.1
	Total Out		2,727.9

The effective airflow through the room and the room mixing factor were determined using the decay of CO concentration as measured by a CO analyzer that provided computerized output. The CO was from the exhaust of the forklift trucks operating in the plant. The decay curves used for these determinations occurred when there were no fork lifts operating in the room. This was done twice, in the morning and the afternoon of the first sampling day. The effective airflows were 19,524 and 26,723 cfm, respectively. This translates into 2.02 and 2.76 effective air changes per hour and k values of 0.20 and 0.28 using the average of the measured airflows into and out of the room.

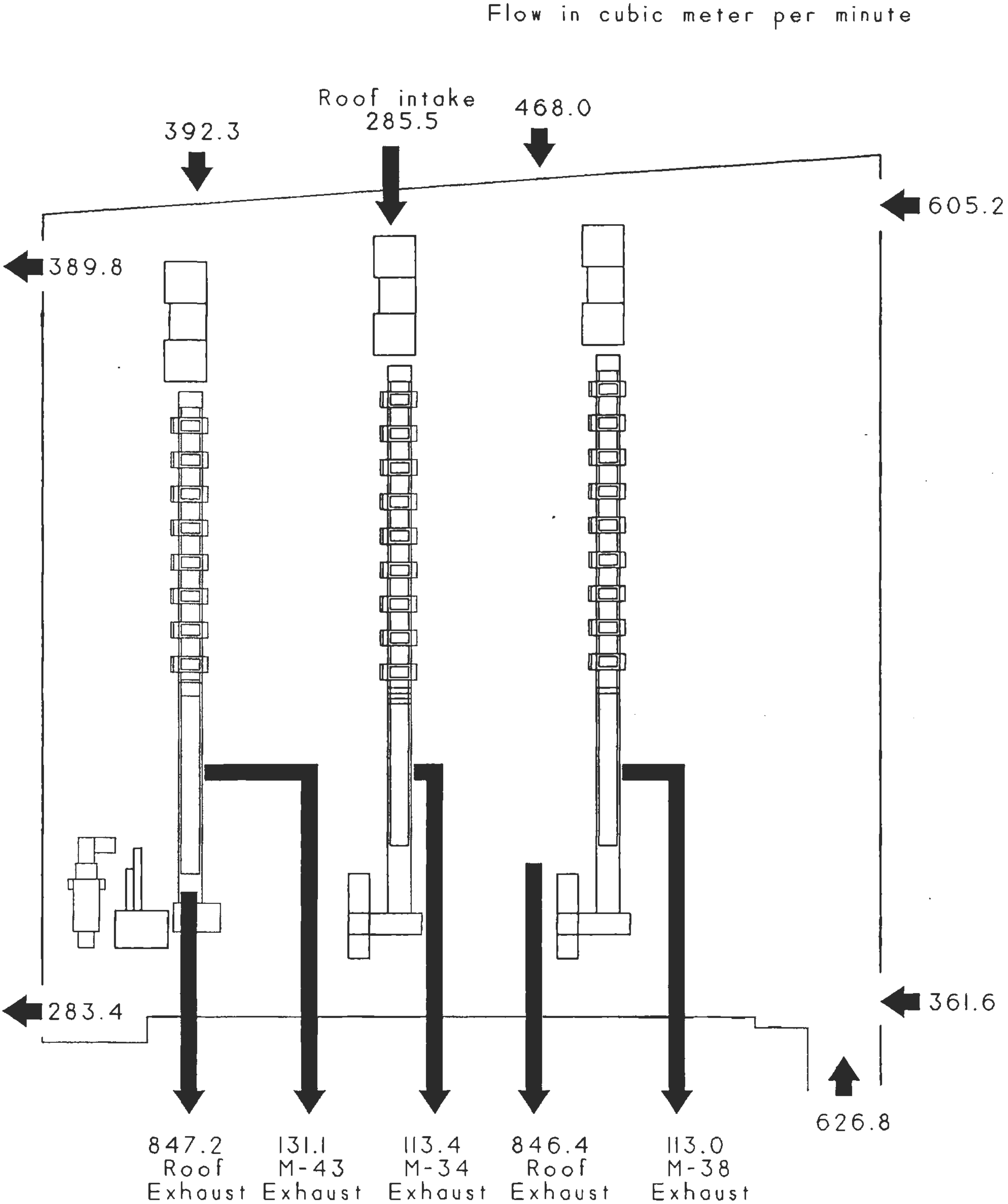

Figure 8. Site 3 Ventilation Schematic.

3.3.3 Site 3 Volatile Organic Compounds

The charcoal tube sampling locations are shown on Figure 7. Additionally, charcoal tube samples were taken in the drier exhausts before and after the catalytic incinerators. All charcoal tube samples were one-hour samples. Approximately 10% of the samples had quality control side-by-side samples taken next to them and analyzed by a contract lab. The contract lab results were highly correlated with the UIC results ($r^2 = 0.85$). A Miran was run in the center of the room side-by-side with a charcoal tube.

The total VOC results from GC analysis are presented in Table 18. The average speciated VOC concentrations is presented in Table 19. Complete speciated VOC data is presented in Appendix C. The samples collected in the drier system before and after the incinerator indicate a destruction efficiency of captured VOC that is generally greater than 98%. Complete data from the drier samples are included in Appendix C.

The Miran output trace for the two sampling days is presented in Figure 9. There was no discernable correlation between Miran averages during the sample periods and the corresponding charcoal tube concentrations. This limited the use of the Miran data since the charcoal tube-GC results were considered to be the primary measurement of total VOC.

Bulk samples of the solvents used on the presses were collected and analyzed on the GC. The results of the bulk sample analysis are presented in Table 20.

TABLE 18. SITE 3 TOTAL VOC RESULTS (MG/M^3)

Location ID	SE Door 1	S Screen 2	N Screen 3	NE Door 4	NW Door 5	Loading Dock 6	SW Door 7	N Roof Exhaust 8	S Roof Exhaust 9	Air Intake 10	M–43 Inlet 17	M–34 Inlet 18	M–38 Inlet 19	Mid Room 20
Day 1														
09:12–10:07	0.47	0.20	3.39	11.76	1.40	0.04	0.11	22.79	11.03	0.23	66.00	9.40	3.63	10.42
10:07–11:06	0.91	0.55	2.74	7.14	1.09	0.02	0.22	14.18	7.82	0.12	26.59	10.07	1.72	7.48
11:06–12:05	3.60	0.90	0.58	4.54	1.35	0.05	0.85	7.40	10.61	0.15	20.08	8.03	1.08	11.90
12:05–13:08	1.06	0.76	0.22	5.91	2.80	0.04	0.64	22.79	7.68	0.13	21.63	5.28	1.30	6.77
13:08–14:06	1.99	0.20	0.82	4.64	1.59	0.08	0.59	8.47	8.56	0.05	7.52	10.55	1.01	8.79
14:06–15:07	2.22	1.93	3.54	7.01	10.79	0.04	0.52	15.75	19.76	0.20	13.22	5.49	3.41	10.58
Average	1.71	0.75	1.88	6.83	3.17	0.05	0.49	15.23	10.91	0.15	25.84	8.14	2.02	9.32
Day 2														
09:05–10:07	0.69	0.26	0.04	3.92	2.09	0.01	0.83	8.98	4.77	0.07	10.01	7.07	0.86	9.23
10:07–11:08	5.14	0.71	0.21	4.17	2.75	0.03	0.11	10.05	8.34	0.06	11.11	9.10	2.02	12.51
11:08–12:06	1.59	0.80	0.21	3.90	3.52	0.96	2.81	7.90	3.82	0.07	9.45	5.00	3.19	7.01
12:06–13:06	2.66	1.39	0.26	3.53	2.59	1.46	1.82	4.47	3.56	0.06	17.65	7.13	12.55	4.07
13:06–14:09	76.07	15.89	3.84	16.22	7.07	0.25	16.96	19.00	15.96	0.04	24.08	24.03	15.19	29.31
14:09–15:08	39.87	8.08	1.73	5.69	2.86	2.66	16.05	15.17	15.80	0.04	22.44	8.63	11.15	10.21
Average	21.00	4.52	1.05	6.24	3.48	0.90	6.43	10.93	8.71	0.06	15.79	10.16	7.49	12.06
Two–day avg	11.36	2.64	1.46	6.54	3.33	0.47	3.46	13.08	9.81	0.10	20.81	9.15	4.76	10.69

TABLE 19. SITE 3 AVERAGE SPECIATED VOC CONCENTRATIONS (MG/M^3)

Location Compound ID	SE Door 1	S Screen 2	N Screen 3	NE Door 4	NW Door 5	Load Dock 6	SW Door 7	N Ceiling Exhaust 8	S Ceiling Exhaust 9	Air Intake 10	M−43 inlet 17	M−34 inlet 18	M−38 inlet 19	Mid Room 20
n−Hexane	0.245	0.024	0.005	0.041	0.037	0.001	0.057	0.064	0.082	bdl	0.063	0.063	0.054	0.090
Isopropanol	0.272	0.126	0.089	0.353	0.077	bdl	0.067	0.891	0.314	bdl	1.746	0.255	0.161	0.616
Benzene	0.362	0.140	0.100	0.361	0.195	0.011	0.112	0.718	0.584	bdl	0.997	0.505	0.249	0.555
Toluene	1.024	0.112	0.039	0.322	0.196	0.021	0.235	0.764	0.854	0.008	1.311	0.823	0.357	0.697
Ethylbenzene	0.162	0.012	bdl	0.035	0.006	bdl	0.037	0.115	0.066	bdl	0.275	0.054	0.010	0.088
p−Xylene	0.083	0.008	bdl	0.016	0.003	bdl	0.009	0.030	0.018	bdl	0.138	0.021	0.004	0.031
m−Xylene	0.165	0.021	0.002	0.024	0.007	0.003	0.037	0.045	0.031	bdl	0.043	0.034	0.013	0.059
Isopropylbenzene	0.175	0.023	0.005	0.031	0.007	0.003	0.051	0.076	0.056	bdl	0.098	0.058	0.036	0.080
o−Xylene	0.236	0.040	0.010	0.089	0.026	0.002	0.059	0.186	0.132	bdl	0.343	0.137	0.093	0.155
n−Propylbenzene	0.395	0.069	0.016	0.078	0.024	0.008	0.114	0.147	0.113	bdl	0.200	0.121	0.083	0.151
m&p−Ethyltoluene	1.765	0.330	0.093	0.384	0.152	0.043	0.527	0.690	0.529	bdl	0.934	0.591	0.407	0.702
Isobutylbenzene	bdl[a]	bdl	bdl	0.024	bdl	bdl	bdl	0.040	0.021	bdl	0.077	0.027	0.029	0.011
1,3,5−Trimethylbenzene	0.669	0.114	0.024	0.124	0.042	0.015	0.195	0.220	0.176	bdl	0.279	0.182	0.134	0.226
o−Ethyltoluene	0.517	0.081	0.016	0.124	0.041	0.011	0.138	0.197	0.155	bdl	0.280	0.173	0.139	0.197
1,2,4−Trimethylbenzene	1.021	0.147	0.088	0.279	0.109	0.031	0.311	0.611	0.341	0.001	1.259	0.463	0.337	0.443
m−Diethylbenzene	0.098	0.073	0.006	0.024	0.005	bdl	0.024	0.082	0.056	bdl	0.200	0.064	0.036	0.063
p−Diethylbenzene	0.062	0.009	bdl	0.026	bdl	bdl	0.008	0.070	0.022	bdl	0.126	0.062	0.034	0.043
o−Diethylbenzene	0.046	0.001	0.002	0.007	0.005	bdl	0.002	0.061	0.014	bdl	0.524	0.018	0.003	0.019
1,2,3−Trimethylbenzene	0.146	0.025	0.022	0.187	0.040	0.008	0.048	0.288	0.201	bdl	0.365	0.254	0.143	0.198
Total VOC	11.355	2.635	1.465	6.535	3.325	0.475	3.460	13.080	9.810	0.105	20.815	9.150	4.755	10.690

[a] bdl: below detection limit (<0.001)

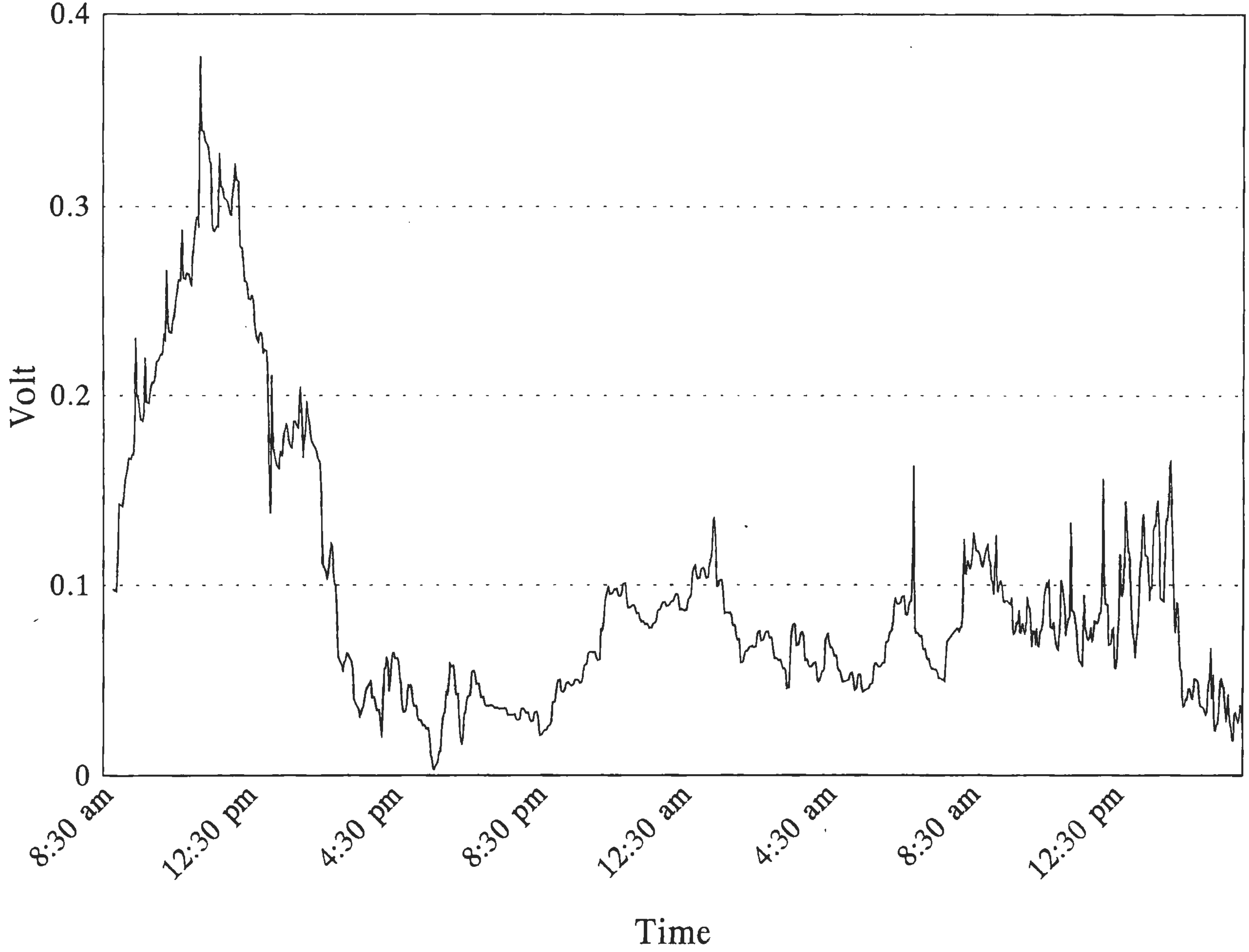

Figure 9. Site 3 Continuous Miran Output.

TABLE 20. SITE 3 BULK SAMPLE ANALYSIS OF SOLVENTS (G/ML).

Name	Blanket Wash	Quad Flash Oil Spray	Quad Blanket Rejuvenator	Automatic Blanket Wash	Profit Plus Kleer Gum	Dupont Kleer Gum	Type Wash
Compound UIC ID	A	C	D	H	J	L	M
n–Hexane	0.0647	0.0655	0.0603	0.0558	0.0446	0.0448	bdl
Isopropanol	bdl[a]	bdl	bdl	bdl	bdl	0.00723	0.508
Benzene	0.0437	bdl	bdl	0.0241	0.0403	0.025	0.048
Toluene	0.029	bdl	bdl	0.0432	0.182	0.0485	bdl
Ethylbenzene	bdl	bdl	bdl	bdl	0.01	bdl	0.00118
p–Xylene	0.0071	bdl	bdl	0.0116	bdl	0.0182	bdl
m–Xylene	0.0035	bdl	bdl	0.00574	0.0447	bdl	bdl
Isopropylbenzene	bdl	bdl	bdl	0.00107	0.0318	0.00219	bdl
o–Xylene	0.0123	bdl	bdl	0.0147	bdl	0.00633	bdl
n–Propylbenzene	bdl	bdl	bdl	0.0048	0.0538	bdl	bdl
m&p–Ethyltoluene	0.0174	bdl	0.592	0.0184	0.0257	0.00187	bdl
Isobutylbenzene	bdl	bdl	bdl	bdl	bdl	0.002	bdl
1,3,5–Trimethylbenzene	0.0936	bdl	bdl	0.0968	0.00418	0.00459	bdl
o–Ethyltoluene	0.0362	bdl	bdl	0.0381	0.00813	0.00637	bdl
1,2,4–Trimethylbenzene	0.0238	bdl	bdl	0.0249	bdl	0.0031	0.00136
m–Diethylbenzene	0.0024	bdl	bdl	0.00214	0.00173	0.00532	bdl
p–Diethylbenzene	0.0533	bdl	bdl	0.0547	0.000825	0.0129	0.00257
o–Diethylbenzene	0.00664	bdl	bdl	0.00446	0.00198	0.00204	0.00251
1,2,3–Trimethylbenzene	0.0128	bdl	bdl	0.00936	0.00784	0.00227	0.00319
Total VOC[b]	1.0419	0.1708	0.7727	0.7851	1.4338	0.5899	0.8198

[a] bdl: below detection limit (<0.0001)

[b] by area under chromatogram

3.3.4 Site 3 Particulates

Six hour particulate samples were collected during the two sampling days at the same locations as the VOC samples. Total particulate and elemental concentrations are presented in Table 21 and Table 22. Bulk samples of the inks used during the two sampling days were analyzed by PIXE. The results of the analysis are shown in Table 23.

3.3.5 Site 3 Activity Measurement

As at the other sites, solvent cleaning was considered the activity variable that would explain the majority of the variation in VOC emissions. UIC observers kept track of the number of solvent cleanings at each press. Solvent cleanings were classified as manual or automatic. Additionally, the time at each press between jobs is a period of high activity. The UIC observers had some difficulty observing all the solvent use events during these periods. However, the management of the company made available a computerized, time indexed, job listing for each press. The number of minutes of "makeready" time was recorded for each press. This activity variable "minutes of makeready" was considered in addition to the specific counts of solvent cleanings. A summary of the activity data at site 3 is presented in Table 24.

The bulk use of cleaning solvents and inks at each press was tracked during the two sample days. These data are presented in Table 25.

Over the two sampling days, Press M-43 printed 404,282 ft of web (1,282,000 ft^2). Press M-38 printed 355,594 ft (1,127,000 ft^2). Press M-34 printed 395,332 ft (1,253,000 ft^2).

TABLE 21. SITE 3 TOTAL PARTICULATE AND ELEMENTAL CONCENTRATION, DAY 1 (µG/M^3).

Element	SE Door (1)	S Screen (2)	N Screen (3)	NE Door (4)	NW Door (5)	Load Dock (6)	SW Door (7)	N Roof Exhaust (8)	S Roof Exhaust (9)	Air Intake (10)	M−43 Inlet (17)	M−34 Inlet (18)	M−38 Inlet (19)	Mid Room (20)
Na	< 0.356	< 0.369	< 0.406	< 0.414	< 0.401	< 0.318	< 0.401	0.759	< 0.428	< 1.218	< 0.368	< 0.387	< 0.345	< 0.328
Mg	< 0.216	< 0.220	< 0.239	< 0.251	< 0.249	0.308	< 0.241	< 0.252	< 0.251	< 0.718	< 0.224	< 0.235	< 0.201	< 0.194
Al	0.317	0.286	0.625	< 0.193	1.834	0.397	0.518	4.547	0.551	1.040	1.827	0.551	0.243	0.363
Si	0.994	0.624	2.434	0.430	4.512	0.789	2.231	9.151	1.685	1.331	4.222	1.809	0.333	0.763
S	0.620	0.599	2.859	0.489	1.835	1.694	2.332	2.612	1.954	3.068	2.318	1.327	0.379	0.528
Cl	0.243	0.087	0.089	0.113	0.552	0.100	0.207	1.719	0.168	0.426	0.240	0.097	0.148	< 0.100
K	0.262	< 0.088	0.271	< 0.096	0.684	< 0.075	0.221	1.803	0.169	< 0.280	0.255	0.062	< 0.077	< 0.078
Ca	1.492	0.605	3.434	0.379	2.456	0.379	3.469	6.907	2.206	0.393	4.205	2.610	0.081	0.747
Ti	< 0.049	0.034	0.093	0.052	0.519	0.037	0.083	1.313	0.360	0.040	0.460	0.066	0.036	< 0.039
V	< 0.027	< 0.023	< 0.025	< 0.024	0.004	< 0.019	< 0.026	< 0.042	< 0.029	0.017	< 0.028	< 0.026	< 0.021	0.008
Cr	< 0.016	< 0.013	< 0.013	< 0.014	< 0.013	0.019	0.035	< 0.017	0.003	< 0.044	< 0.014	< 0.014	0.029	0.017
Mn	< 0.013	< 0.009	0.024	0.006	0.013	0.008	0.012	0.030	0.013	< 0.032	0.018	0.012	< 0.009	0.004
Fe	0.101	0.097	1.032	0.156	0.597	0.169	0.712	1.393	0.396	0.253	0.906	0.311	0.023	0.109
Ni	0.004	< 0.004	< 0.004	0.001	0.004	0.000	< 0.004	0.015	0.001	< 0.013	< 0.004	0.000	0.001	0.003
Cu	0.009	0.000	0.017	0.003	0.031	0.002	0.013	0.111	0.030	0.001	0.076	0.037	< 0.004	0.006
Zn	0.027	0.011	0.064	0.006	0.056	0.028	0.042	0.125	0.042	0.111	0.077	0.021	0.005	0.010
Ga	< 0.007	< 0.004	< 0.004	0.002	< 0.005	< 0.004	< 0.005	0.004	0.002	< 0.016	< 0.005	< 0.005	< 0.004	< 0.004
As	< 0.009	< 0.007	0.007	< 0.007	< 0.009	< 0.005	< 0.008	< 0.012	< 0.008	< 0.020	< 0.007	< 0.008	< 0.006	< 0.006
Br	< 0.023	< 0.013	< 0.014	< 0.015	< 0.015	< 0.011	< 0.014	< 0.018	< 0.015	< 0.042	< 0.014	< 0.015	< 0.013	< 0.014
Rb	0.009	0.015	< 0.027	< 0.029	< 0.024	< 0.025	< 0.030	0.009	< 0.028	< 0.095	0.004	0.007	< 0.025	< 0.023
Sr	0.010	< 0.029	0.009	< 0.026	< 0.025	< 0.022	0.003	0.017	0.013	< 0.091	0.009	0.014	< 0.022	< 0.025
Zr	< 0.067	0.014	< 0.038	< 0.043	< 0.040	0.008	0.025	< 0.053	< 0.040	0.011	0.017	0.007	< 0.033	< 0.038
Pb	< 0.030	0.011	< 0.026	0.005	0.055	< 0.018	0.024	0.087	0.019	0.019	0.022	0.011	< 0.021	0.005
Total PM(mg/m^3)	< 0.011	< 0.012	0.018	< 0.012	0.153	0.082	0.103	0.163	0.048	< 0.035	0.057	0.058	0.017	0.010

TABLE 22. SITE 3 TOTAL PARTICULATE AND ELEMENTAL CONCENTRATION, DAY 2 (μG/M^3).

Element	SE Door (1)	S Screen (2)	N Screen (3)	NE Door (4)	NW Door (5)	Load Dock (6)	SW Door (7)	N Roof Exhaust (8)	S Roof Exhaust (9)	Air Intake (10)	M−43 Inlet (17)	M−34 Inlet (18)	M−38 Inlet (19)	Mid Room (20)
Na	< 0.381	< 0.387	< 0.345	< 0.395	< 0.379	< 0.350	< 0.404	< 0.334	< 0.470	< 0.612	< 0.376	< 0.360	< 0.346	< 0.380
Mg	< 0.227	< 0.209	< 0.203	< 0.220	0.439	< 0.195	< 0.246	< 0.192	< 0.288	< 0.373	< 0.228	< 0.215	< 0.208	< 0.209
Al	0.443	0.344	0.272	0.323	1.958	0.244	0.853	1.322	0.495	0.345	0.611	< 0.184	0.263	0.455
Si	1.148	0.477	0.269	0.674	4.829	1.035	3.418	3.216	0.873	0.682	1.950	0.277	0.297	1.234
S	0.621	0.457	0.306	0.524	1.171	0.824	2.469	1.236	0.449	1.012	1.212	0.310	0.233	0.771
Cl	0.136	0.123	0.124	0.068	0.151	0.110	0.301	0.066	< 0.148	0.035	0.233	0.116	< 0.106	0.207
K	0.105	< 0.082	< 0.078	< 0.096	0.302	0.088	0.486	0.220	< 0.112	< 0.137	0.229	< 0.086	< 0.081	0.078
Ca	1.654	0.355	< 0.071	0.911	3.317	0.984	7.826	3.761	0.656	0.458	3.036	0.070	0.163	1.831
Ti	0.637	0.145	0.016	0.231	0.651	0.067	0.749	0.569	0.129	0.038	0.441	0.043	0.081	0.425
V	0.019	< 0.022	< 0.022	0.007	< 0.024	< 0.026	< 0.029	0.005	< 0.030	< 0.043	< 0.026	0.004	0.006	0.007
Cr	< 0.012	< 0.011	< 0.012	< 0.012	< 0.010	< 0.015	< 0.012	< 0.015	< 0.016	< 0.024	< 0.013	< 0.013	< 0.013	0.003
Mn	0.008	0.008	0.002	0.011	0.019	0.017	0.022	0.015	< 0.013	0.008	0.020	< 0.010	< 0.011	0.006
Fe	0.279	0.339	0.087	0.518	0.908	1.527	1.116	0.841	0.135	0.213	0.895	0.036	0.091	0.489
Ni	0.000	< 0.004	< 0.004	< 0.004	< 0.003	< 0.005	< 0.004	0.003	0.002	< 0.008	< 0.004	< 0.004	< 0.004	< 0.004
Cu	0.005	0.004	0.002	0.023	0.032	0.057	0.029	0.035	0.007	0.002	0.050	0.003	0.002	0.024
Zn	0.037	0.005	0.021	0.029	0.101	0.059	0.157	0.051	0.023	0.009	0.058	0.006	0.010	0.029
Ga	< 0.004	< 0.004	< 0.005	< 0.004	< 0.004	< 0.006	< 0.005	< 0.006	< 0.005	< 0.008	< 0.004	< 0.005	< 0.005	< 0.004
As	< 0.006	< 0.006	< 0.006	< 0.007	< 0.005	< 0.010	< 0.007	< 0.008	< 0.007	< 0.013	< 0.006	0.001	< 0.007	< 0.007
Br	< 0.012	< 0.012	< 0.013	< 0.013	< 0.011	< 0.018	< 0.013	< 0.018	< 0.018	< 0.031	< 0.014	< 0.014	< 0.003	< 0.014
Rb	< 0.025	0.005	< 0.027	0.005	< 0.020	0.013	< 0.024	< 0.035	0.005	0.006	< 0.025	0.009	< 0.029	0.005
Sr	< 0.023	0.003	< 0.025	< 0.025	< 0.023	0.015	0.010	0.004	< 0.032	0.005	0.009	< 0.026	< 0.029	< 0.026
Zr	< 0.039	< 0.034	0.006	< 0.037	0.003	< 0.061	< 0.040	< 0.052	0.007	< 0.080	0.022	0.004	< 0.043	< 0.036
Pb	0.004	0.009	0.003	0.013	0.007	0.044	0.023	0.015	< 0.026	0.017	0.010	< 0.023	< 0.021	0.006
Total PM(mg/m^3)	0.024	0.122	< 0.011	0.054	0.063	0.028	0.105	0.047	0.032	< 0.022	0.028	0.019	0.016	0.038

TABLE 23. SITE 3 PIXE ANALYSIS OF BULK INK SAMPLES (PPM WT.)

Name	DB1000	DK1000	DCK5000	DYC5000	CCK3010	CCR3012	CCB3011	DCR5000	DR1000	CCY1000	DCB5000	DY1000
Color	Blue	Black	Black	Yellow	Black	Red	Blue	Red	Red	Yellow	Blue	Yellow
Element ID	1	2	3	4	5	6	7	8	9	10	11	12
Al	618.702	880.982	442.981	583.882	1090	1130	1440	1200	1060	786.85	421.01	496.414
Si	89.666	270.935	136.852	<62.030	408.651	281.099	512.258	218.184	202.465	<56.120	68.192	173.943
P	<25.610	153.11	102.852	105.502	<34.580	135.446	152.374	111.603	78.873	<33.210	214.393	70.771
S	216.058	1510	1130	234.299	1500	5580	335.603	5430	5000	190.795	123.943	248.089
Cl	56.173	319.652	171.383	7900	361.007	29.137	150.818	255.139	14.734	6510	67.232	7260
K	<8.794	71.446	58.858	<15.940	77.732	58.67	<11.030	25.667	52.947	<14.730	<6.878	<13.980
Ca	78.087	172.199	73.045	210.822	184.858	12020	83.014	10180	9970	93.856	282.81	38.853
Ti	7.452	7.138	<4.551	276.49	<3.302	5.253	14.362	12.208	54.173	23.227	<6.209	8.282
Cr	<2.239	1.166	<1.181	<0.942	0.451	<0.949	4.503	<1.585	<0.776	<0.805	<2.752	0.166
Mn	<2.302	<0.612	0.145	430.773	1.477	<0.788	<2.677	316.148	<0.687	<0.714	<3.264	<0.428
Fe	33.784	87.865	65.152	11.079	69.15	35.77	28.37	36.675	29.449	33.22	298.12	44.47
Co	5.082	0.143	0.224	1.128	0.463	0.427	<2.606	<0.642	0.163	0.127	52.322	0.134
Ni	17.771	0.485	0.333	0.443	0.342	0.611	<3.275	0.643	0.728	0.252	3.166	<0.186
Cu	1047	0.525	<0.492	0.286	1.169	1.091	1.172	0.995	0.849	2.229	15.133	1.708
Zn	50.561	59.078	18.504	2.205	2.778	1.564	<12.540	1.366	1.163	4.69	1082	4.235
Ga	<7.470	<0.360	<0.561	<0.409	<0.353	<0.385	<6.713	<0.438	<0.264	<0.346	65.103	<0.192
As	<1.839	0.038	0.603	0.087	<0.460	0.053	<2.311	<0.544	<0.303	<0.452	<2.949	0.108
Br	0.628	0.986	2.354	2.076	1.632	2.141	<5.076	1.387	1.258	2.806	<6.267	2.23
Sr	4.096	0.529	1.169	<2.388	<2.007	179.874	2.883	144.696	116.086	2.276	<12.070	1.47
Zr	5.258	0.675	1.827	<3.707	5.811	3.18	8.859	1.064	<4.510	<3.328	11.973	0.295
Mo	27.964	<3.982	1.016	0.63	<5.232	<5.054	14.842	<5.371	<2.933	1.327	35.804	<2.498
Ba	<22.260	<10.160	<14.360	<27.180	<11.190	88.142	<24.050	994.426	281.692	37.847	<19.450	20.138
Pb	<5.288	<1.223	1.116	<1.813	<10.552	<1.642	<7.515	0.452	<1.007	0.287	<9.545	<0.797

TABLE 24. SITE 3 ACTIVITY SUMMARY (TOTALS FOR ALL THREE PRESSES)

			Makeready	Blanket Wash	
Run	Start	Stop	(min)	Automatic	Manual
1	09:12	10:07	55	2	10
2	10:07	11:06	59	0	10
3	11:06	12:05	59	1	12
4	12:05	13:08	26	2	22
5	13:08	14:06	71	1	9
6	14:06	15:07	109	2	2
7	09:05	10:07	64	1	14.5
8	10:07	11:08	118	0	7.5
9	11:08	12:06	14	0	24
10	12:06	13:06	0	2	6
11	13:06	14:09	24	1	14
12	14:09	15:08	9	1	3.5

TABLE 25. SITE 3 BULK SOLVENT AND INK USE.

	M−34		M−43		M−38	
Material	Day 1	Day 2	Day 1	Day 2	Day 1	Day 2
Fountain Solution (gal)	105	65	91.35	51.11	105	65
Auto Blanket Wash (lb)	71	4	0	0	0	10.36
Blanket Wash (lb)	8.3	6.95	11.08	7.88	13.48	0.98
Type Wash (lb)	0.68	0.14	0	0.38	0.25	0.06
Blanket Rejuvenator (lb)	0	0	0	0	0.07	0
Black Ink (lb)	57	53	100	54	70	22
Blue Ink (lb)	102	88	160	103	154	28
Red Ink (lb)	100	92	184	102	122	26
Yellow Ink (lb)	95	87	145	92	78	32

4 DATA ANALYSIS

The concentration, ventilation, and activity data collected at each site were used to determine emission rates and emission factors for each site. Emission rates were developed using forms of the experimental mass balance model and the completely mixed space model. Emission factors were developed by correlating activity variables with emission rates using linear regression analysis.

4.1 Site 1 Data Analysis

4.1.1 Site 1 Emission Rates

A long term estimate of VOC emissions was made based on the estimated bulk use of cleaning solvents provided by the printers (Table 9). Based on the estimated volume used and the densities determined by GC (Table 7), the weekly VOC emissions are 38.0 kg. This is equivalent to 7.60 kg/day and 1,900 kg/year based on 50 weeks of work per year. These emission rates assume that all cleaning solvent evaporates into the atmosphere. This assumption is supported by observations at the site. The cleaning solvents were put on rags to clean the presses. After cleaning, the rags were left in open waste cans where they would off-gas to dryness.

The experimental mass balance model and the charcoal tube-determined VOC concentrations were used to determine the emission rate during each sampling period. The ambient air VOC concentration for the geographic area of site 1 can reasonably be assumed to be zero, thus the VOC mass flow into the room was assumed to be zero. Therefore the emission rate in the press room is equal to the mass flow rate out of the room. The airflow out of the room was 140 m^3/min, based on the makeup airflow, but the exact locations of airflow out were not determined and would be difficult to determine. The VOC concentration of the exfiltrating air was estimated two ways. First, the average concentration in the room using all press room charcoal tube samples was used. Second, the average of the samples taken at a distance from the presses (air supply, air return, and workbench) was used. Table 26 presents the emission rates during the two sampling days using this approach.

TABLE 26. SITE 1 EMISSION RATES USING THE EXPERIMENTAL MASS BALANCE MODEL.

	All Press Room Samples		Samples Remote from Presses	
Time	Avg Concentration (mg/m^3)	Emission Rate (g/hr)	Avg Concentration (mg/m^3)	Emission Rate (g/hr)
09:08 - 10:07	72.08	604.61	53.40	447.92
10:07 - 11:09	47.82	401.11	37.93	318.16
11:11 - 12:02	35.64	298.95	37.16	311.70
13:13 - 14:11	38.65	324.20	37.44	314.05
14:12 - 15:14	62.58	524.92	49.45	414.79
15:15 - 16:13	155.08	1,300.81	126.28	1,059.24
09:11 - 10:04	21.86	183.36	20.35	170.70
10:05 - 11:01	31.27	262.29	22.61	189.65
11:02 - 12:00	41.57	348.69	33.99	285.11
13:21 - 14:21	65.35	548.16	58.85	493.63
14:22 - 15:18	150.43	1,261.81	113.99	956.15
15:18 - 16:19	147.74	1,239.24	133.61	1,120.72
Average		608.2		506.8

The two approaches correlate well (r^2 = 0.98) with the difference being that the second approach predicts approximately 80% of the emissions of the first due to the lower average concentrations. The presses were operated approximately 10 hours a day during the test period. Using this as an average workday and 50 weeks per year of operation, the annual emissions predicted using these approaches are 1,520 kg/year and 1,267 kg/yr. These yearly emission rates are on the same order of magnitude as the yearly emissions based on the estimate of bulk usage. This agreement is quite good considering the bulk usage was estimated and the emission rates were modelled on only two days that may or may not have been typical workdays. The emission rates determined using the samples remote from the presses will be considered the appropriate estimation using the mass balance model. The air exfiltrating from the room most likely leaves at the border of the room where the concentration is better represented without the near press samples.

The emission rates at site 1 were also modelled using the completely mixed space model. The completely mixed space model requires a measure of instantaneous concentration in the room at the start of the sampling period, and a measure of the average concentration in the room during the sampling period. Since the Miran ran continuously, there is a measure of the instantaneous start concentration. The Miran output was calibrated to the room average concentration using the data in Table 6. The room average could be determined in three ways: 1) the Miran average calibrated to room concentration determined by charcoal tubes could be used, 2) the charcoal tube measured room average concentration could be determined using all samples, or 3) the charcoal tube average using only the three samples taken at a distance from the presses. The Miran average was not used because of the multiple steps in calibrating the voltage to room equivalent total VOC, which included the charcoal tube data. In the completely mixed space model it is appropriate to include the near-press samples in determining the average concentration. Less than complete mixing and variation in concentration in the room is accounted for in the mixing factor. The use of the Miran data for the initial concentration is retained for two reasons: 1) it is the only available measure of instantaneous concentration and 2) in spaces with relatively high k values (thus high effective air-change rates) and long sampling times, the effect of initial concentration on the solution is small.

The effective airflow through the room (kq) was 3,524 m^3/hr using the make-up air flow and the experimentally determined k of 0.42 (Table 3). The volume of the airspace served by the ventilation system was 1631.2 m^3. Using equation 9, the average VOC emission rate in the room was 278.3 g/hr. This is equivalent to 695.8 kg/yr. Again this is in the same order of magnitude predicted using the bulk usage estimates. Table 27 presents the hourly data and results. The results of the completely mixed space model correlates well with the results of the experimental mass balance model ($r^2 = 0.82$) but predicts only 65% of the emissions of the experimental mass balance model.

TABLE 27. SITE 1 EMISSION RATES USING THE COMPLETELY MIXED SPACE MODEL.

Time	Ci (mg/m^3)	Cav (mg/m^3)	Time (min)	S (g/hr)
09:08 - 10:07	75.82	72.08	58	244.5
10:08 - 11:09	62.38	47.82	61	133.6
11:11 - 12:02	64.55	35.64	52	41.6
13:13 - 14:11	37.24	38.65	58	139.8
14:12 - 15:14	52.79	62.58	62	243.5
15:15 - 16:13	62.93	155.08	58	781.2
09:11 - 10:04	29.52	21.86	53	55.3
10:05 - 11:01	35.92	31.27	56	97.8
11:02 - 12:00	21.24	41.57	58	198.3
13:21 - 14:21	51.76	65.35	60	263.5
14:22 - 15:18	83.72	150.43	56	707.4
15:18 - 16:19	184.46	147.74	61	432.7
Average				278.3

4.1.2 Site 1 Emission Factors

Emission factors for printing at site 1 were developed using the emission rates in the previous section and the process activity variation reported in Table 8. The activities were reported per run period, which was approximately, but not exactly, one hour. The emission rates previously reported in g/hour were converted to g/run so the two variables would have a common denominator. Table 28 summarizes the data used in emission factor development at site 1.

TABLE 28. SITE 1 EMISSION FACTOR DATA.

	Emission Rates		Activity					
	EMB	CMS	(solvent cleanings/run)					
Time	(g/run)	(g/run)	Press 1	Press 3	Press 4	Dup. 1	Dup. 3	Total
09:08 - 10:07	433.0	236.3	0	2	7	2	0	11
10:08 - 11:09	323.5	135.9	2	0	4	1	2	9
11:11 - 12:02	270.1	36.0	0	0	0	0	2	2
13:13 - 14:11	303.6	135.1	0	0	2	1	4	7
14:12 - 15:14	428.6	251.6	0	3	5	2.5	3.5	14
15:15 - 16:13	1023.9	755.2	2	6	4	3.5	1.5	17
09:11 - 10:04	150.8	48.8	0	1	0	1	2.5	4.5
10:05 - 11:01	177.0	91.3	0	2	3	0	0	5
11:02 - 12:00	275.6	191.7	0	2	1	5	0	8
13:21 - 14:21	493.6	263.5	2	0	0	0	7	9
14:22 - 15:18	892.4	660.2	0	8	5	0	5	18
15:18 - 16:19	1139.4	439.9	0	2	0	0	0	2

A total room emission factor was developed by plotting the total number of solvent cleanings against the emissions from each model. These plots are shown in Figure 10 and Figure 11. The data points seem to lie in a generally straight line except for the point for 15:18 to 16:19 the second day. This time period had only two solvent cleanings but both models predicted very high emissions. In reviewing the activity data an explanation was discovered. During that time period the observer noted that solvent was transferred from large bulk containers to the smaller bottles used at the presses. In fitting a line through the points, this outlier was excluded because of the large amount of VOC emissions from this transfer process that would mask any emissions from cleaning activities.

The emission factor is the slope of the lines plotted in Figures 10 and 11. The total emission factor for site 1 is 48.51 g/cleaning using the experimental mass balance model ($r^2 = 0.78$) and 42.11 g/cleaning using the completely mixed space model ($r^2 = 0.82$).

Using these emission factors, the expected emissions from 2 solvent cleaning is 97.02 or 84.22 grams VOC. The modelled emissions during the run in which solvent transfer occurred was 1,139 or 440 grams VOC. The difference between what was modelled and what was expected based on solvent cleaning alone is a measure of the emissions from the solvent transfer process. The two models give emission factors of 1,042 and 356 grams VOC per bulk solvent transfer.

The next step in the emission factor analysis was to determine if the contributions from the individual presses could be separated using multiple independent activity variables. Due to the limited number of data points, presses were grouped by category giving three process variables. Cleaning events at presses 1 and 4, the two color presses, were added to give a two color sheet press variable. The activities at the duplicators were combined also.

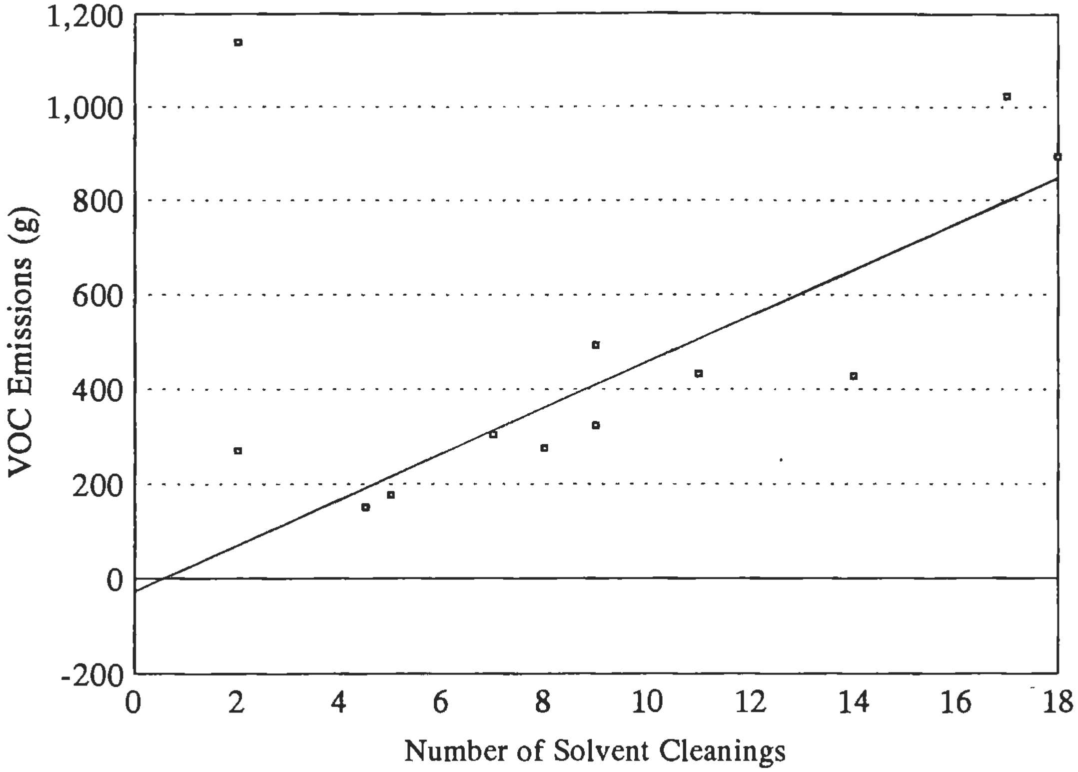

Figure 10. Site 1 Room Total Emission Factor Using the Experimental Mass Balance Model.

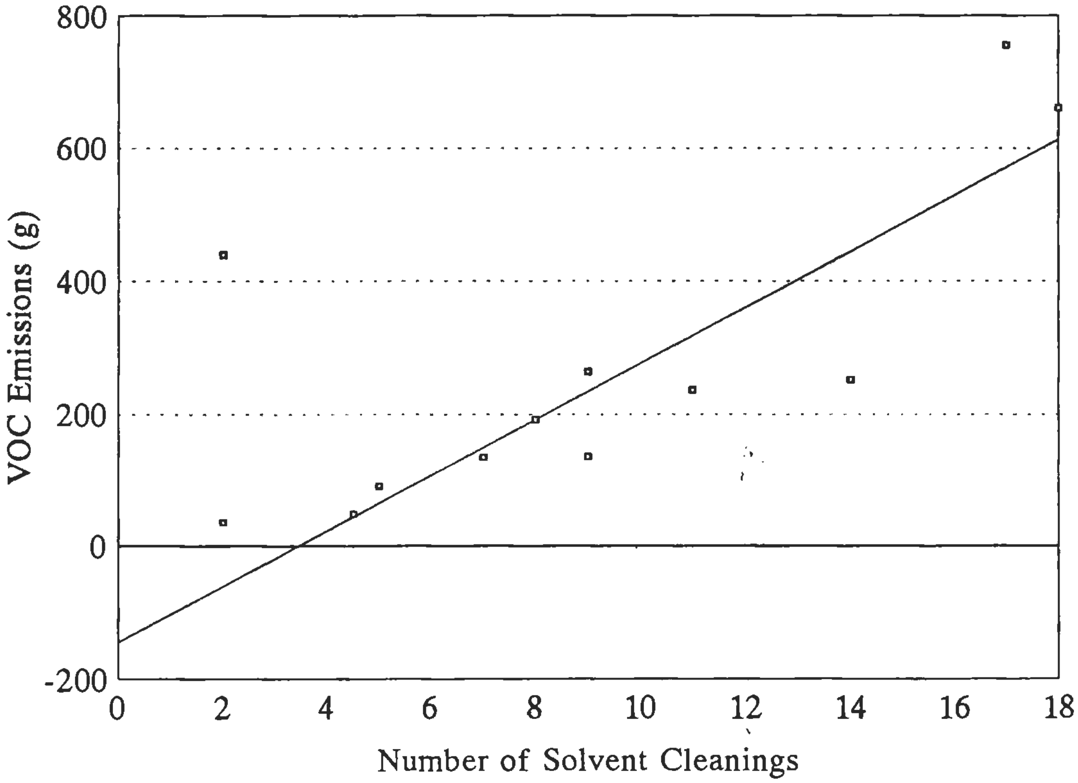

Figure 11. Site 1 Room Total Emission Factor Using the Completely Mixed Space Model.

Solvent cleaning at press 3, the single color sheet press, was the third independent variable in this analysis. The appropriate physical model includes all three types of press cleanings as predictors of emission rate variability. However, each variable was modelled against the emission rate independently and then in combination. This was done to see which variable accounted for the most variability in the emission rate and to see if the coefficients changed much when multiple variables were modelled together. Table 29 shows the results of modelling these variables separately and in combination for each of the emission rate model results.

TABLE 29. INDIVIDUAL SOURCE EMISSION FACTOR DEVELOPMENT.

	Coefficient (p value)				
Emission Rate Model	One-Color Press (g VOC/cleaning)	Two-Color Presses (g VOC/cleaning)	Duplicators (g VOC/cleaning)	β_0	r^2
EMB	87.3 (0.002)	-[a]	-	243	0.67
EMB	-	63.0 (0.07)	-	222	0.32
EMB	-	-	60.1 (0.18)	196	0.19
EMB	75.6 (0.01)	25.3 (0.32)	-	184	0.71
EMB	81.2 (0.003)	-	39.7 (0.14)	99.5	0.75
EMB	-	63.6 (0.05)	60.6 (0.11)	-18.8	0.52
EMB	66.8 (0.01)	29.8 (0.20)	43.6 (0.10)	15.4	0.81
CMS	79.5 (<0.001)	-	-	81.7	0.78
CMS	-	52.4 (0.07)	-	78.6	0.31
CMS	-	-	49.6 (0.19)	59.0	0.18
CMS	71.8 (0.002)	16.6 (0.35)	-	42.8	0.80
CMS	74.8 (<0.001)	-	30.8 (0.10)	-29.9	0.85
CMS	-	52.7 (0.05)	50.0 (0.12)	-120	0.50
CMS	65.1 (0.002)	20.1 (0.19)	33.4 (0.07)	-86.5	0.88

[a] - : not in model

The y-intercept is an artifact of the least squares fit of the data that retains little physical meaning. A positive intercept could be interpreted as a measure of invariable emissions. A negative intercept has no physical meaning. Including all three variables in the model produces an F-test value significant at an $\alpha = 0.1$. The partial F-test for each variable in the three variable models indicates that the Two-color press variable does not significantly improve the model at this significance level. Regardless of the statistical interpretation of the multiple regression analysis results, there are good physical justifications to include all three variables in the model. There is no reason to assume that a press type has no VOC emissions with cleaning activities. On the contrary, there is measurable bulk use of solvent at each press type which must end up as VOC emissions. The residuals of the three variable model have been examined and there is no indication that inclusion of the third variable with a $p > 0.10$ alters their pattern. For this reason it was included in the model.

The total VOC emission factor for site 1 is 45.31 g VOC/solvent cleaning. The source specific emission factors at this site were: 65.95 g VOC/one-color press cleaning, 24.95 g VOC/two-color press cleaning and 38.5 g VOC/duplicator cleaning. The total mass emissions of VOC for a given time period can be calculated using equation 10. Also, the transfer of solvent from bulk containers to working containers emits 699 g VOC. These emission factors are the average of the emission factors developed using the two emission rate models.

$$S' = 65.95 \times X_1 + 24.95 \times X_2 + 38.50 \times X_3 \tag{10}$$

S' = grams of VOC emitted from press cleaning
X_1 = number of cleanings of one-color press
X_2 = number of cleanings of two-color presses
X_3 = number of cleanings of duplicators

4.2 Site 2 Data Analysis

4.2.1 Site 2 Emission Rates

The bulk solvent inventory provided by the management of site 2 was used to determine the yearly emission rate. The inventory was for the 12 month period immediately following the test dates. The plant employees reported that there was no major process change during that period. The data in Table 16 represent 530 kg VOC/year emitted from the printing operations. This assumes all cleaning solvent evaporates, which, as at site 1, is a reasonable assumption.

The experimental mass balance model and the completely mixed space model were used to model the emission rates during the sample periods. Both models had difficulties which will be discussed with the model results.

The experimental mass balance model assumed that the VOC mass flow into the room was zero. VOC generation in the room would equal the VOC mass flow out of the room determined by the product of the airflow out of the room and the VOC concentration of that air. The only identified location of airflow out of the room was the stairway in the northeast corner of the room (120.3 m^3/min). VOC concentration measurements were also taken at that location. Table 30 presents the results of the experimental mass balance model at site 2. Using the stair flow and concentration, the average emission rate was 51.52 g VOC/hr. Site 2 operated one eight hour shift a day. For eight hours of VOC emissions a day, five days a week and fifty weeks per years, the emission rates are 0.41 kg/day and 103 kg/year. This emission rate is one fifth of the emissions from the bulk solvent inventory. The modelled emissions could be lower than the inventory predicted emissions for a number of reasons. The test days could have been low emission days compared to average days.

There could be other unidentified air outlets. The inventory used for long term emissions may not be accurate. Another problem could be that the air flow out the stairs containing VOC may continue for more than eight hours, which is supported by the Miran trace (Figure 6). The three independent air recirculation systems that run the length of the room make it difficult to determine the mixing pattern in the room. The air and VOC mass in the west portion of the room may be resident in the room for a long time before exiting down the stairs.

TABLE 30. SITE 2 EMISSION RATES USING THE EXPERIMENTAL MASS BALANCE MODEL.

Time	Stair VOC Concentration (mg/m^3)	Emission Rate (g/hr)
09:16 - 10:07	6.56	47.4
10:07 - 11:04	6.01	43.4
11:04 - 12:02	6.61	47.7
12:02 - 13:07	6.95	50.2
13:07 - 13:59	7.19	51.9
13:59 - 15:16	8.56	61.8
09:07 - 10:14	5.42	39.1
10:14 - 11:02	3.58	25.8
11:02 - 12:02	8.49	61.3
12:02 - 13:03	9.80	70.7
13:03 - 13:59	6.56	47.4
13:59 - 15:07	9.92	71.6
Average		51.52

A completely mixed space model was also used at site 2. The completely mixed space model used the average of the two Miran readings for concentration data. The Miran data could not be extrapolated to a room average concentration because there was no clear association between the charcoal tube samples collected adjacent to the Mirans and the other charcoal tube samples. Part of the problem is that we did not have enough hourly samples out in the space at fixed locations. Also, the relationship between the return and supply air VOC concentrations was not what was expected. The supply air concentration should be slightly lower than the return air concentration if there is a small amount of make-up air. However, the supply air concentrations were often higher than the return air concentrations. This could be a result of high concentration room air mixing with the supply air in the vicinity of the charcoal tube, which was positioned one to three inches from the diffuser face. This remains a difficulty and limits the use of those samples.

Miran data calibrated to the adjacent charcoal tube was used in the completely mixed space model for the initial concentration and the average concentration in the press room. The data in Table 13 was used to generate a calibration curve for each Miran converting voltage output to total VOC concentration. The instantaneous VOC concentration measured by each Miran at the beginning of the sampling period was averaged to estimate the instantaneous average room concentration. The continuous total VOC measurements made by the Mirans were converted to average concentrations during each sampling period. The sampling period average concentrations measured by the two Mirans were averaged to estimate the average room concentration during the sampling period.

Table 31 presents the data and results for the completely mixed space model. The concentration data reported was determined as described above. The full room volume (7,777.4 m^3) was used, k was assumed to be 0.3, and the net flow through the room (q) was the airflow down the stairs (120.3 m^3/min).

TABLE 31. SITE 2 EMISSION RATES USING A COMPLETELY MIXED SPACE MODEL

Time	C_i (mg/m^3)	C_{av} (mg/m^3)	Time (min)	S (g/hr)
08:13 - 09:16	28.3	40.8	63	260.7
09:16 - 10:07	48.0	45.6	51	56.8
10:07 - 11:04	42.1	51.6	57	260.8
11:04 - 12:02	51.5	39.0	58	0.0
12:02 - 13:07	30.8	24.3	65	0.0
13:07 - 13:59	17.8	18.7	52	56.9
13:59 - 15:16	15.6	69.4	77	765.4
15:16 - 15:45	158.7	156.2	29	292.1
08:00 - 09:07	4.3	3.1	76	0.0
09:07 - 10:14	0.9	3.0	67	34.4
10:14 - 11:02	2.9	18.0	48	322.8
11:02 - 12:02	17.2	23.0	60	136.7
12:02 - 13:03	21.9	18.4	61	0.0
Average				168.2

The average emission rate using the completely mixed space model is 168.2 g/hr which is equivalent to 1.34 kg/day or 336 kg/yr. This is closer to the emissions predicted based on the bulk inventory than the results of the mass balance model. The results of the experimental mass balance and completely mixed space models exhibit no correlation at all at site 2 ($r^2 < 0.001$, $p = 0.94$). This may be due to a delay in the transport of VOC mass generated in the west side of the room, where measured concentrations were used in the CMS model, to the stairway, where measured concentrations were used in EMB model. If the emission rate modelled using the EMB model are compared to the CMS emission rates for the previous hour, a slight correlation is evident ($r^2 = 0.11$, $p = 0.31$). There is not enough information available to describe the mass transport delay in more detail. However, the simple, one-hour delay comparison seems to indicate that the concentrations measured exiting the room will not be representative of concentrations near the presses influenced by process activity during the same measurement period.

4.2.2 Site 2 Emission Factors

Emission factors for site 2 were developed using the emission rates from the previous section and the activity variables in Table 15. As in the evaluation of site 1, the emission rates were converted to g/run so they would have the same denominator as the activity data. Table 32 summarizes the data used in emission factor development. The emission rates from the experimental mass balance model are excluded because there was no identifiable relationship between those emission rates and any process variable.

TABLE 32. SITE 2 EMISSION FACTOR DATA.

Time	CMS (g/run)	Activity (solvent cleanings/run)				
		Web 1 & 2	Sheet 1 & 2	Duplicator	Two - Color	Total
08:13 - 09:16	273.74	3	2	1	2	8
09:16 - 10:07	48.24	3	0	3	0	6
10:07 - 11:04	247.7	1.5	0	4	0	5.5
11:04 - 12:02	0	4.5	0	2	5	11.5
12:02 - 13:07	0	0.5	0	4.5	3	8
13:07 - 13:59	49.35	4.5	0	0.5	2	7
13:59 - 15:16	982.3	13.5	1.5	6	12.5	33.5
15:16 - 15:45	141.16	2.5	5.5	2	1.5	11.5
08:00 - 09:07	0	7	0	0.5	6	13.5
09:07 - 10:14	38.4	2	3.5	3.5	16	25
10:14 - 11:02	258.17	3	3	1	15	22
11:02 - 12:02	136.7	3	3.5	5	0	11.5
12:02 - 13:03	0	3	1	2	0	6

Figure 12 is a plot of the total number of solvent cleanings per run against the completely mixed space emissions. The slope of the least-squares fit line is 20.9 g VOC/solvent cleaning. The r^2 is 0.46. There is more scatter to the points in the plot of total activity than there was at site 1. This may be due to the difficulty in defining the air flows and mixing volume in the space, or there may be other significant variables that effect the emission of VOC.

As at site 1, the next step in emission factor development is to separate the emissions from solvent cleaning by press type. The presses were grouped into four categories: web, sheet, duplicator, and two-color. The combined activities in these categories were used as variables to determine the emission factor from each press type. Table 33 presents the results of modelling the categorized press cleanings in different combinations.

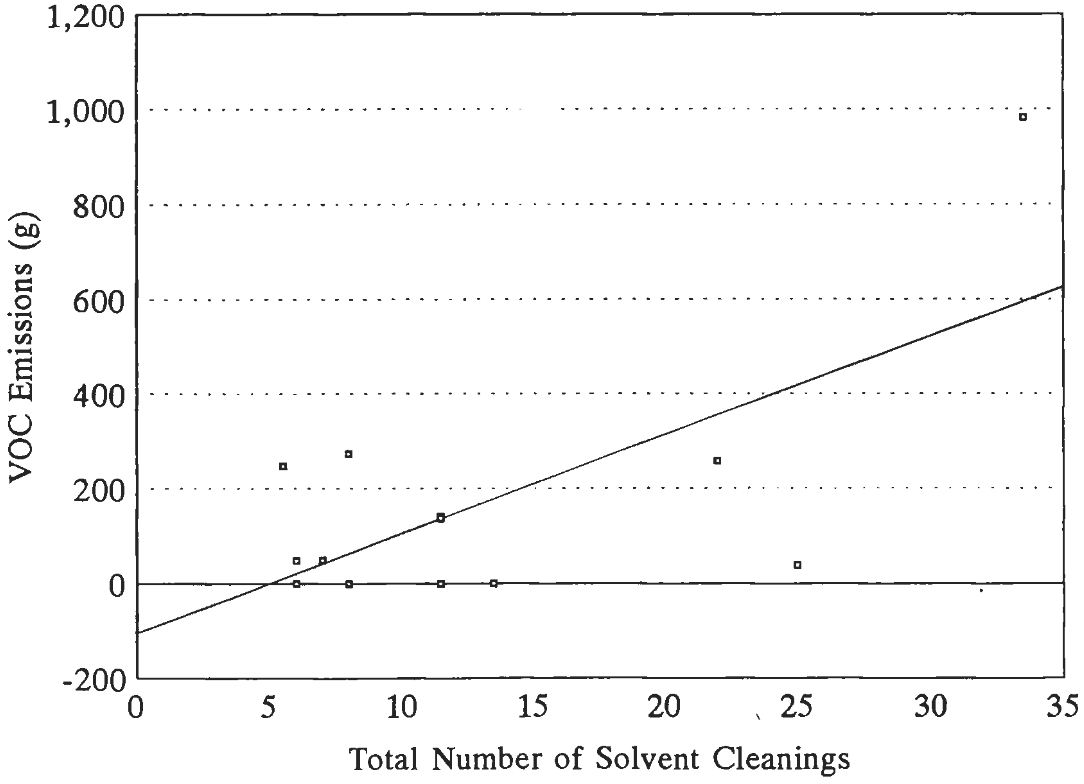

Figure 12. Site 2 Total Emission Factor

TABLE 33. SITE 2 INDIVIDUAL SOURCE EMISSION FACTOR DEVELOPMENT.

Model	Coefficient (p value)				β_0	r^2
	Webs (g VOC/cleaning)	Sheets (g VOC/cleaning)	Duplicator (g VOC/cleaning)	Two-Color (g VOC/cleaning)		
CMS	61.0 (0.003)	-[a]	-	-	-72.1	0.57
CMS	-	20.8 (0.64)	-	-	135	0.02
CMS	-	-	17.2 (0.20)	-	-29.0	0.24
CMS	-	-	-	17.2 (0.20)	81.4	0.14
CMS	63.4 (0.002)	34.9 (0.25)	-	-	-135	0.62
CMS	55.1 (0.004)	-	52.0 (0.03)	-	-189	0.69
CMS	57.4 (0.01)	-	-	5.56 (0.59)	-85.0	0.58
CMS	57.6 (0.003)	30.1 (0.27)	48.9 (0.10)	-	-236	0.73
CMS	62.2 (0.008)	33.1 (0.32)	-	1.79 (0.87)	-136	0.63
CMS	55.7 (0.01)	27.5 (0.37)	49.2 (0.12)	2.50 (0.80)	-238	0.73

[a] -: not in model

Combinations not including the web presses are not shown since it is clear that the solvent cleanings at the web presses are the most significant predictor of VOC emissions. All four variables have been left in the model for the same reasons as in site 1. The residuals of the models have been analyzed and the addition of the "non-significant" variables do not change the pattern.

The total emission factor from site 2 is 20.9 g VOC/solvent cleaning. The press specific emission factors are: 55.7 g VOC/web press cleaning, 27.5 g VOC/sheet press cleaning, 49.2 g VOC/duplicator cleaning, and 2.50 g VOC/two-color press cleaning. Mass emissions for a given time period at site 2 can be calculated using Equation 11.

$$S' = 55.7 \times X_1 + 27.5 \times X_2 + 49.2 \times X_3 + 2.50 \times X_4 \qquad (11)$$

S' = grams of VOC emitted from press cleaning
X_1 = number of cleanings of web presses
X_2 = number of cleanings of sheet presses
X_3 = number of cleanings of duplicators
X_4 = number of cleanings of two-color sheet press

4.3 Site 3 Data Analysis

4.3.1 Site 3 Emission Rates

The bulk usage of solvents reported in Table 25 was used to estimate a 14 hour emission rate. Solvents in the ink were not included since they are generally very low vapor pressure compounds and fugitive emissions into the room from the inks is minimal. The cleanup solvent use totalled 135.54 lbs or 61.61 kg for 14 hours during the two sample days. These solvents were 100% volatile so all the mass becomes fugitive emissions. The total fountain solution use for the 14 hours was 482.46 gallons. The fountain solution was reported by the company to be 7.51 lbs per gallon and is made by combining 5 ounces of a 9% VOC (butyl cellusolve) solution with one gallon of water. This is equivalent to 5.76 kg VOC from fountain solution for 14 hours. Combining cleanup solvent and fountain solution emissions gives a 14 hour total VOC fugitive emission of 67.4 kg or 4.81 kg/hr. This plant operated 24 hours a day year round. The yearly fugitive emission of VOC based on bulk use during the sampling periods is 42,136 kg.

Another estimate of long term emission rates was determined using information provided by the plant management. The management of the company estimates yearly VOC emissions from cleanup solvents and fountain solution to be approximately 10,310 kg/press and therefore 30,930 kg/yr for the three press room.

The completely mixed space model was not used at site 3. The Miran voltage output was not correlated to the charcoal tube - GC measurement of total VOC so no continuous measure of total VOC was available and thus there was no measure of the instantaneous concentration at the beginning of a sample period. In a large space such as site 3 the initial concentration may have a large impact on the solution. As was reported earlier, the effective airflow at Site 3 was measured twice, the morning and the afternoon of the first sampling day. The decay of CO concentrations when there were no forklift trucks operating in the area indicated effective airflow rates of 2.02 and 2.76 air-changes per hour, respectively. The removal of the concentration at the beginning of the sample period is modelled in the CMS model by the expression $C_s e^{-(kq/V \times t)}$. Kq/V is the effective air change rate and t is the sampling time. For a one-hour sampling period and the measured effective air change rates, 6% to 13% of the start concentration will remain at the end of the hour. This is in addition to any new pollutant generated during the sample period. Thirteen percent of the initial concentration was considered a substantial, unmeasurable component. An attempt at using the CMS was made using the average VOC from the previous hour as the start concentration. The results using this approach produced a large number of negative emission rates, which is a physical impossibility. Therefore, without Miran data to support it, the completely mixed space model was not used.

The experimental mass balance model was the only model used to determine emission rates at site 3. The experimental mass balance model is well supported by the data collected at this site. There is a high net air flow (approximately 11 air changes per hour) and no recirculation of air. Also, there is a good air balance and a measure of airflow at all points into and out of the room. Charcoal tube samples were also collected at all airflow locations. Observations were made on a regular basis to confirm the direction of the airflow through the open doors in the room. For the most part, the flows were in the direction indicated in Figure 8. During sample periods when the flow was opposite, it was considered to be at the same volumetric flow rate, but in the other direction. Table 34 presents the data used to determine the emission rates. If the mass generation rate was

TABLE 34. SITE 3 EMISSION RATES USING THE EXPERIMENTAL MASS BALANCE MODEL.

Time		SE door 36314 (m^3/hr)			S screen 28078 (m^3/hr)			N screen 23537 (m^3/hr)			Loading dock 37610 (m^3/hr)			SW door 21695 (m^3/hr)			Spot cooler intake 17128 (m^3/hr)			NE door 23386 (m^3/hr)		
			(mg/m^3)	(g/hr)		(mg/m^3)	(g/hr)		(mg/m^3)	(g/hr)		(mg/m^3)	(g/hr)		(mg/m^3)	(g/hr)		(mg/m^3)	(g/hr)		(mg/m^3)	(g/hr)
09:12	10:07	+[a]	0.5	17.1	+	0.2	5.6	+	3.4	79.8	−[b]	0.0	1.5	−	0.1	2.4	+	0.2	3.9	−	11.8	275.0
10:07	11:06	+	0.9	33.0	+	0.6	15.4	+	2.7	64.5	+	0.0	0.8	+	0.2	4.8	+	0.1	2.1	0[c]	7.1	167.0
11:06	12:05	+	3.6	130.7	+	0.9	25.3	+	0.6	13.7	+	0.1	1.9	+	0.9	18.4	+	0.2	2.6	−	4.5	106.2
12:05	13:08	+	1.1	38.5	+	0.8	21.3	+	0.2	5.2	+	0.0	1.5	+	0.6	13.9	+	0.1	2.2	0	5.9	138.2
13:08	14:06	+	2.0	72.3	+	0.2	5.6	+	0.8	19.3	+	0.1	3.0	+	0.6	12.8	+	0.1	0.9	−	4.6	108.5
14:06	15:07	+	2.2	80.6	+	1.9	54.2	+	3.5	83.3	+	0.0	1.5	+	0.5	11.3	+	0.2	3.4	−	7.0	163.9
09:05	10:07	+	0.7	25.1	+	0.3	7.3	+	0.0	0.9	+	0.0	0.4	+	0.8	18.0	+	0.1	1.2	−	3.9	91.7
10:07	11:08	+	5.1	186.7	+	0.7	19.9	+	0.2	4.9	+	0.0	1.1	+	0.1	2.4	+	0.1	1.0	−	4.2	97.5
11:08	12:06	+	1.6	57.7	+	0.8	22.5	+	0.2	4.9	+	1.0	36.1	+	2.8	61.0	+	0.1	1.2	−	3.9	91.2
12:06	1306	+	2.7	96.6	+	1.4	39.0	+	0.3	6.1	+	1.5	54.9	+	1.8	39.5	+	0.1	1.0	+	3.5	82.6
1306	14:09	+	76.1	2762.4	+	15.9	446.2	+	3.8	90.4	+	0.3	9.4	+	17.0	367.9	+	0.0	0.7	−	16.2	379.3
14:09	15:08	+	39.9	1447.8	+	8.1	226.9	+	1.7	40.7	+	2.7	100.0	+	16.1	348.2	+	0.0	0.7	−	5.7	133.1

Time		NW door 17104 (m^3/hr)			N roof fan 50835 (m^3/hr)			S roof fan 50784 (m^3/hr)			M−43 7985 (m^3/hr)			M−34 6802 (m^3/hr)			M−38 6780 (m^3/hr)			Emission Rate (g/hr)
			(mg/m^3)	(g/hr)		(mg/m^3)	(g/hr)		(mg/m^3)	(g/hr)		(mg/m^3)	(g/hr)		(mg/m^3)	(g/hr)		(mg/m^3)	(g/hr)	
09:12	10:07	−	1.4	23.9	−	22.8	1158.5	−	11.0	560.1	−	66.0	527.0	−	9.4	63.9	−	3.6	24.6	2531
10:07	11:06	−	1.1	18.6	−	14.2	720.8	−	7.8	397.1	−	26.6	212.3	−	10.1	68.5	−	1.7	11.7	1309
11:06	12:05	−	1.4	23.1	−	7.4	376.2	−	10.6	538.8	−	20.1	160.3	−	8.0	54.6	−	1.1	7.3	1074
12:05	13:08	−	2.8	47.9	−	22.8	1158.5	−	7.7	390.0	−	21.6	172.7	−	5.3	35.9	−	1.3	8.8	1731
13:08	14:06	−	1.6	27.2	−	8.5	430.6	−	8.6	434.7	−	7.5	60.0	−	10.6	71.8	−	1.0	6.8	1026
14:06	15:07	−	10.8	184.6	−	15.8	800.7	−	19.8	1003.5	−	13.2	105.6	−	5.5	37.3	−	3.4	23.1	2084
09:05	10:07	−	2.1	35.7	−	9.0	456.5	−	4.8	242.2	−	10.0	79.9	−	7.1	48.1	−	0.9	5.8	907
10:07	11:08	−	2.8	47.0	−	10.1	510.9	−	8.3	423.5	−	11.1	88.7	−	9.1	61.9	−	2.0	13.7	1027
11:08	12:06	−	3.5	60.2	−	7.9	401.6	−	3.8	194.0	−	9.5	75.5	−	5.0	34.0	−	3.2	21.6	695
12:06	1306	+	2.6	44.3	−	4.5	227.2	−	3.6	180.8	−	17.7	140.9	−	7.1	48.5	−	12.6	85.1	319
1306	14:09	0	7.1	120.9	−	19.0	965.9	−	16.0	810.5	−	24.1	192.3	−	24.0	163.5	−	15.2	103.0	0
14:09	15:08	0	2.9	48.9	−	15.2	771.2	−	15.8	802.4	−	22.4	179.2	−	8.6	58.7	−	11.2	75.6	0

[a] airflow into the room during this period

[b] airflow out of room during this period

[c] airflow approximately neutral during this period

calculated to be less than zero for a sampling period, it was considered to be zero. The average emission rate calculated using the experimental mass balance model was 1.06 kg VOC/hr or 9,273 kg VOC/yr. This value is 22% of the emissions predicted by the bulk solvent inventory and 30% of the management's emission estimates. The difference between the emission rates may be because some of the solvent is retained on the paper and carried into the drier and incinerator where it is evaporated and destroyed. Auto blanket wash is applied whilepaper is running through the presses. The company estimates that up to 15% of the autoblanket wash is carried into the drier. Also, the modelled emission rates represent only 12 hours of operation. The employee measurement of bulk solvent use also may contain some errors, such as refilling past the initial measurement level.

In addition to VOC emissions from cleanup solvents another possible source of fugitive VOC emissions at high speed presses like those at site 3, is solvent evaporation from wet ink that has been aerosolized during the running of the presses. This possibility was tested by doing a mass balance on the ink solid aerosol. Knowing the ratio of solid to solvent in the ink (approximately 60% solid by weight), a determination of ink solid aerosol emissions can be used to estimate VOC emissions from the aerosolized ink.

First a total particulate mass balance was done around the room. Six-hour TP samples were collected each day, and the volumetric flow through each air entrance and exit to the room was measured. Table 35 presents the TP mass balance. The second day resulted in a negative particulate emission rate. The average of the two days was 23.26 g/ 6 hours. The corresponding ink use for the two days was 643,800 g. So if all the particulate generated in the room is from inks, 0.0072% of the ink used is aerosolized and only 15.7 g of VOC emitted during that period was from aerosolized ink.

TABLE 35. SITE 3 TOTAL PARTICULATE MASS BALANCE

		Day 1		Day 2	
Location	(m^3/6hr)	(mg/m^3)	(g/6 hr)	(mg/m^3)	(g/6 hr)
Into Room					
SE Door	217882	0.00	0.00	0.024	5.23
S Screen	168465	0.00	0.00	0.122	20.55
N Screen	141224	0.018	2.54	0.00	0.00
SW Door	130172	0.103	13.41	0.105	13.67
Dock	225661	0.082	18.5	0.028	6.32
Intake	102768	0.00	0.00	0.00	0.00
Out of Room					
NE Door	140317	0.00	0.00	0.054	7.58
NW Door	102625	0.153	15.70	0.063	6.47
N Ceiling Fan	305010	0.163	49.72	0.047	14.34
S Ceiling Fan	304704	0.048	14.63	0.032	9.75
M-38 Exhaust	40679	0.017	0.69	0.016	0.65
M-34 Exhaust	40811	0.058	2.37	0.019	0.78
M-43 Exhaust	47907	0.057	2.73	0.028	1.34
TP Emission Rate			51.38		-4.87

The second approach to determining the ink particulate emissions was a chemical mass balance based on the elemental composition of the inks and the elemental composition of the particulate matter measured at the exits from the room. The vector of elemental concentrations at a sampling point is a linear combination of the contribution of TP from each TP source times the vector of the elemental mass fractions or "fingerprint" of that source (Equation 12).

$$C_i = \sum_{1}^{j} A_{ij} B_j \qquad (12)$$

C_i: Vector of concentrations of i compounds ($\mu g/m^3$) at a sample location
A_{ij}: Vector of elemental mass fractions (mass element i / mass TP emitted) for j emission sources
B_j: TP ($\mu g/m^3$) from source j

First, elemental fingerprints were developed for the three source categories that could contribute to total particulate exiting the press room: printing inks, outside air, and other operations in the plant. The outside air fingerprint was the ratio of the specific elemental concentration measured in the outside air divided by the TP concentration in the outside air. The other plant activity fingerprint was developed in the same way by using the average elemental and TP concentrations measured at the two south doors where airflow was predominantly into the room from a warehousing area. This would include fingerprints from materials handling and fork lift operation. The ink fingerprint was developed using the bulk ink elemental data (Table 23) weighted by the mass use of each kind of ink. The first day, press M-34 used the D*1000 series inks. The other two presses used the DC*5000 series inks both days as did M-34 the second day. Ink, outside, and warehouse fingerprints were developed for both days. Table 36 gives the fingerprints used for the two days.

Each horizontal vector was weighted by the concentration of the element in that vector. This was done to give the low concentration elements a more even influence to the solution. The weighted equations included the concentration and the three source fingerprints and were solved for the source contributions by a least squares fit. The coefficients for each source category have the dimensions of $\mu g/m^3$, which is that source's contribution to TP. This was done for the daily average concentration at all air exit point from the room. Table

37 shows the results of the least squares fit at each air exit for each sample day. The sum of the source contributions is a prediction of the TP that would be at that location. The predicted TP concentrations are generally greater than what was measured at the same location (Table 21), but are on the same order of magnitude.

The predicted concentrations from the ink source and the six hour airflows can be used to estimate the mass flow of particulate originating from the ink (Table 37). The total ink solids mass flow for the two 6 hour periods using this approach is 204 g/ 12 hours. This represents 0.032% of the total ink solids used during the same period. The VOC portion that would be associated with 204 g solid ink (based on 60% of total ink is solids) is 136 g for the twelve hour period or 11.3 g VOC / hour from aerosolized ink. Even if the higher emission values are correct, the aerosolized ink is not a major contributor to VOC emissions since it is only about 1% of the average total VOC emission rate.

TABLE 36. SITE 3 FINGERPRINTS USED FOR PARTICULATE COMPONENT MASS BALANCE (PPM MASS).

	Day 1			Day2		
	Ink	Outside Air	Warehouse	Ink	Outside Air	Warehouse
Al	323.00	29716.16	8638.45	313.07	15677.97	10980.17
Si	57.46	38018.47	32083.65	47.02	30982.53	36775.78
S	856.73	87662.17	27750.52	826.79	45983.39	24169.19
Cl	866.24	12160.70	5052.14	1026.88	1603.15	3643.87
K	9.05	0	5428.78	7.73	0	4556.20
Ca	1423.75	11219.88	49143.49	1374.40	20796.08	72984.13
Ti	24.19	1136.00	686.96	35.61	1742.55	12506.94
Cr	0.03	0	288.43	0	0	0
Mn	64.12	0	100.69	93.63	383.36	244.69
Fe	44.56	7216.35	7254.34	49.07	9693.55	10902.78
Ni	1.08	0	51.17	0.57	0	1.25
Cu	356.90	40.04	228.64	2.10	94.60	255.48
Zn	117.33	3182.80	713.30	140.10	393.32	1506.24
Ga	6.80	0	0	8.32	0	0
As	0.04	0	0	0.06	0	0
Br	0.58	0	0	0.61	0	0
Sr	18.84	0	163.22	18.66	243.96	71.20
Zr	1.66	320.28	202.32	1.80	0	0
Pb	0.11	530.47	198.56	0.14	791.62	206.40

TABLE 37. SITE 3 RESULTS OF COMPONENT MASS BALANCE AT EACH EXIT POINT.

Day	Location	Source Coefficients (ug/m^3)			Total Predicted[a] (ug/m^3)	Airflow (m^3/6hr)	Ink Mass Flow[b] (g/6 hr)
		Outside air	Warehouse	Inks			
Day 1	NE Door	0	13.2	0	13.2	140317	0
	NW Door	6.29	63.8	63.0	133	102625	6.46
	N Exhaust	14.2	18.2	324	356	305010	98.8
	S Exhaust	9.65	17.1	86.9	114	304704	26.5
	M−38	1.59	1.64	8.77	12.0	40679	0.357
	M−34	7.16	3.78	58.9	69.8	40811	2.40
	M−43	4.96	55.0	127	187	47907	6.08
Day 2	NE Door	8.09	13.9	22	44.0	140317	3.09
	NW Door	0	48.9	61.8	111	102625	6.34
	N Exhaust	2.96	9.06	0	12.0	305010	0
	S Exhaust	5.32	0.148	143	148	304704	43.6
	M−38	5.99	0.759	59.4	66.1	40679	2.42
	M−34	4.04	0	32.1	36.1	40811	1.31
	M−43	4.35	39.0	127	170	47907	6.08

[a] Total Predicted = sum of source coefficients

[b] Ink Mass Flow = Ink source coefficient x airflow

4.3.2 Site 3 Emission Factors

Site 3 was unlike the first two sites in that the three presses were virtually identical. The total number of cleaning events at each press was recorded, but they were grouped by type of cleaning. The types of cleaning were: manual blanket washing, automatic blanket washing, and the nonspecific use of solvent between jobs measured by the number of minutes spent performing a makeready. Table 38 summarizes the data used in developing emission factors for site 3.

TABLE 38. SITE 3 EMISSION FACTOR DEVELOPMENT DATA

Time	Makeready (min)	Blanket Washes Automatic	Blanket Washes Manual	Emission Rate (g/run)
09:12 - 10:07	55	2	10	2,320
10:07 - 11:06	59	0	10	1,287
11:06 - 12:05	59	1	12	1,056
12:05 - 13:08	26	2	22	1,818
13:08 - 14:06	71	1	9	992
14:06 - 15:07	109	2	2	2,119
09:05 - 10:07	64	1	14.5	937
10:07 - 11:08	118	0	7.5	1,044
11:08 - 12:06	14	0	24	672
12:06 - 13:06	0	2	6	318
13:06 - 14:09	24	1	14	0
14:09 - 15:08	9	1	3.5	0

The only activity variable that shows any correlation to emission rate when considered alone is the time spent classified as makeready for all three presses during the sample period. Figure 13 shows "minutes of makeready" plotted against the emission rate for the sampling period. When the variable "minutes of makeready" is considered by itself, each minute of makeready results in 15.3 g VOC emitted ($p = 0.02$, $r^2 = 0.42$).

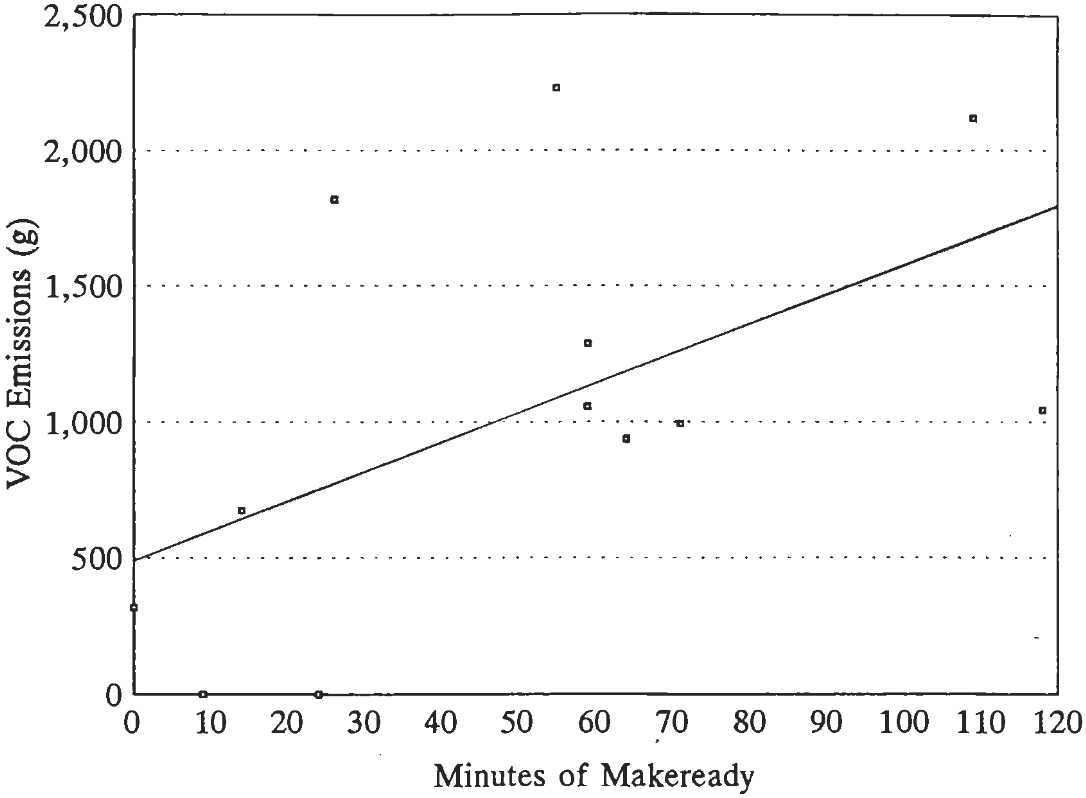

Figure 13. Site Emission Factor for Makeready Time

The other uses of solvent, and thus sources of fugitive VOC emissions, in the room were the automatic blanket washing and the manual blanket washing. Adding these activity variables to the emission factor model along with the makeready time accounts for the physical sources of fugitive VOC. Equation 13 is a model that can be used to predict the mass emission of total VOC into the room during a given time period.

$$S' = 16.7 \times X_1 + 572 \times X_2 + 49.2 \times X_3 \qquad (13)$$

S' = grams of VOC emitted from cleaning activities
X_1 = total minutes of makeready for all three presses
X_2 = number of automatic blanket washes
X_3 = number of manual blanket washes

Equation 13 has an r^2 of 0.69 and a p-value < 0.01. Each of the three variables is significant by a partial F-test at $\alpha = 0.10$.

Based on the mass of auto blanket wash solvent reported to be used for the two days (38.8 kg) and the 13 automatic washes recorded, a emission factor of 2.98 kg VOC/automatic wash could be expected. The modelled emission factor was 19% of that. Possible reasons for this are the retention of the solvent in the paper and inaccuracies in the measurement of bulk solvent use as were mentioned previously.

The emission factor for manual blanket washes is about one third the expected 164 g/wash based on a two day bulk use of 22.1 kg and 134.5 manual washes. This may be because of the additional use of blanket wash used during the makeready periods that was not recorded as a manual wash as was discussed in the site 3 results section.

5 DISCUSSION

5.1 Solvent Concentrations

It is clear that there is a significant amount of fugitive VOC emissions inside spaces which contain offset printing operations. The maximum concentrations measured at each site by charcoal tube -- GC were well below the PEL for Stoddard Solvent (2,900 mg/m^3). However, speciated GC analysis of the air samples revealed that for the specific compounds that constitute the cleaning solvents, there may be an exposure problem. This was particularly true in the case of benzene (PEL = 3.2 mg/m^3).

At site 1, the average benzene concentration for all samples, including the sample in the adjacent room, was 4.73 mg/m^3. This average is probably higher than the actual benzene concentration because the GC analysis for site 1 did not clearly separate benzene and isopropanol. However, the contract lab GC-MS bulk analysis of the solvents confirmed the presence of benzene in the solvents.

At sites 2 and 3 GC analysis did separate benzene and isopropanol. At site 2 the average benzene concentration at the indoors sampling locations ranged from 0.10 to 0.70 mg/m^3. While 0.70 mg/m^3 is only 22% of the PEL, the maximum hourly concentration measured was 1.76 mg/m^3 which is above the action level. These measurements were area measurements. Depending on a worker's solvent use and work patterns, personal exposure levels may be higher or lower.

At site 3, the maximum six hour benzene level measured by the area samples was 0.997 mg/m^3. No samples were taken near blanket washing events where the solvent exposure would presumably be higher. The blanket wash solvents were 3 to 4% benzene by weight. In an earlier study, worker time weighted exposures to total VOC were reported from 19 ppm to 45 ppm which is equivalent to approximately 50 to 150 mg/m^3 depending on the composition of the solvent (Hansen and Whitehead, 1988). If these total VOC exposure levels had the same composition as the solvents used at site 3, the benzene exposure would be 1.5 to 4.5 mg/m^3.

5.2 Emission Rates

The emission rates calculated with the completely mixed space and experimental mass balance models predict less emissions than would be expected based on the bulk solvent inventories. Table 39 presents the modelled yearly fugitive emissions and the VOC emissions based on solvent inventories and company estimates. The company estimate of site 3 fugitive VOC emissions excluded ink vehicle emissions. The ink vehicle emissions listed by the company were from incinerator inefficiency and paper off-gassing, which generally would be emitted in another part of the plant since product was generally removed from the room soon after being printed.

TABLE 39. COMPARISON OF YEARLY EMISSION ESTIMATES.

Site	Emission Rate Model	Modelled Yearly Emissions (kg)	Other Estimate of Yearly Emissions (kg)	Source of Estimate
1	EMB	1,267	1,900	Printers Estimate of Weekly Usage
1	CMS	696	1,900	Printer Estimate of Weekly Usage
2	CMS	336	530	Solvent Inventory for Year following test
3	EMB	9,273	30,927	Company estimate for permitting (less ink vehicle)
3	EMB	9,273	42,136	Measured bulk use of solvent during test

The modelled emission rates projected out to yearly estimates accounted for 22% to 67% of the yearly emission estimates based on other data. Considering that the modelled emission rates were measured over only two days and the other yearly estimates may have associated errors, the agreement is good.

Using the modelled emission values or other estimates site 3, is the largest emitter of VOC mass. However, the total emissions during the sampling period can be compared with the surface area of printed material produced to see if the relative emissions based on throughput are the same with the different scale operations. Table 40 presents this comparison. These comparisons of emissions and production rates should not be considered emission factors since there is no discernable correlation between printing volume and VOC emissions at each site. Rather this demonstrates that smaller shops may be relatively large emitters of VOC. The type of printing jobs done by the shop probably influence the relative emission rates, which will be discussed. Depending on the distribution of different size facilities in a geographic region, the smaller offset shops may account for a large portion of the VOC emissions from offset graphic arts industries.

TABLE 40. COMPARISON OF VOC EMISSIONS WITH VOLUME PRODUCED.

Site	Printed material produced during the sampling periods. (ft^2)	Total VOC emissions during the same periods, based on modelled emission rates (g)	mg VOC / ft^2 printed
1	262,250	10,140	38.7
2	698,600	2,690	3.85
3	3,662,000	12,700	3.47

In this study the smallest shop had the largest emissions relative to the surface area printed by a factor of about 10. This may be because of the type of jobs such shops perform. The presses at site 1 were used to produce multi-colored product. This entailed cleaning the presses, changing the plates and ink colors and running the same sheets through the press multiple times. Thus every square foot of final product created in this manner actually represents printing on two to four times that surface area, depending on how many passes through the press were required. Site 2 printed over twice the area that site 1 did, yet had less than a third of the emissions. Site 2 was printing instruction manuals and forms for in-house use by the manufacturer. The printing was primarily in black and occasionally in red. This required less press cleaning and all jobs were printed with one plate installation. Part of the difference in emissions per product between the two sites can be explained by this difference in the type of materials printed and the accompanying processes.

5.3 Emission Rate Models

The experimental mass balance model and the completely mixed space model produced good results for the short term emission rates at the three sites. The models produced emission rates that compared favorably with long term measures of emission rates and with each other in the case of site 1 where both models were supported by the data.

The key to the success of any emission rate model to understand the ventilation and airflow in the room and to be able to measure it. The sampling strategy should be based on the ventilation, which determines the characteristics of air pollutant mass transport in the space. With a clear understanding of the airflow in the room, a strong hypothesis can be made about how mass is transported in the room. From this an appropriate sampling strategy can be implemented. In cases where points of airflow into and out of the room can be identified and measured, the EMB is a strong model. In cases where there are unidentified points of airflow the CMS is a good model is supported by appropriate concentration measurements, measures of effective airflow, and a means of estimating mixing volume. Also the CMS is more appropriate in air spaces with lower net air change rates which result a longer residence time for the pollutant and a greater opportunity to mix throughout the space prior to removal. The analysis of site 2 was limited by a lack of information which was the result of not understanding the ventilation and not measuring concentrations at appropriate locations. However, the robustness of the model was demonstrated by producing results comparable with other estimates and that could be used to develop emission factors. This illustrates that carefully made assumptions can be used effectively in this model.

5.4 Emission Factors

Table 41 summarizes the emission factors that have been developed for the three offset printing shops.

TABLE 41. SUMMARY OF EMISSION FACTORS.

Site	Process Variable	g VOC/ activity
1	Total number of solvent Cleanings	48.51
1	Number of Two Color Sheet Press (25" x 38" stock) Solvents Cleanings	24.95
1	Number of One Color Sheet Press (24" x 29" stock) Solvent Cleanings	65.95
1	Number of Duplicator Solvent Cleanings (8.5" x 11 and 4" x 9")	38.5
1	Transfer of Solvent from Large to Small Containers	699
2	Total Number of Solvent Cleanings	20.9
2	Number of Web Press (11" and 17.25" wide webs)	55.7
2	Number of One Color Sheet Press Cleanings (20.25" x 24" and 17.25" x 22.25" stock)	27.5
2	Number of Duplicator Cleanings (8.5" x 11")	49.2
2	Number of Two-Color Sheet Press Cleanings (11" x 17" stock)	2.50
3	Minutes of Makeready	16.7
3	Manual Web Press Blanket Cleaning (38" wide Web)	49.2
3	Automatic Web Press Blanket Cleaning (38" wide web)	572

The range of emission factors for manual cleaning processes is relatively small (24.95 to 65.95 g VOC/cleaning). This range represents a wide variety of press types. The two-color press at site 2 was excluded from this comparison which, while it was considered an offset press, was quite different than all the other presses studied. The emission factors for cleaning duplicators at two different sites are very similar (38.5 and 49.2 g VOC/cleaning). The similarity in emission factors demonstrates that the emission rate models accurately describe VOC emissions. Machines as similar as the duplicators at sites 1 and 2 would be expected to have similar mass emissions from cleaning regardless of the setting in which they were used. Likewise the manual blanket washing at all three sites produced similar emission factors. The manual cleanings of web blankets at sites 2 and 3 had emission factors within 13% of each other (55.7 and 49.2 g VOC/cleaning). The sheet press blanket cleanings exhibited the widest range of emission factors.

5.5 Applications

The emission factors developed here have a number of applications to the printing industry. They can be used for pollution control permitting and compliance estimations. They can be used for evaluating the effectiveness of existing pollution control measures and prioritizing future efforts. They can also be used for estimating worker exposure to VOC.

For printing shops that have permitted levels of VOC emissions, emission factors can be used to estimate changes in emission rates from process modification. These estimates along with information about planned or already in-place pollution control equipment can be used to evaluate emission minimization approaches. Additionally, the management of site 3 has expressed an interest in passing some of the cost of air pollution control to their customers. The emission factors that have been developed are a way for them to quantify the VOC emissions associated with each job. This provides a measurable means of charging the customer for the VOC emissions created by their print orders.

The emission factors themselves are an example of prioritizing control efforts. The process for transferring solvent at site 1 clearly needs modification. During the time period that the transfer occurred the emission rate was 5 to 10 times the expected rate based on the number of solvent cleanings. The solvent transfer accounted for almost 18% of the

VOC emissions for that day. Likewise at site 3, the mass of VOC emissions from each automatic blanket wash is much higher than manual washing. Automatic blanket washing has the advantage of being done without stopping the press. However, evaluating the metering system that delivers the solvent to the blanket may reveal ways to better control the amount of solvent used.

If the ventilation characteristics of a work-space are known or can be estimated, emission factors can be used to estimate the pollutant concentration in the room. The effect of changes in processes or ventilation on the concentration in the room can be estimated prior to instituting the changes. In print shops using cleaning solvents containing benzene, the benzene concentration can be estimated as the total VOC concentration based on the benzene fraction in the bulk solvent. The fraction of benzene in the solvents could then be used as a specification when purchasing the cleaning solvents. Another example of the use of emission factors for worker protection is in the installation of new equipment. Emission rates can be estimated based on projected use and these emission rates can be used to see if the existing ventilation is adequate to keep exposures to a safe level.

6 CONCLUSIONS

1. The concentrations of total VOC in the print shops studied were well below any appropriate exposure standard for such a mixture. However, the concentration of specific components of the VOC mixture, particularly benzene, should be monitored.

2. In general, the composition of total VOC in the air at the three sites was quite similar. The same class of industrial organic solvents is evidently used throughout the offset printing industry. This information is useful to those using chemical mass balance approaches to model the ambient air.

3. This approach to modelling emission rates is effective in offset printing shops, which have previously been considered too complex an operation to model this way. The emission rates determined at each site using concentration and ventilation data accounted for 22% to 67% of the emissions determined by bulk inventory mass balance. Considering the modelled emission rates were only for two days and the bulk solvent inventories have limitations, the agreement is quite good.

4. Future efforts at modelling emission rates should take time to understand, as much as possible, the ventilation and air mixing characteristics of the space being studied before selecting air sampling locations and strategies. The evaluation of site 2 was hindered because this was not done.

5. Manual cleaning of press blankets and rollers results in a remarkably similar emission of VOC regardless of the type and size of the press. Each manual cleaning is accompanied by an emission of 25 to 66 grams of VOC. The type of work a shop performs

and the number of job changes and plate changes determines the number of solvent cleanings that are needed and thus also the amount of VOC emissions.

6. Small shops, which generally have no pollution control devices, may when considered collectively account for a substantial portion of the emissions from the larger category of graphic arts industries.

7. Aerosolized ink is not a significant contributor to total VOC emissions at site 3. However, it was demonstrated that a component mass balance approach works for apportioning the contribution of printing inks to TP in the work-space. This approach could be applied to other sites where less viscous inks are used and the potential for ink aerosolization is greater.

8. The use of multiple regression modelling of activity data was very successful in separating the emission factors for the individual sources. Previous studies have stopped at modelling emission factors for the total room activity.

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APPENDICES

TABLE 42. SITE 1 SPECIATED VOC CONCENTRATIONS AT WORKBENCH (LOCATION F)(MG/M^3).

Compound	Day 1						Day 2						Avg
	09:08–10:07	10:07–11:09	11:11–12:02	13:13–14:11	14:12–15:14	15:15–16:13	09:11–10:04	10:05–11:01	11:02–12:00	13:31–14:21	14:22–15:18	15:18–16:19	
n–Hexane	1.40	1.30	2.60	2.70	3.49	2.10	1.60	1.20	1.60	3.20	1.70	1.80	2.06
Benzene[a]	7.76	4.64	2.63	2.95	3.91	12.53	1.63	2.35	2.27	4.37	7.29	8.75	5.09
Toluene	27.03	14.27	13.40	8.90	15.17	25.51	7.50	6.42	11.95	28.87	56.74	61.94	23.14
Ethylbenzene	0.33	0.18	0.17	0.13	0.09	1.59	0.04	0.06	0.13	0.43	0.76	1.41	0.44
p–Xylene	0.18	0.11	0.12	0.12	0.12	0.61	0.05	0.07	0.09	0.20	0.34	0.58	0.22
m–Xylene	0.46	0.26	0.29	0.31	0.33	0.79	0.16	0.19	0.22	0.57	0.94	0.81	0.44
o–Xylene	0.51	0.45	0.59	0.49	0.48	1.37	0.20	0.26	0.27	0.48	0.83	1.37	0.61
n–Propylbenzene	1.49	1.21	0.85	0.99	1.24	3.97	0.49	0.77	0.82	1.35	2.32	3.60	1.59
p–Ethyltoluene	6.18	5.18	3.67	4.25	5.29	15.84	2.12	2.30	3.51	5.61	9.38	14.09	6.45
1,3,5–Trimethylbenzene	2.18	1.79	1.28	1.45	1.80	5.79	0.73	1.15	1.20	1.99	3.27	4.86	2.29
o–Ethyltoluene	1.32	1.13	0.79	0.93	1.16	4.30	0.51	0.85	0.76	1.21	2.01	2.99	1.50
1,2,4–Trimethylbenzene	3.05	2.60	1.88	2.07	2.53	7.54	1.04	1.59	1.66	2.72	4.42	6.70	3.15
m–Diethylbenzene	0.37	0.29	0.22	0.22	0.25	0.86	0.12	0.18	0.17	0.33	0.53	0.84	0.37
1,2,3–Trimethylbenzene	0.31	0.26	0.19	0.21	0.26	0.81	0.09	0.15	0.15	0.27	0.45	0.72	0.32
Total VOC	69.86	48.48	51.39	50.38	62.38	152.61	22.83	27.74	35.95	73.39	135.51	175.51	75.50

[a]: Sum of benzene and isopropanol concentrations

TABLE 43. SITE 1 SPECIATED VOC CONCENTRATIONS AT SUPPLY AIR (LOCATION G)(MG/M^3).

	Day 1						Day 2						Avg
Compound	09:08–10:07	10:07–11:09	11:11–12:02	13:13–14:11	14:12–15:14	15:15–16:13	09:11–10:04	10:05–11:01	11:02–12:00	13:31–14:21	14:22–15:18	15:18–16:19	
n–Hexane	0.78	0.61	1.44	1.80	1.50	1.10	0.85	0.50	0.70	<0.01	0.70	0.80	0.90
Benzene[a]	4.18	2.59	1.76	1.87	2.17	8.14	1.00	1.54	1.88	2.81	5.44	6.16	3.30
Toluene	14.31	8.04	8.68	6.31	8.43	13.93	5.00	3.24	11.52	22.75	46.59	49.72	16.54
Ethylbenzene	0.06	0.12	0.05	0.15	0.15	1.00	0.03	<0.01	0.03	0.21	0.55	0.90	0.27
p–Xylene	0.08	0.07	0.06	0.10	0.10	0.40	0.04	0.04	0.05	0.10	0.23	0.64	0.16
m–Xylene	0.23	0.18	0.18	0.25	0.24	0.52	0.13	0.13	0.15	0.28	0.32	0.59	0.27
o–Xylene	0.37	0.29	0.38	0.33	0.30	0.92	0.19	0.19	0.23	0.30	0.57	0.88	0.41
n–Propylbenzene	1.18	0.85	0.69	0.67	0.79	2.77	0.50	0.60	0.74	0.94	1.67	2.33	1.14
p–Ethyltoluene	5.00	3.78	3.06	2.88	3.42	11.19	2.15	2.59	3.17	4.06	6.78	9.17	4.77
1,3,5–Trimethylbenzene	1.66	1.21	0.98	0.97	1.16	4.02	0.75	0.87	1.07	1.40	2.28	3.24	1.63
o–Ethyltoluene	1.04	0.76	0.62	0.62	0.75	2.50	0.55	0.65	0.79	0.88	1.43	0.42	0.92
1,2,4–Trimethylbenzene	2.40	1.72	1.43	1.39	1.63	5.33	1.06	1.22	1.49	2.00	3.12	4.40	2.27
m–Diethylbenzene	0.28	0.18	0.14	0.14	0.16	0.59	0.12	0.12	0.15	0.22	0.35	0.54	0.25
1,2,3–Trimethylbenzene	0.24	0.17	0.13	0.13	0.15	0.60	0.09	0.11	0.13	0.20	0.30	0.47	0.23
Total VOC	42.71	30.79	29.54	29.52	33.17	98.98	18.64	18.22	30.44	51.43	101.51	116.73	50.14

[a]: Sum of benzene and isopropanol concentrations

TABLE 44. SITE 1 SPECIATED VOC CONCENTRATIONS AT AIR RETURN (LOCATION H)(MG/M^3).

Compound	Day 1						Day 2						Avg
	09:08–10:07	10:07–11:09	11:11–12:02	13:13–14:11	14:12–15:14	15:15–16:13	09:11–10:04	10:05–11:01	11:02–12:00	13:31–14:21	14:22–15:18	15:18–16:19	
n–Hexane	0.81	1.00	2.00	2.60	2.40	1.70	1.10	0.55	0.90	<0.01	1.70	0.93	1.31
Benzene[a]	5.12	2.83	1.94	2.16	3.18	10.25	1.19	1.81	2.11	2.90	4.87	6.16	3.71
Toluene	17.35	10.32	9.34	7.87	11.93	21.29	5.58	3.95	14.40	23.98	46.63	43.88	18.04
Ethylbenzene	0.04	0.04	0.11	0.06	0.24	1.40	0.03	0.03	0.10	0.30	0.36	0.89	0.30
p–Xylene	0.08	0.05	0.09	0.08	0.15	0.53	0.05	0.05	0.08	0.13	0.23	0.36	0.16
m–Xylene	0.22	0.17	0.22	0.23	0.37	0.66	0.14	0.14	0.19	0.39	0.61	0.49	0.32
o–Xylene	0.39	0.32	0.36	0.33	0.41	1.20	0.19	0.22	0.26	0.35	0.62	0.88	0.46
n–Propylbenzene	1.20	0.86	0.64	0.69	1.08	3.31	0.52	0.71	0.80	0.97	1.70	2.31	1.23
p–Ethyltoluene	5.10	3.73	2.84	2.98	4.55	13.04	2.25	3.08	3.41	4.06	6.94	9.07	5.09
1,3,5–Trimethylbenzene	1.73	1.34	0.94	1.04	1.59	4.72	0.73	1.08	1.20	1.50	2.35	3.25	1.79
o–Ethyltoluene	1.08	0.83	0.59	0.77	1.01	2.90	0.53	0.81	0.74	1.12	1.48	1.93	1.15
1,2,4–Trimethylbenzene	2.49	1.90	1.37	1.48	2.18	6.21	1.05	1.47	1.64	2.03	3.24	4.29	2.45
m–Diethylbenzene	0.29	0.22	0.14	0.16	0.23	0.72	0.12	0.16	0.18	0.25	0.37	0.55	0.28
1,2,3–Trimethylbenzene	0.25	0.19	0.14	0.16	0.22	0.67	0.09	0.13	0.16	0.20	0.32	0.45	0.25
Total VOC	47.64	34.51	30.55	32.43	52.80	127.26	19.59	21.87	35.59	51.72	104.95	108.59	55.63

[a]: Sum of benzene and isopropanol concentrations

TABLE 45. SITE 1 SPECIATED VOC CONCENTRATIONS IN ADJACENT ROOM (LOCATION I)(MG/M^3).

	Day 1						Day 2						Avg
Compound	09:08–10:07	10:07–11:09	11:11–12:02	13:13–14:11	14:12–15:14	15:15–16:13	09:11–10:04	10:05–11:01	11:02–12:00	13:31–14:21	14:22–15:18	15:18–16:19	
n–Hexane	0.13	<0.01	<0.01	<0.01	0.30	0.40	0.10	0.16	0.21	<0.01	0.20	0.25	0.15
Benzene[a]	2.63	3.41	2.17	2.45	7.25	9.52	1.77	2.21	2.13	1.81	1.75	9.42	3.88
Toluene	10.77	10.67	4.15	3.28	9.38	8.50	1.60	1.69	57.87	46.45	64.67	70.72	24.15
Ethylbenzene	0.12	0.18	0.05	0.15	0.11	1.24	0.04	0.15	<0.01	<0.01	<0.01	1.62	0.31
p–Xylene	0.08	0.10	0.06	0.10	0.40	0.48	0.06	0.09	0.05	0.03	0.07	0.55	0.17
m–Xylene	0.13	0.16	0.17	0.24	0.39	0.51	0.17	0.22	0.15	0.11	0.17	0.51	0.24
o–Xylene	0.30	0.34	0.30	0.33	0.68	0.98	0.31	0.35	0.27	0.17	0.21	0.92	0.43
n–Propylbenzene	0.91	1.17	1.00	1.13	1.67	3.09	1.09	1.35	1.01	0.63	0.75	2.46	1.36
p–Ethyltoluene	4.02	5.21	4.43	4.96	6.28	12.59	4.62	5.80	4.44	2.81	3.28	9.13	5.63
1,3,5–Trimethylbenzene	1.40	1.84	1.59	1.69	2.25	4.53	1.53	1.98	1.53	0.97	1.14	3.34	1.98
o–Ethyltoluene	0.88	1.17	1.01	1.28	1.66	2.89	1.16	1.31	1.00	0.63	0.74	2.09	1.32
1,2,4–Trimethylbenzene	2.19	2.72	2.20	2.40	3.04	6.22	2.06	2.71	2.15	1.40	1.62	4.34	2.75
m–Diethylbenzene	0.21	0.28	0.24	0.24	0.35	0.69	0.18	0.25	0.20	0.13	0.16	0.51	0.29
1,2,3–Trimethylbenzene	0.30	0.33	0.22	0.24	0.34	0.71	0.17	0.27	0.21	0.13	0.15	0.51	0.30
Total VOC	36.08	44.46	26.98	35.61	80.13	107.59	25.64	31.91	81.64	62.19	84.26	167.54	65.34

[a]: Sum of benzene and isopropanol concentrations

TABLE 46. SITE 1 SPECIATED VOC CONCENTRATIONS AT PRESS #4 (LOCATION J)(MG/M^3).

	Day 1						Day 2						Avg
Compound	09:08–10:07	10:07–11:09	11:11–12:02	13:13–14:11	14:12–15:14	15:15–16:13	09:11–10:04	10:05–11:01	11:02–12:00	13:31–14:21	14:22–15:18	15:18–16:19	
n-Hexane	0.65	0.60	1.40	1.60	1.25	1.10	0.75	0.50	0.60	<0.01	0.35	1.11	0.83
Benzene[a]	8.03	4.17	1.74	3.59	8.20	27.89	4.48	8.06	2.36	2.96	18.75	7.85	8.17
Toluene	20.29	10.93	9.14	6.90	11.27	32.50	5.35	4.68	23.16	33.01	122.84	66.04	28.84
Ethylbenzene	0.88	0.42	0.14	0.30	0.79	3.33	0.03	0.10	0.23	0.31	2.31	1.25	0.84
p-Xylene	0.44	0.20	0.09	0.16	0.44	1.07	0.05	0.13	0.13	0.14	0.75	0.51	0.34
m-Xylene	1.15	0.29	0.23	0.42	1.08	1.15	0.16	0.34	0.31	0.39	0.80	0.69	0.58
o-Xylene	1.15	0.71	0.53	0.50	1.24	1.92	0.24	0.56	0.40	0.39	1.33	1.20	0.85
n-Propylbenzene	3.95	2.33	0.88	1.25	4.05	5.34	0.66	2.12	1.43	1.23	3.77	3.26	2.52
p-Ethyltoluene	16.57	10.17	3.87	5.31	16.66	20.62	2.84	9.20	6.25	5.28	14.62	12.85	10.35
1,3,5-Trimethylbenzene	5.85	3.67	1.41	1.92	5.84	7.60	0.98	3.11	2.22	1.84	5.21	4.50	3.68
o-Ethyltoluene	3.63	2.33	0.87	1.22	4.49	5.67	0.69	0.30	1.68	1.17	3.92	2.73	2.39
1,2,4-Trimethylbenzene	8.10	5.31	2.12	2.68	7.65	10.22	1.48	4.37	3.06	2.64	6.89	6.26	5.07
m-Diethylbenzene	0.96	0.60	0.26	0.29	0.79	1.29	0.16	0.43	0.33	0.29	0.80	0.82	0.59
1,2,3-Trimethylbenzene	0.82	0.55	0.22	0.28	0.78	1.15	0.17	0.42	0.30	0.27	0.72	0.69	0.53
Total VOC	119.10	73.37	34.09	41.88	109.41	267.37	24.48	58.07	61.97	70.94	295.10	159.05	109.57

[a]: Sum of benzene and isopropanol concentrations

TABLE 47. SITE 1 SPECIATED VOC CONCENTRATIONS AT PRESS #3 (LOCATION K)(MG/M^3).

	Day 1						Day 2						Avg
Compound	09:08–10:07	10:07–11:09	11:11–12:02	13:13–14:11	14:12–15:14	15:15–16:13	09:11–10:04	10:05–11:01	11:02–12:00	13:31–14:21	14:22–15:18	15:18–16:19	
n–Hexane	1.01	0.70	0.80	1.00	1.50	1.45	0.85	0.60	0.70	2.50	0.90	0.80	1.07
Benzene[a]	6.28	2.50	2.70	2.98	5.38	15.36	1.82	2.35	2.04	1.49	8.12	6.21	4.77
Toluene	32.28	7.88	9.83	7.98	12.99	25.93	5.42	5.32	16.12	25.73	63.00	58.72	22.60
Ethylbenzene	0.47	0.18	0.05	0.09	0.50	1.84	0.04	0.04	0.15	0.32	0.96	1.38	0.50
p–Xylene	0.24	0.09	0.07	0.10	0.28	0.71	0.05	0.08	0.10	0.15	0.40	0.56	0.24
m–Xylene	0.37	0.16	0.20	0.28	0.71	0.85	0.15	0.23	0.23	0.24	0.57	0.74	0.39
o–Xylene	0.92	1.00	0.56	0.47	0.78	1.58	0.21	0.37	0.31	0.39	0.94	1.28	0.73
n–Propylbenzene	2.21	1.22	0.78	1.01	2.29	4.83	0.60	1.27	1.04	1.14	2.75	3.41	1.88
p–Ethyltoluene	9.18	5.26	3.37	4.38	9.47	19.41	2.56	5.42	4.45	4.83	10.95	13.31	7.72
1,3,5–Trimethylbenzene	3.14	1.95	1.28	1.57	3.39	7.01	0.88	1.85	1.58	1.71	3.79	4.91	2.76
o–Ethyltoluene	1.95	1.19	0.92	1.18	2.61	5.28	0.65	1.38	1.18	1.33	2.86	3.68	2.02
1,2,4–Trimethylbenzene	4.51	2.76	1.78	2.17	4.42	9.30	1.28	2.55	2.15	2.43	5.15	6.48	3.75
m–Diethylbenzene	0.55	0.34	0.23	0.24	0.48	1.08	0.15	0.27	0.24	0.30	0.60	0.90	0.45
1,2,3–Trimethylbenzene	0.48	0.28	0.18	0.22	0.45	1.02	0.13	0.25	0.21	0.25	0.53	0.71	0.39
Total VOC	95.31	42.56	34.45	39.57	71.22	178.40	19.88	34.64	42.00	62.29	147.13	157.17	77.05

[a]: Sum of benzene and isopropanol concentrations

TABLE 48. SITE 1 SPECIATED VOC CONCENTRATIONS AT PRESS #1 (LOCATION L)(MG/M^3).

	Day 1						Day 2						Avg
Compound	09:08–10:07	10:07–11:09	11:11–12:02	13:13–14:11	14:12–15:14	15:15–16:13	09:11–10:04	10:05–11:01	11:02–12:00	13:31–14:21	14:22–15:18	15:18–16:19	
n–Hexane	0.70	1.50	1.80	2.20	2.40	2.00	1.96	0.35	1.20	0.40	1.40	0.59	1.38
Benzene[a]	5.37	3.92	2.17	2.91	3.66	7.91	1.45	1.91	2.30	4.81	5.65	8.52	4.22
Toluene	22.66	15.70	12.76	12.66	15.74	18.96	9.19	6.81	14.33	30.50	50.83	55.08	22.10
Ethylbenzene	0.05	0.20	0.10	0.20	0.10	1.03	0.05	0.04	0.16	0.52	0.68	1.36	0.37
p–Xylene	0.08	0.13	0.11	0.14	0.12	0.45	0.07	0.07	0.12	0.25	0.35	0.61	0.21
m–Xylene	0.25	0.32	0.30	0.35	0.33	0.63	0.19	0.19	0.29	0.39	0.93	0.85	0.42
o–Xylene	0.47	0.49	0.40	0.41	0.43	1.06	0.28	0.27	0.38	0.70	0.94	1.65	0.62
n–Propylbenzene	1.47	1.37	0.81	0.82	1.04	3.04	0.71	0.81	1.15	2.04	2.51	4.41	1.68
p–Ethyltoluene	6.27	5.92	3.53	3.58	4.48	12.17	3.03	3.47	4.92	8.54	10.19	17.67	6.98
1,3,5–Trimethylbenzene	2.32	2.20	1.30	1.28	1.68	4.34	1.05	1.18	1.72	3.12	3.86	6.30	2.53
o–Ethyltoluene	1.60	1.50	0.95	0.92	1.24	3.34	0.74	0.86	1.25	1.88	2.82	3.73	1.74
1,2,4–Trimethylbenzene	3.08	2.98	1.87	1.84	2.28	5.62	1.54	1.69	2.43	4.38	4.92	8.49	3.43
m–Diethylbenzene	0.41	0.39	0.25	0.22	0.27	0.60	0.20	0.20	0.29	0.56	0.68	1.09	0.43
1,2,3–Trimethylbenzene	0.30	0.30	0.20	0.20	0.25	0.59	0.15	0.17	0.24	0.47	0.49	0.90	0.36
Total VOC	57.87	57.21	33.81	38.10	46.47	105.88	25.71	27.05	43.49	82.33	118.38	169.40	67.14

[a]: Sum of benzene and isopropanol concentrations

TABLE 49. SITE 2 HOURLY SPECIATED VOC CONCENTRATIONS AT MIDDLE AIR SUPPLY (LOCATION S)(MG/M^3).

Compound	Day 1						Day 2						Avg
	09:16–10:07	10:07–11:04	11:04–12:02	12:02–13:07	13:07–13:59	13:59–15:16	09:07–10:14	10:14–11:02	11:02–12:02	12:02–13:03	13:03–13:59	13:59–15:07	
n–Hexane	0.08	0.09	0.10	0.08	0.11	0.15	0.09	0.07	0.10	0.14	0.14	0.16	0.11
Isopropanol	0.93	1.29	2.55	1.25	2.65	2.74	2.93	1.56	1.32	1.31	1.37	1.94	1.82
Benzene	bdl[a]	bdl	bdl	bdl	0.22	0.52	bdl	0.40	bdl	0.54	0.63	0.98	0.27
Toluene	0.19	0.35	0.25	0.33	0.35	0.60	0.20	0.26	0.17	0.34	0.44	0.58	0.34
Ethylbenzene	0.06	0.07	0.08	0.09	0.09	0.33	0.05	0.05	0.07	0.09	0.08	0.13	0.10
p–Xylene	0.04	0.04	0.04	0.04	0.04	0.20	bdl	bdl	bdl	bdl	bdl	0.40	0.07
m–Xylene	0.10	0.13	0.14	0.15	0.15	0.43	0.14	0.11	0.16	0.22	0.23	bdl	0.16
Isopropylbenzene	0.08	0.08	0.10	0.09	0.09	0.18	0.09	0.10	0.13	0.15	0.16	0.23	0.12
o–Xylene	0.11	0.12	0.15	0.12	0.14	0.29	0.11	0.11	0.14	0.18	0.19	0.24	0.16
n–Propylbenzene	0.15	0.17	0.22	0.18	0.20	0.44	0.21	0.24	0.30	0.34	0.38	0.58	0.29
m&p Ethyltoluene	0.69	0.79	1.02	0.85	0.91	1.96	0.93	1.11	1.37	1.55	1.72	2.57	1.29
Isobutylbenzene	bdl	bdl	bdl	bdl	0.37	0.83	bdl	0.43	0.54	bdl	bdl	1.06	0.27
1,3,5–Trimethylbenzene	0.23	0.28	0.37	0.30	bdl	bdl	0.32	bdl	bdl	0.53	0.59	bdl	0.22
o–Ethyltoluene	0.15	0.19	0.25	0.21	0.22	0.49	0.22	0.26	0.32	0.37	0.41	0.10	0.26
1,2,4–Trimethylbenzene	0.54	0.66	0.89	0.74	0.76	1.70	0.72	0.89	1.08	1.21	1.33	2.06	1.05
m–Diethylbenzene	0.04	0.06	0.08	0.07	0.05	0.16	0.06	0.06	0.09	0.10	0.10	0.18	0.09
p–Diethylbenzene	bdl	0.03	0.05	0.04	bdl	0.08	0.03	0.04	0.04	0.04	0.04	0.08	0.04
o–Diethylbenzene	0.02	0.03	0.05	0.04	0.03	0.09	0.03	0.04	0.04	0.04	0.04	0.28	0.06
1,2,3–Trimethylbenzene	0.08	0.12	0.15	0.13	0.12	0.27	0.11	0.13	0.15	0.16	0.17	0.03	0.14
Total VOC	8.03	9.73	11.33	10.09	11.23	21.47	9.84	12.08	15.08	14.58	15.51	27.24	13.85

[a] bdl: Below detection limit (<0.01)

TABLE 50. SITE 2 HOURLY SPECIATED VOC CONCENTRATIONS AT MIDDLE AIR RETURN (LOCATION L)(MG/M^3).

	Day 1						Day 2						Avg
Compound	09:16–10:07	10:07–11:04	11:04–12:02	12:02–13:07	13:07–13:59	13:59–15:16	09:07–10:14	10:14–11:02	11:02–12:02	12:02–13:03	13:03–13:59	13:59–15:07	
n–Hexane	0.08	0.08	0.50	0.06	0.07	0.09	0.09	0.07	0.08	0.13	0.13	0.13	0.13
Isopropanol	0.80	0.79	5.78	0.67	1.29	1.49	1.09	1.07	0.96	0.31	0.32	0.36	1.24
Benzene	0.25	0.25	1.56	0.21	0.22	0.24	0.22	0.29	0.32	0.30	0.31	0.55	0.39
Toluene	0.42	0.33	1.93	0.26	0.28	0.41	0.13	0.14	0.29	0.21	0.21	0.43	0.42
Ethylbenzene	0.07	0.07	0.43	0.06	0.07	0.07	0.05	0.04	0.06	0.07	0.08	0.10	0.10
p–Xylene	0.04	0.05	0.26	0.03	0.04	0.04	0.03	0.02	0.03	0.04	0.04	0.05	0.06
m–Xylene	0.12	0.11	0.62	0.09	0.10	0.11	0.09	0.08	0.10	0.12	0.14	0.16	0.15
Isopropylbenzene	0.05	0.06	0.40	0.05	0.06	0.06	0.08	0.09	0.10	0.10	0.11	0.17	0.11
o–Xylene	0.10	0.10	0.65	0.08	0.09	0.10	0.10	0.10	0.11	0.15	0.13	0.18	0.16
n–Propylbenzene	0.11	0.11	0.76	0.10	0.11	0.12	0.18	0.22	0.24	0.22	0.24	0.40	0.23
m&p Ethyltoluene	0.48	0.51	3.45	0.47	0.50	0.53	0.80	1.02	1.07	1.05	1.08	1.78	1.06
Isobutylbenzene	bdl[a]	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
1,3,5–Trimethylbenzene	0.16	0.17	1.15	0.16	0.17	0.18	0.27	0.34	0.36	0.35	0.36	0.63	0.36
o–Ethyltoluene	0.10	0.11	0.72	0.10	0.11	0.11	0.19	0.24	0.25	0.25	0.25	0.42	0.24
1,2,4–Trimethylbenzene	0.40	0.42	2.80	0.40	0.43	0.46	0.60	0.80	0.85	0.81	0.83	1.38	0.85
m–Diethylbenzene	0.03	0.03	0.22	0.04	0.03	0.05	0.05	0.05	0.08	0.11	0.07	0.13	0.07
p–Diethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	0.02	bdl	0.03	0.04	0.02	0.06	0.01
o–Diethylbenzene	0.02	0.02	0.12	0.02	0.02	0.03	0.02	0.03	0.04	0.04	0.03	0.06	0.04
1,2,3–Trimethylbenzene	0.06	0.06	0.42	0.06	0.06	0.09	0.08	0.10	0.12	0.18	0.11	0.18	0.13
Total VOC	6.28	7.04	5.32	6.18	6.17	7.84	7.84	10.00	10.70	9.12	9.57	17.54	8.63

[a] bdl: Below detection limit (<0.01)

TABLE 51. SITE 2 HOURLY SPECIATED VOC CONCENTRATIONS AT STAIRWAY (LOCATION N)(MG/M^3).

	Day 1						Day 2						Avg
Compound	09:16–10:07	10:07–11:04	11:04–12:02	12:02–13:07	13:07–13:59	13:59–15:16	09:07–10:14	10:14–11:02	11:02–12:02	12:02–13:03	13:03–13:59	13:59–15:07	
n–Hexane	bdl[a]	0.07	0.07	0.07	0.07	0.09	0.00	0.05	0.08	0.13	0.07	0.09	0.07
Isopropanol	0.67	0.63	0.76	0.73	1.52	1.12	0.76	0.42	0.85	0.90	0.53	0.32	0.63
Benzene	bdl	0.21	0.24	bdl	bdl	bdl	0.21	bdl	0.27	bdl	bdl	0.33	0.13
Toluene	0.41	0.35	0.29	0.30	0.39	0.35	0.19	0.06	0.18	0.20	0.24	0.19	0.18
Ethylbenzene	0.07	0.06	0.06	0.07	0.07	0.08	0.04	bdl	0.06	0.08	0.06	0.07	0.05
p–Xylene	0.04	0.04	0.04	0.04	0.04	0.05	0.03	bdl	0.03	0.04	0.03	0.04	0.03
m–Xylene	0.10	0.08	0.09	0.10	0.12	0.11	0.07	0.04	0.09	0.13	0.09	0.10	0.09
Isopropylbenzene	0.05	0.05	0.06	0.06	0.06	0.07	0.06	0.04	0.08	0.09	0.07	0.10	0.07
o–Xylene	0.09	0.08	0.09	0.10	0.10	0.11	0.08	0.04	0.10	0.12	0.09	0.12	0.09
n–Propylbenzene	0.10	0.09	0.12	0.13	0.12	0.14	0.13	0.09	0.18	0.19	0.14	0.23	0.16
m&p Ethyltoluene	0.45	0.42	0.55	0.59	0.55	0.65	0.56	0.41	0.82	0.89	0.64	1.01	0.72
Isobutylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
1,3,5–Trimethylbenzene	0.15	0.14	0.18	0.20	0.18	0.22	0.19	0.13	0.27	0.30	0.21	0.34	0.24
o–Ethyltoluene	0.10	0.09	0.12	0.14	0.12	0.15	0.12	0.08	0.19	0.21	0.13	0.23	0.16
1,2,4–Trimethylbenzene	0.38	0.34	0.44	0.50	0.47	0.56	0.42	0.30	0.65	0.71	0.49	0.76	0.56
m–Diethylbenzene	0.03	0.03	0.03	0.04	0.04	0.05	0.03	0.02	0.06	0.06	0.03	0.06	0.04
p–Diethylbenzene	bdl	bdl	bdl	0.02	bdl	0.03	bdl	bdl	0.03	0.03	bdl	0.03	0.01
o–Diethylbenzene	0.02	0.01	0.02	0.19	0.02	0.03	0.01	0.00	0.03	0.03	0.02	0.03	0.02
1,2,3–Trimethylbenzene	0.06	0.05	0.06	0.07	0.08	0.10	0.06	0.04	0.10	0.11	0.08	0.10	0.08
Total VOC	7.18	6.45	7.19	7.64	4.71	8.86	6.56	7.12	9.58	8.89	7.88	10.93	8.50

[a] bdl: Below detection limit (<0.01)

TABLE 52. SITE 2 HOURLY SPECIATED VOC CONCENTRATIONS ON ROOF (LOCATION P)(MG/M^3).

	Day 1						Day 2						Avg
Compound	09:16–10:07	10:07–11:04	11:04–12:02	12:02–13:07	13:07–13:59	13:59–15:16	09:07–10:14	10:14–11:02	11:02–12:02	12:02–13:03	13:03–13:59	13:59–15:07	
n–Hexane	bdl[a]	bdl	bdl	0.07	bdl	bdl	0.03	bdl	bdl	0.02	0.23	0.26	0.14
Isopropanol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Benzene	bdl	bdl	bdl	0.02	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Toluene	bdl	bdl	bdl	0.03	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Ethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
p–Xylene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
m–Xylene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Isopropylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
o–Xylene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
n–Propylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
m&p Ethyltoluene	bdl	bdl	bdl	0.06	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Isobutylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
1,3,5–Trimethylbenzene	bdl	bdl	bdl	0.02	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
o–Ethyltoluene	bdl	bdl	bdl	0.01	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
1,2,4–Trimethylbenzene	bdl	bdl	bdl	0.03	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
m–Diethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
p–Diethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
o–Diethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
1,2,3–Trimethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Total VOC	0.42	0.44	0.03	0.02	bdl	0.05	0.07	0.54	0.20	0.11	0.06	0.92	0.48

[a] bdl: Below detection limit (<0.01)

TABLE 53. SITE 2 ONE HOUR SPECIATED VOC VONCENTRATIONS AROUND PRESSES, DAY 1 (MG/M^3).

	Web 1		Web 2		Sheet 1		Sheet 2		2 Color Press		Duplicator	
Compound	09:16–10:07	12:02–13:07	10:07–11:04	13:07–13:59	11:04–12:02	13:59 15:16	09:16–10:07	12:02–13:07	11:04–12:02	13:07–13:59	10:07–11:04	13:59 15:16
n–Hexane	0.19	0.09	0.10	0.14	0.11	0.14	0.54	0.30	0.14	0.12	0.16	a
Isopropanol	2.03	0.95	1.23	1.17	3.54	2.54	1.41	2.79	1.61	1.13	2.12	3.96
Benzene	bdl[a]	0.32	0.34	0.38	bdl	0.57	0.58	0.37	0.72	0.48	a	1.49
Toluene	0.61	0.35	0.23	0.41	0.65	0.66	0.87	0.36	0.68	0.40	0.90	1.21
Ethylbenzene	0.17	0.19	0.08	0.12	0.10	0.42	0.15	0.11	0.22	0.11	0.31	0.55
p–Xylene	bdl	0.10	bdl	0.39	bdl	0.60	0.08	0.05	0.08	0.06	0.13	0.26
m–Xylene	0.42	0.29	0.19	bdl	0.21	bdl	0.22	0.19	0.20	0.15	0.25	0.50
Isopropylbenzene	0.22	0.12	0.10	0.14	0.13	0.18	0.15	0.10	0.20	0.14	0.27	0.40
o–Xylene	0.28	0.17	0.14	0.19	0.17	0.25	0.21	0.14	0.22	0.17	0.30	0.44
n–Propylbenzene	0.52	0.27	0.22	0.32	0.31	0.42	0.34	0.23	0.50	0.34	0.74	1.09
m&p Ethyltoluene	2.32	1.25	0.98	1.42	1.39	1.87	1.53	1.04	2.27	1.52	3.28	4.78
Isobutylbenzene	bdl	0.52	bdl	0.59	0.59	0.79	bdl	bdl	bdl	bdl	bdl	bdl
1,3,5–Trimethylbenzene	0.84	bdl	0.35	bdl	bdl	bdl	0.55	0.38	0.77	0.51	1.14	1.71
o–Ethyltoluene	0.57	0.33	0.24	0.37	0.34	0.51	0.37	0.26	0.53	0.36	0.79	1.17
1,2,4–Trimethylbenzene	1.84	1.04	0.83	1.20	1.19	1.53	1.27	0.93	1.88	1.27	2.72	4.09
m–Diethylbenzene	0.16	0.10	0.08	0.11	0.11	0.14	0.12	0.09	0.16	0.11	0.26	0.38
p–Diethylbenzene	0.08	0.05	0.04	0.06	0.06	0.07	0.06	0.05	0.06	0.05	0.12	0.17
o–Diethylbenzene	0.08	0.21	0.05	0.24	0.06	0.27	0.07	0.05	0.07	0.05	0.12	0.16
1,2,3–Trimethylbenzene	0.29	0.03	0.15	0.04	0.19	0.04	0.20	0.16	0.24	0.18	0.34	0.50
Total VOC	22.83	13.17	11.42	13.34	15.48	23.62	18.24	12.45	22.87	14.73	33.16	58.06

[a] bdl: Below detection limit (<0.01)

TABLE 54. SITE 2 ONE HOUR SPECIATED VOC VONCENTRATIONS AROUND PRESSES, DAY 2 (MG/M^3).

	Web 1		Web 2		Sheet 1		Sheet 2		2 Color Press		Duplicator	
	11:02–12:02	13:59–15:07	10:14–11:02	13:03–13:59	09:07–10:14	12:02–13:03	09:00–10:00	12:00–13:00	10:00–11:00	13:00–14:00	11:00–12:00	14:00–15:00
n–Hexane	0.16	0.30	0.14	0.32	0.12	0.16	0.10	0.15	0.21	0.15	0.11	0.19
Isopropanol	2.14	3.88	1.54	0.54	5.69	1.36	2.78	1.05	2.31	1.06	1.25	2.16
Benzene	0.69	1.76	0.62	bdl[a]	bdl	0.55	0.30	0.44	1.09	0.51	0.52	0.96
Toluene	0.47	1.31	bdl	1.20	0.21	0.41	0.13	0.34	bdl	0.42	0.21	0.97
Ethylbenzene	0.14	0.48	0.13	0.44	0.08	0.12	0.05	0.10	0.13	0.10	0.09	0.27
p–Xylene	bdl	bdl	0.07	0.16	bdl	bdl	bdl	0.37	0.07	0.05	0.00	0.09
m–Xylene	0.41	0.62	0.16	0.45	0.23	0.24	0.12	bdl	0.16	0.16	0.19	0.27
Isopropylbenzene	0.23	0.52	0.24	0.50	0.14	0.19	0.09	0.15	0.33	0.17	0.17	0.29
o–Xylene	0.28	0.49	0.25	0.55	0.17	0.21	0.11	0.18	0.32	0.19	0.18	0.31
n–Propylbenzene	0.59	1.39	0.58	1.29	0.35	0.45	0.22	0.36	0.93	0.40	0.43	0.77
m&p Ethyltoluene	2.65	6.04	2.63	5.50	1.56	2.01	0.98	1.62	4.12	1.79	1.95	3.33
Isobutylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
1,3,5–Trimethylbenzene	0.96	2.16	0.88	1.97	0.53	0.68	0.33	0.55	1.47	0.60	0.65	1.18
o–Ethyltoluene	0.65	1.45	0.59	1.37	0.37	0.47	0.23	0.39	1.02	0.42	0.45	0.82
1,2,4–Trimethylbenzene	2.20	4.75	1.97	4.31	1.24	1.50	0.77	1.29	3.63	1.36	1.56	2.72
m–Diethylbenzene	0.19	0.44	0.17	0.35	0.09	0.12	0.06	0.10	0.34	0.11	0.13	0.24
p–Diethylbenzene	0.10	0.19	0.06	0.16	0.03	0.04	0.03	0.03	0.15	0.04	0.04	0.11
o–Diethylbenzene	0.10	0.19	0.07	0.14	0.04	0.05	0.03	0.04	0.15	0.05	0.05	0.11
1,2,3–Trimethylbenzene	0.34	0.56	0.25	0.51	0.16	0.19	0.11	0.16	0.44	0.17	0.19	0.34
Total VOC	24.36	55.09	19.69	48.87	15.99	18.11	9.71	15.08	34.20	16.21	16.42	31.02

[a] bdl: Below detection limit (<0.01)

TABLE 55. SITE 2 SIX HOUR SAMPLE CONCENTRATIONS (MG/M^3).

	Day 1				Day 2			
Compounds	West Supply	West Return	East Supply	East Return	West Supply	West Return	East Supply	East Return
n−Hexane	0.12	0.14	0.08	0.05	0.15	0.13	0.09	0.07
Isopropanol	1.63	1.63	0.54	0.58	2.34	1.67	0.90	0.43
Benzene	0.00	0.53	0.27	0.15	0.00	0.61	0.38	0.20
Toluene	0.53	0.61	0.47	0.32	0.66	0.53	0.66	0.32
Ethylbenzene	0.28	0.30	0.09	0.05	0.35	0.26	0.16	0.07
p−Xylene	0.16	0.14	0.05	0.04	0.13	0.10	0.07	0.03
m−Xylene	0.42	0.34	0.13	0.07	0.48	0.31	0.15	0.11
Isopropylbenzene	0.14	0.14	0.06	0.02	0.25	0.19	0.12	0.06
o−Xylene	0.22	0.21	0.11	0.06	0.30	0.23	0.14	0.09
n−Propylbenzene	0.33	0.33	0.12	0.04	0.61	0.49	0.28	0.12
m&p Ethyltoluene	1.53	1.48	0.57	0.17	2.62	2.14	1.24	0.55
Isobutylbenzene	bdl[a]	bdl	bdl	bdl	bdl	bdl	bdl	bdl
1,3,5−Trimethylbenzene	0.56	0.53	0.20	0.06	0.96	0.77	0.44	0.18
o−Ethyltoluene	0.37	0.36	0.14	0.04	0.66	0.53	0.29	0.13
1,2,4−Trimethylbenzene	1.26	1.23	0.51	0.16	2.18	1.74	0.98	0.44
m−Diethylbenzene	0.11	0.11	0.05	0.01	0.19	0.15	0.09	0.04
p−Diethylbenzene	0.05	0.05	0.03	0.00	0.09	0.07	0.04	0.02
o−Diethylbenzene	0.06	0.06	0.03	0.01	0.08	0.06	0.04	0.02
1,2,3−Trimethylbenzene	0.20	0.18	0.10	0.03	0.29	0.22	0.13	0.07
Total VOC	18.02	17.99	8.12	3.98	17.74	20.90	13.12	6.57

[a] bdl: Below detection limit (<0.01)

TABLE 56. SITE 3 HOURLY SPECIATED VOC CONCENTRATIONS AT SE DOOR (LOCATION 1) (MG/M^3).

	Day 1						Day 2					
Compound	09:12–10:07	10:07–11:06	11:06–12:05	12:05–13:08	13:08–14:06	14:06–15:07	09:05–10:07	10:07–11:08	11:08–12:06	12:06–13:06	13:06–14:09	14:09–15:08
n–Hexane	bdl[a]	bdl	bdl	bdl	bdl	bdl	0.117	2.570	bdl	0.142	0.116	bdl
Isopropanol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	2.443	0.821
Benzene	bdl	0.032	0.053	bdl	0.030	0.043	0.012	0.049	0.053	0.186	2.634	1.253
Toluene	0.052	0.251	1.716	0.355	0.766	1.078	0.145	2.112	0.724	0.339	2.615	2.134
Ethylbenzene	bdl	bdl	0.201	0.075	0.101	0.107	bdl	0.039	bdl	bdl	0.809	0.617
p–Xylene	bdl	bdl	0.160	0.053	0.079	0.089	bdl	0.029	bdl	bdl	0.362	0.219
m–Xylene	bdl	0.048	0.381	0.119	0.202	0.242	bdl	0.076	0.027	0.034	0.563	0.287
Isopropylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.047	1.436	0.616
o–Xylene	bdl	bdl	0.106	0.033	0.053	0.067	bdl	0.029	bdl	0.061	1.730	0.749
n–Propylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.100	3.253	1.382
m&p–Ethyltoluene	0.026	bdl	bdl	bdl	bdl	bdl	bdl	0.039	0.033	0.433	14.023	6.621
Isobutylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
1,3,5–Trimethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.132	5.131	2.767
o–Ethyltoluene	0.076	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.097	3.957	2.077
1,2,4–Trimethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.026	0.022	0.229	7.478	4.493
m–Diethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	0.010	bdl	bdl	bdl	0.661	0.509
p–Diethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.424	0.325
o–Diethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.299	0.249
1,2,3–Trimethylbenzene	0.016	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.027	0.982	0.725
Total VOC	0.47	0.91	3.60	1.06	1.99	2.22	0.69	5.14	1.59	2.66	76.07	39.87

[a] bdl: Below detection limit (<0.001)

TABLE 57. SITE 3 HOURLY SPECIATED VOC CONCENTRATIONS AT S SCREEN (LOCATION 2) (MG/M^3).

	Day 1						Day 2					
Compound	09:12–10:07	10:07–11:06	11:06–12:05	12:05–13:08	13:08–14:06	14:06–15:07	09:05–10:07	10:07–11:08	11:08–12:06	12:06–13:06	13:06–14:09	14:09–15:08
n–Hexane	bdl[a]	0.005	bdl	bdl	bdl	bdl	bdl	0.203	0.084	bdl	bdl	bdl
Isopropanol	bdl	0.005	bdl	0.025	bdl	0.105	bdl	bdl	bdl	0.056	0.555	0.765
Benzene	0.024	0.035	bdl	0.095	bdl	0.149	0.020	0.032	0.050	0.159	0.678	0.442
Toluene	bdl	0.093	0.258	0.101	0.040	0.317	0.030	0.252	0.169	0.084	bdl	bdl
Ethylbenzene	bdl	bdl	0.037	bdl	bdl	0.032	bdl	bdl	bdl	bdl	0.071	bdl
p–Xylene	bdl	bdl	0.031	bdl	bdl	0.026	bdl	bdl	bdl	bdl	0.041	bdl
m–Xylene	bdl	bdl	0.065	0.027	bdl	0.053	bdl	bdl	bdl	bdl	0.073	0.033
Isopropylbenzene	bdl	bdl	bdl	bdl	bdl	0.000	bdl	bdl	bdl	bdl	0.276	bdl
o–Xylene	bdl	bdl	0.025	bdl	bdl	0.000	bdl	bdl	bdl	bdl	0.326	0.135
n–Propylbenzene	bdl	bdl	bdl	bdl	bdl	0.000	bdl	bdl	bdl	0.020	0.635	0.178
m&p–Ethyltoluene	bdl	0.034	0.022	0.041	bdl	0.031	bdl	bdl	0.038	0.083	2.834	0.873
Isobutylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
1,3,5–Trimethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.020	1.018	0.329
o–Ethyltoluene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.025	0.734	0.214
1,2,4–Trimethylbenzene	bdl	0.030	0.024	0.030	bdl	0.026	bdl	bdl	0.027	0.067	1.565	bdl
m–Diethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.125	0.746
p–Diethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.074	0.030
o–Diethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.014	bdl
1,2,3–Trimethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.041	0.257	bdl
Total VOC	0.20	0.55	0.90	0.76	0.20	1.93	0.26	0.71	0.80	1.39	15.89	8.08

[a] bdl: Below detection limit (<0.001)

TABLE 58. SITE 3 HOURLY SPECIATED VOC CONCENTRATIONS AT N SCREEN (LOCATION 3) (MG/M^3).

	Day 1						Day 2					
Compound	09:12–10:07	10:07–11:06	11:06–12:05	12:05–13:08	13:08–14:06	14:06–15:07	09:05–10:07	10:07–11:08	11:08–12:06	12:06–13:06	13:06–14:09	14:09–15:08
n–Hexane	bdl[a]	bdl	bdl	bdl	bdl	bdl	bdl	0.040	0.016	bdl	bdl	bdl
Isopropanol	0.564	bdl	0.004	bdl	0.009	0.249	bdl	bdl	bdl	bdl	0.149	0.097
Benzene	0.268	0.195	0.033	0.027	0.057	0.276	0.000	0.006	0.012	0.011	0.208	0.111
Toluene	bdl	bdl	0.116	bdl	0.055	0.231	bdl	0.045	0.021	bdl	bdl	bdl
Ethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
p–Xylene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
m–Xylene	bdl	bdl	bdl	bdl	bdl	0.026	bdl	bdl	bdl	bdl	bdl	bdl
Isopropylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.063	bdl
o–Xylene	bdl	0.037	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.078	bdl
n–Propylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.148	0.041
m&p–Ethyltoluene	0.054	0.047	0.028	0.025	0.055	0.051	bdl	bdl	bdl	bdl	0.666	0.196
Isobutylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
1,3,5–Trimethylbenzene	bdl	bdl	bdl	bdl	0.013	0.012	bdl	bdl	bdl	bdl	0.207	0.058
o–Ethyltoluene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.157	0.035
1,2,4–Trimethylbenzene	0.062	0.172	0.032	0.008	0.048	0.047	bdl	bdl	0.035	0.042	0.418	0.188
m–Diethylbenzene	0.061	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.013	bdl
p–Diethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
o–Diethylbenzene	bdl	bdl	bdl	bdl	0.011	0.014	bdl	bdl	bdl	bdl	bdl	bdl
1,2,3–Trimethylbenzene	0.056	0.086	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.076	0.044
Total VOC	3.39	2.74	0.58	0.22	0.82	3.54	0.04	0.21	0.21	0.26	3.84	1.73

[a] bdl: Below detection limit (<0.001)

TABLE 59. SITE 3 HOURLY SPECIATED VOC CONCENTRATIONS AT NE DOOR (LOCATION 4) (MG/M^3).

Compound	Day 1						Day 2					
	09:12–10:07	10:07–11:06	11:06–12:05	12:05–13:08	13:08–14:06	14:06–15:07	09:05–10:07	10:07–11:08	11:08–12:06	12:06–13:06	13:06–14:09	14:09–15:08
n–Hexane	bdl[a]	bdl	bdl	bdl	bdl	bdl	0.093	0.367	bdl	bdl	bdl	0.029
Isopropanol	0.953	0.627	0.064	0.283	0.256	0.462	0.220	0.244	bdl	0.200	0.645	0.286
Benzene	0.828	0.406	0.198	0.285	0.263	0.474	0.257	0.216	0.201	0.174	0.730	0.299
Toluene	bdl	0.069	0.483	0.292	0.256	0.600	0.198	0.734	0.502	0.163	0.570	bdl
Ethylbenzene	0.038	0.065	0.068	0.061	0.052	0.056	bdl	bdl	bdl	bdl	0.079	bdl
p–Xylene	bdl	bdl	0.050	0.037	0.035	0.033	bdl	bdl	bdl	bdl	0.039	bdl
m–Xylene	bdl	bdl	0.079	0.050	0.045	0.051	bdl	bdl	bdl	bdl	0.068	bdl
Isopropylbenzene	0.016	0.013	bdl	0.029	0.027	bdl	bdl	bdl	bdl	bdl	0.240	0.044
o–Xylene	0.111	0.139	0.090	0.084	0.079	0.041	0.029	bdl	0.046	0.049	0.325	0.073
n–Propylbenzene	0.045	0.045	0.035	0.063	0.051	0.020	bdl	bdl	0.026	0.025	0.527	0.102
m&p–Ethyltoluene	0.224	0.218	0.171	0.363	0.259	0.095	0.075	0.057	0.107	0.113	2.369	0.554
Isobutylbenzene	0.069	0.103	0.058	bdl	0.055	bdl	bdl	bdl	bdl	bdl	bdl	bdl
1,3,5–Trimethylbenzene	0.066	0.075	0.045	0.091	0.074	0.021	0.016	0.013	0.024	0.029	0.839	0.201
o–Ethyltoluene	0.114	0.096	0.062	0.111	0.169	0.031	0.031	bdl	0.050	0.042	0.622	0.163
1,2,4–Trimethylbenzene	0.180	0.504	0.161	0.194	bdl	0.087	0.069	0.048	0.103	0.094	1.397	0.512
m–Diethylbenzene	bdl	0.021	bdl	0.049	0.050	bdl	bdl	bdl	bdl	bdl	0.123	0.049
p–Diethylbenzene	bdl	0.029	0.065	0.063	bdl	bdl	bdl	bdl	bdl	bdl	0.098	0.056
o–Diethylbenzene	bdl	bdl	0.018	0.016	0.016	bdl	bdl	bdl	bdl	bdl	0.018	0.015
1,2,3–Trimethylbenzene	0.316	0.277	0.203	0.185	0.215	0.121	0.143	0.049	0.149	0.142	0.274	0.167
Total VOC	11.76	7.14	4.54	5.91	4.64	7.01	3.92	4.17	2.90	3.53	16.22	5.69

[a] bdl: Below detection limit (<0.001)

TABLE 60. SITE 3 HOURLY SPECIATED VOC CONCENTRATIONS AT NW DOOR (LOCATION 5) (MG/M^3).

	Day 1						Day 2					
Compound	09:12–10:07	10:07–11:06	11:06–12:05	12:05–13:08	13:08–14:06	14:06–15:07	09:05–10:07	10:07–11:08	11:08–12:06	12:06–13:06	13:06–14:09	14:09–15:08
n–Hexane	0.025	0.011	0.024	bdl	bdl	bdl	bdl	0.195	0.191	bdl	bdl	bdl
Isopropanol	0.096	bdl[a]	0.065	0.220	0.136	bdl	bdl	bdl	bdl	bdl	0.411	bdl
Benzene	0.064	0.022	0.031	0.127	0.062	0.697	0.157	0.171	0.217	0.190	0.443	0.160
Toluene	bdl	bdl	0.169	0.190	0.106	0.719	0.036	0.260	0.324	0.041	0.396	0.114
Ethylbenzene	bdl	bdl	bdl	bdl	bdl	0.070	bdl	bdl	bdl	bdl	bdl	bdl
p–Xylene	bdl	bdl	bdl	bdl	bdl	0.034	bdl	bdl	bdl	bdl	bdl	bdl
m–Xylene	bdl	bdl	0.030	bdl	bdl	0.057	bdl	bdl	bdl	bdl	bdl	bdl
Isopropylbenzene	bdl	bdl	bdl	bdl	bdl	0.038	bdl	bdl	bdl	bdl	0.051	bdl
o–Xylene	bdl	bdl	0.026	0.028	bdl	0.090	bdl	0.027	0.031	bdl	0.073	0.038
n–Propylbenzene	bdl	bdl	bdl	0.024	bdl	0.052	bdl	0.022	0.025	bdl	0.112	0.048
m&p–Ethyltoluene	0.081	0.075	0.075	0.112	0.067	0.262	0.083	0.101	0.115	0.067	0.546	0.243
Isobutylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
1,3,5–Trimethylbenzene	0.020	0.018	0.018	0.026	0.016	0.066	0.019	0.024	0.028	0.017	0.185	0.075
o–Ethyltoluene	0.016	0.029	0.026	0.035	0.014	0.070	0.015	0.032	0.021	0.027	0.142	0.069
1,2,4–Trimethylbenzene	0.075	0.054	0.056	0.072	0.053	0.139	0.056	0.069	0.078	0.056	0.370	0.233
m–Diethylbenzene	bdl	bdl	bdl	bdl	bdl	0.039	bdl	bdl	bdl	bdl	0.014	0.011
p–Diethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
o–Diethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.065	bdl
1,2,3–Trimethylbenzene	0.031	0.027	0.036	0.050	0.027	0.113	0.026	0.029	0.034	0.032	bdl	0.075
Total VOC	1.40	1.09	1.35	2.80	1.59	10.79	2.09	2.75	3.52	2.59	7.07	2.86

[a] bdl: Below detection limit (<0.001)

TABLE 61. SITE 3 HOURLY SPECIATED VOC CONCENTRATIONS AT LOADING DOCK (LOCATION 6) (MG/M^3).

Compound	Day 1						Day 2					
	09:12–10:07	10:07–11:06	11:06–12:05	12:05–13:08	13:08–14:06	14:06–15:07	09:05–10:07	10:07–11:08	11:08–12:06	12:06–13:06	13:06–14:09	14:09–15:08
n–Hexane	bdl[a]	bdl	0.012	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Isopropanol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Benzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.012	bdl	0.003	0.116
Toluene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.194	0.061	bdl	bdl
Ethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
p–Xylene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
m–Xylene	bdl	bdl	bdl	bdl	0.032	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Isopropylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.031
o–Xylene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.027
n–Propylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.094
m&p–Ethyltoluene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.030	bdl	bdl	0.487
Isobutylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
1,3,5–Trimethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.178
o–Ethyltoluene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.128
1,2,4–Trimethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.024	bdl	bdl	0.344
m–Diethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
p–Diethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
o–Diethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
1,2,3–Trimethylbenzene	0.014	bdl	bdl	0.010	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.067
Total VOC	0.04	0.02	0.05	0.04	0.08	0.04	0.01	0.03	0.96	1.46	0.25	2.66

[a] bdl: Below detection limit (<0.001)

TABLE 62. SITE 3 HOURLY SPECIATED VOC CONCENTRATIONS AT SW DOOR (LOCATION 7) (MG/M^3).

	Day 1						Day 2					
Compound	09:12–10:07	10:07–11:06	11:06–12:05	12:05–13:08	13:08–14:06	14:06–15:07	09:05–10:07	10:07–11:08	11:08–12:06	12:06–13:06	13:06–14:09	14:09–15:08
n–Hexane	0.010	0.013	0.022	0.016	bdl	bdl	0.242	bdl	0.382	bdl	bdl	bdl
Isopropanol	bdl[a]	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.009	0.476	0.322
Benzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.089	0.029	0.666	0.560
Toluene	bdl	0.035	0.025	0.180	0.017	0.215	0.276	bdl	0.611	0.188	0.633	0.645
Ethylbenzene	bdl	bdl	0.044	0.047	bdl	bdl	bdl	bdl	bdl	bdl	0.077	0.278
p–Xylene	bdl	bdl	0.036	0.033	bdl	bdl	bdl	bdl	bdl	bdl	0.044	bdl
m–Xylene	bdl	bdl	0.078	0.070	0.037	0.029	bdl	bdl	0.035	bdl	0.088	0.107
Isopropylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.023	0.319	0.269
o–Xylene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.025	0.029	0.360	0.290
n–Propylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.027	0.049	0.729	0.561
m&p–Ethyltoluene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.120	0.224	3.236	2.748
Isobutylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
1,3,5–Trimethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.043	0.064	1.127	1.109
o–Ethyltoluene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.023	0.040	0.793	0.796
1,2,4–Trimethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.098	0.127	1.665	1.844
m–Diethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.013	bdl	0.106	0.173
p–Diethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.091
o–Diethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.008	0.022
1,2,3–Trimethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.038	0.017	0.222	0.302
Total VOC	0.11	0.22	0.85	0.64	0.59	0.52	0.83	0.11	2.81	1.82	16.96	16.05

[a] bdl: Below detection limit (<0.001)

TABLE 63. SITE 3 HOURLY SPECIATED VOC CONCENTRATIONS AT N ROOF EXHAUST (LOCATION 8) (MG/M^3).

	Day 1						Day 2					
Compound	09:12–10:07	10:07–11:06	11:06–12:05	12:05–13:08	13:08–14:06	14:06–15:07	09:05–10:07	10:07–11:08	11:08–12:06	12:06–13:06	13:06–14:09	14:09–15:08
n–Hexane	bdl[a]	bdl	bdl	bdl	bdl	bdl	bdl	0.432	0.273	0.068	bdl	bdl
Isopropanol	3.202	1.249	0.557	1.158	0.348	0.970	0.525	0.604	0.447	0.116	0.826	0.696
Benzene	1.686	0.763	0.353	0.979	0.400	0.966	0.535	0.625	0.482	0.163	0.899	0.767
Toluene	bdl	1.157	0.926	1.181	0.361	1.188	0.630	0.865	0.743	0.229	0.734	1.150
Ethylbenzene	0.158	0.107	0.084	0.497	0.080	0.202	0.030	0.035	bdl	bdl	0.104	0.079
p–Xylene	bdl	bdl	0.055	0.152	0.041	0.068	bdl	bdl	bdl	bdl	0.047	bdl
m–Xylene	bdl	bdl	0.088	0.192	0.060	0.094	bdl	bdl	bdl	bdl	0.066	0.041
Isopropylbenzene	0.021	0.020	0.018	0.213	0.078	0.055	0.065	0.038	0.024	0.014	0.218	0.142
o–Xylene	0.200	0.212	0.151	0.367	0.183	0.142	0.158	0.066	0.069	0.089	0.345	0.244
n–Propylbenzene	0.068	0.075	0.053	0.370	0.120	0.078	0.098	0.071	0.047	0.044	0.426	0.312
m&p–Ethyltoluene	0.337	0.336	0.255	1.658	0.623	0.411	0.487	0.331	0.222	0.194	1.952	1.469
Isobutylbenzene	0.155	0.173	0.043	bdl	bdl	bdl	bdl	bdl	0.013	0.097	bdl	bdl
1,3,5–Trimethylbenzene	0.121	0.111	0.062	0.535	0.202	0.129	0.111	0.086	0.042	0.049	0.635	0.554
o–Ethyltoluene	0.081	0.077	0.115	0.446	0.184	0.126	0.135	0.093	0.078	0.083	0.522	0.419
1,2,4–Trimethylbenzene	0.764	0.770	0.209	1.112	0.324	0.237	0.246	0.169	0.164	0.622	1.464	1.253
m–Diethylbenzene	0.112	0.030	bdl	0.200	0.099	0.067	0.077	0.020	bdl	0.084	0.155	0.138
p–Diethylbenzene	0.170	0.058	0.095	0.066	bdl	bdl	bdl	bdl	bdl	0.122	0.170	0.154
o–Diethylbenzene	bdl	0.479	bdl	0.079	0.025	0.020	0.018	bdl	0.015	bdl	0.059	0.040
1,2,3–Trimethylbenzene	0.532	0.021	0.331	0.419	0.286	0.211	0.219	0.100	0.183	0.373	0.410	0.373
Total VOC	22.79	14.18	7.40	22.79	8.47	15.75	8.98	10.05	7.90	4.47	19.00	15.17

[a] bdl: Below detection limit (<0.001)

TABLE 64. SITE 3 HOURLY SPECIATED VOC CONCENTRATIONS AT S ROOF EXHAUST (LOCATION 9) (MG/M^3).

	Day 1						Day 2					
Compound	09:12–10:07	10:07–11:06	11:06–12:05	12:05–13:08	13:08–14:06	14:06–15:07	09:05–10:07	10:07–11:08	11:08–12:06	12:06–13:06	13:06–14:09	14:09–15:08
n–Hexane	bdl[a]	bdl	0.016	bdl	bdl	bdl	bdl	0.575	0.307	0.090	bdl	bdl
Isopropanol	0.773	0.436	bdl	0.448	0.504	1.297	0.312	bdl	bdl	bdl	bdl	bdl
Benzene	0.696	0.418	0.563	0.464	0.493	1.283	0.374	0.531	0.238	0.204	0.855	0.886
Toluene	0.908	0.304	1.307	0.452	0.930	1.375	0.349	1.282	0.494	0.289	1.265	1.291
Ethylbenzene	0.066	0.071	0.111	0.067	0.070	0.239	bdl	bdl	bdl	bdl	0.086	0.080
p–Xylene	bdl	bdl	0.066	bdl	0.036	0.071	bdl	bdl	bdl	bdl	0.041	bdl
m–Xylene	bdl	bdl	0.110	0.051	0.060	0.094	bdl	bdl	bdl	bdl	0.061	bdl
Isopropylbenzene	0.053	0.067	0.064	0.035	0.047	0.052	bdl	bdl	bdl	bdl	0.207	0.153
o–Xylene	0.164	0.201	0.196	0.079	0.141	0.141	bdl	0.050	0.035	0.050	0.325	0.203
n–Propylbenzene	0.079	0.086	0.089	0.063	0.065	0.068	bdl	0.041	0.035	0.034	0.432	0.365
m&p–Ethyltoluene	0.378	0.397	0.419	0.310	0.343	0.345	0.020	0.192	0.164	0.139	1.908	1.728
Isobutylbenzene	0.076	0.103	0.078	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
1,3,5–Trimethylbenzene	0.126	0.127	0.133	0.064	0.074	0.080	0.107	0.047	0.038	0.029	0.650	0.642
o–Ethyltoluene	0.148	0.175	0.161	0.083	0.093	0.091	0.026	0.063	0.047	0.062	0.462	0.451
1,2,4–Trimethylbenzene	0.242	0.268	0.278	0.191	0.200	0.214	0.034	0.121	0.095	0.131	1.119	1.197
m–Diethylbenzene	0.078	0.096	0.088	0.053	0.070	0.071	bdl	bdl	bdl	bdl	0.104	0.113
p–Diethylbenzene	bdl	0.134	bdl	bdl	bdl	bdl	0.074	bdl	bdl	bdl	0.027	0.031
o–Diethylbenzene	0.022	0.031	0.026	0.016	0.021	0.019	bdl	bdl	bdl	bdl	0.018	0.020
1,2,3–Trimethylbenzene	0.269	0.334	0.303	0.178	0.225	0.219	bdl	0.121	0.059	0.160	0.260	0.278
Total VOC	11.03	7.82	10.61	7.68	8.56	19.76	4.77	8.34	3.82	3.56	15.96	15.80

[a] bdl: Below detection limit (<0.001)

TABLE 65. SITE 3 HOURLY SPECIATED VOC CONCENTRATIONS AT ROOF AIR INTAKE (LOCATION 10) (MG/M^3).

Compound	Day 1 09:12–10:07	Day 1 10:07–11:06	Day 1 11:06–12:05	Day 1 12:05–13:08	Day 1 13:08–14:06	Day 1 14:06–15:07	Day 2 09:05–10:07	Day 2 10:07–11:08	Day 2 11:08–12:06	Day 2 12:06–13:06	Day 2 13:06–14:09	Day 2 14:09–15:08
n–Hexane	bdl[a]	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Isopropanol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Benzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Toluene	bdl	bdl	bdl	bdl	bdl	0.092	bdl	bdl	bdl	bdl	bdl	bdl
Ethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
p–Xylene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
m–Xylene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Isopropylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
o–Xylene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
n–Propylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
m&p–Ethyltoluene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Isobutylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
1,3,5–Trimethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
o–Ethyltoluene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
1,2,4–Trimethylbenzene	0.007	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
m–Diethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
p–Diethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
o–Diethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
1,2,3–Trimethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Total VOC	0.23	0.12	0.15	0.13	0.05	0.20	0.07	0.06	0.07	0.06	0.04	0.04

[a] bdl: Below detection limit (<0.001)

TABLE 66. SITE 3 HOURLY SPECIATED VOC CONCENTRATIONS AT M–43 (LOCATION 17) (MG/M^3).

	Day 1						Day 2					
Compound	09:12–10:07	10:07–11:06	11:06–12:05	12:05–13:08	13:08–14:06	14:06–15:07	09:05–10:07	10:07–11:08	11:08–12:06	12:06–13:06	13:06–14:09	14:09–15:08
n–Hexane	bdl[a]	bdl	bdl	bdl	bdl	bdl	0.090	0.443	0.137	0.086	bdl	bdl
Isopropanol	8.627	3.081	1.861	1.833	0.688	1.709	0.479	0.000	0.286	0.910	0.786	0.697
Benzene	4.112	0.646	0.873	0.844	0.393	0.925	0.558	0.650	0.364	0.940	0.887	0.767
Toluene	4.404	0.533	1.823	1.473	0.705	0.897	0.942	1.438	0.850	0.841	0.953	0.875
Ethylbenzene	1.276	0.627	0.187	0.365	0.061	0.086	0.063	0.073	0.074	0.112	0.214	0.167
p–Xylene	0.625	0.501	0.101	0.130	bdl	0.038	bdl	bdl	bdl	0.047	0.086	0.129
m–Xylene	bdl	bdl	0.134	0.135	0.044	0.054	bdl	bdl	bdl	0.056	0.092	bdl
Isopropylbenzene	bdl	bdl	0.187	0.191	0.045	0.033	0.079	0.046	0.059	0.139	0.261	0.136
o–Xylene	0.523	0.433	0.479	0.450	0.098	0.078	0.147	0.091	0.281	0.263	0.576	0.693
n–Propylbenzene	0.188	0.157	0.301	0.301	0.088	0.066	0.124	0.098	0.081	0.233	0.509	0.248
m&p–Ethyltoluene	0.615	0.622	1.454	1.497	0.459	0.360	0.605	0.497	0.384	1.046	2.566	1.099
Isobutylbenzene	0.264	0.276	bdl	bdl	bdl	bdl	bdl	bdl	0.185	bdl	bdl	0.195
1,3,5–Trimethylbenzene	0.206	0.205	0.410	0.437	0.130	0.108	0.193	0.160	0.105	0.331	0.728	0.340
o–Ethyltoluene	0.206	0.207	0.425	0.444	0.125	0.098	0.173	0.144	0.146	0.275	0.737	0.376
1,2,4–Trimethylbenzene	2.371	2.445	1.332	1.368	0.480	0.368	0.291	0.432	1.106	0.489	1.393	3.033
m–Diethylbenzene	0.424	0.435	0.208	0.232	0.072	0.052	0.078	0.067	0.118	0.125	0.259	0.336
p–Diethylbenzene	bdl	bdl	0.239	0.069	0.080	0.067	bdl	0.023	0.180	0.134	0.306	0.419
o–Diethylbenzene	2.294	2.329	0.174	0.172	0.022	0.018	0.252	0.018	bdl	0.382	0.224	0.399
1,2,3–Trimethylbenzene	0.094	0.094	0.606	0.566	0.250	0.202	bdl	0.202	0.570	0.047	0.772	0.980
Total VOC	66.00	26.59	20.08	21.63	7.52	13.22	10.01	11.11	9.45	17.65	24.08	22.44

[a] bdl: Below detection limit (<0.001)

TABLE 67. SITE 3 HOURLY SPECIATED VOC CONCENTRATIONS AT M–34 (LOCATION 18) (MG/M^3).

	Day 1						Day 2					
Compound	09:12–10:07	10:07–11:06	11:06–12:05	12:05–13:08	13:08–14:06	14:06–15:07	09:05–10:07	10:07–11:08	11:08–12:06	12:06–13:06	13:06–14:09	14:09–15:08
n–Hexane	bdl[a]	bdl	bdl	bdl	bdl	bdl	0.139	0.425	0.138	0.049	bdl	bdl
Isopropanol	0.455	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.250	1.858	0.494
Benzene	0.517	0.396	0.459	0.233	0.610	0.378	0.481	0.565	0.227	0.457	1.173	0.557
Toluene	0.884	0.826	1.079	0.254	1.043	0.526	0.798	0.922	0.382	0.550	1.974	0.633
Ethylbenzene	bdl	0.077	0.086	0.059	0.084	0.048	bdl	0.058	bdl	bdl	0.234	bdl
p–Xylene	bdl	0.047	0.052	0.036	0.044	bdl	bdl	bdl	bdl	bdl	0.079	bdl
m–Xylene	bdl	0.050	0.089	0.048	0.064	0.045	bdl	bdl	bdl	bdl	0.112	bdl
Isopropylbenzene	0.067	0.088	0.044	0.017	0.021	bdl	bdl	0.032	0.031	0.030	0.308	0.056
o–Xylene	0.174	0.266	0.136	0.100	0.117	0.045	0.071	0.105	0.093	0.085	0.375	0.076
n–Propylbenzene	0.101	0.139	0.061	0.050	0.061	0.025	0.027	0.036	0.063	0.068	0.678	0.140
m&p–Ethyltoluene	0.556	0.752	0.320	0.258	0.312	0.118	0.144	0.181	0.323	0.330	3.078	0.716
Isobutylbenzene	bdl	bdl	bdl	0.093	0.100	bdl	0.023	0.023	0.081	bdl	bdl	bdl
1,3,5–Trimethylbenzene	0.172	0.198	0.070	0.070	0.088	0.024	0.025	0.035	0.089	0.072	1.074	0.270
o–Ethyltoluene	0.165	0.217	0.080	0.120	0.134	0.039	0.054	0.060	0.125	0.109	0.783	0.187
1,2,4–Trimethylbenzene	0.297	0.377	0.198	0.626	0.707	0.098	0.363	0.138	0.192	0.223	1.738	0.597
m–Diethylbenzene	0.079	0.121	0.046	0.071	0.080	bdl	0.036	bdl	0.061	0.065	0.155	0.052
p–Diethylbenzene	bdl	0.149	bdl	0.110	0.116	bdl	0.058	0.055	bdl	0.090	0.114	0.048
o–Diethylbenzene	0.023	0.059	0.015	bdl	0.032	bdl	bdl	0.013	0.019	0.018	0.024	0.013
1,2,3–Trimethylbenzene	0.279	0.398	0.179	0.353	0.327	0.129	0.208	0.171	0.247	0.259	0.332	0.168
Total VOC	9.40	10.07	8.03	5.28	10.55	5.49	7.07	9.10	5.00	7.13	24.03	8.63

[a] bdl: Below detection limit (<0.001)

TABLE 68. SITE 3 HOURLY SPECIATED VOC CONCENTRATIONS AT M−38 (LOCATION 19) (MG/M^3).

	Day 1						Day 2					
Compound	09:12–10:07	10:07–11:06	11:06–12:05	12:05–13:08	13:08–14:06	14:06–15:07	09:05–10:07	10:07–11:08	11:08–12:06	12:06–13:06	13:06–14:09	14:09–15:08
n−Hexane	0.034	bdl	bdl	0.007	bdl	bdl	0.076	0.357	0.177	bdl	bdl	bdl
Isopropanol	0.332	0.016	0.008	0.011	0.014	0.184	0.009	0.091	0.000	0.326	0.461	0.479
Benzene	0.267	0.036	0.017	0.035	0.027	0.222	0.071	0.108	0.321	0.472	0.781	0.628
Toluene	0.180	0.051	0.190	0.097	0.033	0.181	0.108	0.399	0.394	0.715	1.019	0.921
Ethylbenzene	bdl[a]	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.000	0.052	0.069	bdl
p−Xylene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.017	0.036	bdl
m−Xylene	bdl	bdl	0.039	0.027	bdl	0.026	bdl	bdl	bdl	bdl	0.064	bdl
Isopropylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.028	0.079	0.228	0.098
o−Xylene	0.030	0.047	0.025	0.023	bdl	0.031	bdl	bdl	0.042	0.444	0.300	0.179
n−Propylbenzene	bdl	0.024	bdl	0.020	bdl	0.031	bdl	bdl	0.057	0.111	0.511	0.238
m&p−Ethyltoluene	0.090	0.092	0.065	0.092	0.083	0.144	0.061	0.041	0.279	0.487	2.288	1.166
Isobutylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.351	bdl	bdl
1,3,5−Trimethylbenzene	0.021	0.023	0.017	0.021	0.021	0.035	0.012	bdl	0.076	0.138	0.802	0.448
o−Ethyltoluene	0.079	0.105	0.050	0.060	0.056	0.095	0.034	0.029	0.159	0.112	0.588	0.305
1,2,4−Trimethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	1.832	1.307	0.910
m−Diethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.014	0.229	0.107	0.081
p−Diethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.274	0.074	0.061
o−Diethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.016	0.015
1,2,3−Trimethylbenzene	0.071	0.091	bdl	0.024	bdl	0.085	bdl	bdl	0.057	0.925	0.248	0.222
Total VOC	3.63	1.72	1.08	1.30	1.01	3.41	0.86	2.02	3.19	12.55	15.19	11.15

[a] bdl: Below detection limit (<0.001)

TABLE 69. SITE 3 HOURLY SPECIATED VOC CONCENTRATIONS AT MID–ROOM (LOCATION 20) (MG/M^3).

	Day 1						Day 2					
Compound	09:12– 10:07	10:07– 11:06	11:06– 12:05	12:05– 13:08	13:08– 14:06	14:06– 15:07	09:05– 10:07	10:07– 11:08	11:08– 12:06	12:06– 13:06	13:06– 14:09	14:09– 15:08
n–Hexane	bdl[a]	bdl	bdl	bdl	bdl	bdl	0.189	0.549	0.173	0.066	0.100	bdl
Isopropanol	0.836	0.467	0.954	0.641	0.511	0.924	0.602	0.749	0.459	0.151	1.094	bdl
Benzene	0.585	0.304	0.611	0.301	0.482	0.604	0.573	0.743	0.463	0.187	1.232	0.568
Toluene	0.731	0.305	1.100	0.312	0.583	0.915	0.574	1.211	0.287	0.357	1.301	0.683
Ethylbenzene	0.072	0.069	0.131	0.073	0.079	0.104	0.064	0.076	0.028	bdl	0.297	0.065
p–Xylene	bdl	0.039	0.079	0.042	0.042	0.059	bdl	bdl	bdl	bdl	0.107	bdl
m–Xylene	bdl	0.045	0.159	0.065	0.068	0.109	0.040	0.045	bdl	bdl	0.183	bdl
Isopropylbenzene	0.068	0.071	0.063	0.042	0.031	0.052	0.042	0.046	0.053	0.028	0.395	0.073
o–Xylene	0.166	0.196	0.169	0.143	0.095	0.124	0.093	0.099	0.112	0.075	0.485	0.099
n–Propylbenzene	0.097	0.087	0.096	0.047	0.048	0.078	0.061	0.070	0.072	0.060	0.909	0.191
m&p–Ethyltoluene	0.500	0.392	0.472	0.228	0.244	0.376	0.318	0.349	0.346	0.255	4.042	0.897
Isobutylbenzene	bdl	0.096	bdl	0.033	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
1,3,5–Trimethylbenzene	0.133	0.111	0.140	0.047	0.061	0.109	0.090	0.100	0.080	0.059	1.434	0.345
o–Ethyltoluene	0.154	0.157	0.137	0.087	0.095	0.101	0.088	0.093	0.088	0.077	1.049	0.235
1,2,4–Trimethylbenzene	0.262	0.265	0.415	0.173	0.189	0.301	0.151	0.289	0.175	0.166	2.245	0.684
m–Diethylbenzene	0.064	0.073	0.051	0.053	0.056	0.041	0.033	0.034	0.037	0.031	0.208	0.074
p–Diethylbenzene	bdl	0.103	0.059	0.076	0.077	bdl	bdl	0.042	bdl	bdl	0.136	0.021
o–Diethylbenzene	0.020	0.027	0.017	0.019	0.021	0.013	0.011	0.011	0.010	0.012	0.045	0.017
1,2,3–Trimethylbenzene	0.237	0.297	0.180	0.222	0.218	0.135	0.108	0.116	0.134	0.138	0.383	0.211
Total VOC	10.42	7.48	11.90	6.77	8.79	10.58	9.23	12.51	7.01	4.07	29.31	10.21

[a] bdl: Below detection limit (<0.001)

TABLE 70. SITE 3 HOURLY SPECIATED VOC CONCENTRATIONS IN M–38 STACK GAS (LOCATION 11) (MG/M^3).

	Day 1						Day 2					
Compound	09:12–10:07	10:07–11:06	11:06–12:05	12:05–13:08	13:08–14:06	14:06–15:07	09:05–10:07	10:07–11:08	11:08–12:06	12:06–13:06	13:06–14:09	14:09–15:08
n–Hexane	2.193	bdl	bdl	0.204	bdl	0.577	bdl	0.093	0.092	0.566	0.140	0.154
Isopropanol	bdl[a]	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Benzene	0.036	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Toluene	0.285	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.077	bdl
Ethylbenzene	0.017	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
p–Xylene	0.019	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
m–Xylene	0.030	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Isopropylbenzene	0.022	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
o–Xylene	0.039	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
n–Propylbenzene	0.020	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
m&p–Ethyltoluene	0.102	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Isobutylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
1,3,5–Trimethylbenzene	0.015	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
o–Ethyltoluene	0.026	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
1,2,4–Trimethylbenzene	0.023	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
m–Diethylbenzene	0.019	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
p–Diethylbenzene	0.018	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
o–Diethylbenzene	0.005	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
1,2,3–Trimethylbenzene	0.020	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Total VOC	2.660	0.760	0.730	0.640	0.650	0.920	0.540	0.650	0.750	0.810	0.690	0.570

[a] bdl: Below detection limit (<0.001)

TABLE 71. SITE 3 HOURLY SPECIATED VOC CONCENTRATIONS IN M–34 STACK GAS (LOCATION 12) (MG/M^3).

Compound	Day 1						Day 2					
	09:12–10:07	10:07–11:06	11:06–12:05	12:05–13:08	13:08–14:06	14:06–15:07	09:05–10:07	10:07–11:08	11:08–12:06	12:06–13:06	13:06–14:09	14:09–15:08
n–Hexane	0.124	0.359	0.313	0.542	0.510	0.530	0.236	0.256	0.318	0.656	0.649	0.217
Isopropanol	bdl[a]	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Benzene	bdl	0.090	0.041	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Toluene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Ethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
p–Xylene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
m–Xylene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Isopropylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
o–Xylene	bdl	0.044	0.052	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
n–Propylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
m&p–Ethyltoluene	bdl	0.132	0.161	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Isobutylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
1,3,5–Trimethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
o–Ethyltoluene	bdl	0.025	0.029	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
1,2,4–Trimethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
m–Diethylbenzene	bdl	0.023	0.028	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
p–Diethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
o–Diethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
1,2,3–Trimethylbenzene	bdl	bdl	0.030	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Total VOC	0.720	2.190	2.010	0.730	0.660	0.620	0.710	0.660	0.980	0.970	0.970	0.580

[a] bdl: Below detection limit (<0.001)

TABLE 72. SITE 3 HOURLY SPECIATED VOC CONCENTRATIONS IN M–43 STACK GAS (LOCATION 13) (MG/M^3).

Compound	Day 1						Day 2					
	09:12– 10:07	10:07– 11:06	11:06– 12:05	12:05– 13:08	13:08– 14:06	14:06– 15:07	09:05– 10:07	10:07– 11:08	11:08– 12:06	12:06– 13:06	13:06– 14:09	14:09– 15:08
n–Hexane	bdl[a]	0.202	0.257	0.181	0.231	0.645	0.207	17.696	0.911	1.124	0.620	3.250
Isopropanol	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.552	bdl	bdl	bdl	bdl
Benzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.067	bdl	bdl	bdl	bdl
Toluene	bdl	bdl	bdl	0.090	0.100	bdl	bdl	0.242	bdl	bdl	bdl	0.051
Ethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.017	bdl	bdl	bdl	bdl
p–Xylene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.016	bdl	bdl	bdl	bdl
m–Xylene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.028	bdl	bdl	bdl	bdl
Isopropylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.023	bdl	bdl	bdl	bdl
o–Xylene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.043	bdl	bdl	bdl	bdl
n–Propylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
m&p–Ethyltoluene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.093	bdl	bdl	bdl	bdl
Isobutylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
1,3,5–Trimethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.014	bdl	bdl	bdl	bdl
o–Ethyltoluene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.030	bdl	bdl	bdl	bdl
1,2,4–Trimethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.036	bdl	bdl	bdl	bdl
m–Diethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
p–Diethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.024	bdl	bdl	bdl	bdl
o–Diethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.007	bdl	bdl	bdl	bdl
1,2,3–Trimethylbenzene	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.021	bdl	bdl	bdl	bdl
Total VOC	0.800	0.470	0.770	0.670	0.570	1.010	0.840	16.000	1.440	1.510	1.130	3.020

[a] bdl: Below detection limit (<0.001)

TABLE 73. SITE 3 HOURLY SPECIATED VOC CONCENTRATIONS IN M–38 DRIER GAS PRE–INCINERATOR (LOCATION 14) (MG/M^3).

	Day 1						Day 2					
Compound	09:12–10:07	10:07–11:06	11:06–12:05	12:05–13:08	13:08–14:06	14:06–15:07	09:05–10:07	10:07–11:08	11:08–12:06	12:06–13:06	13:06–14:09	14:09–15:08
n–Hexane	0.805	0.577	bdl	3.904	bdl	7.831	1.781	bdl	3.036	bdl	1.136	bdl
Isopropanol	bdl[a]	bdl	1.525	2.207	2.730	5.128	bdl	2.536	bdl	2.155	bdl	7.269
Benzene	1.940	0.730	2.068	4.753	3.145	5.981	1.231	2.924	bdl	2.491	1.777	7.636
Toluene	0.826	0.643	2.087	1.530	2.916	2.413	1.085	1.652	0.086	2.799	bdl	bdl
Ethylbenzene	1.075	0.605	1.351	2.038	1.882	3.726	0.995	2.214	bdl	2.164	0.099	4.935
p–Xylene	0.034	bdl	bdl	bdl	bdl	0.807	bdl	bdl	bdl	bdl	bdl	bdl
m–Xylene	0.296	0.122	0.294	0.503	0.395	bdl	0.250	0.463	bdl	0.521	bdl	1.061
Isopropylbenzene	0.483	0.195	0.283	0.459	0.360	4.661	0.357	0.765	bdl	0.718	0.085	1.886
o–Xylene	1.624	0.671	1.374	3.375	1.991	bdl	1.340	3.060	bdl	3.581	0.114	3.270
n–Propylbenzene	0.470	0.147	0.342	0.807	0.406	1.028	0.229	0.552	bdl	0.712		1.931
m&p–Ethyltoluene	1.531	0.565	1.068	4.172	1.757	5.183	1.035	2.757	bdl	3.513	0.747	4.661
Isobutylbenzene	0.814	0.308	0.651	bdl	0.609	2.321	0.273	bdl	bdl	bdl	bdl	3.149
1,3,5–Trimethylbenzene	0.620	0.225	0.446	1.788	0.757	1.861	0.433	0.959	bdl	1.222	0.175	2.618
o–Ethyltoluene	0.900	0.398	0.729	1.696	0.781	20.072	0.550	1.129	bdl	1.491	0.284	2.010
1,2,4–Trimethylbenzene	0.072	2.961	5.761	15.756	7.774	3.413	3.482	7.929	bdl	10.194	0.544	4.416
m–Diethylbenzene	1.865	0.696	1.286	8.737	2.133	4.765	1.480	2.711	bdl	3.453	0.122	3.641
p–Diethylbenzene	2.820	1.275	2.409	bdl	bdl	19.192	bdl	bdl	bdl	bdl	bdl	4.437
o–Diethylbenzene	0.018	bdl	bdl	17.989	9.706	6.565	4.736	12.045	bdl	13.895	0.152	bdl
1,2,3–Trimethylbenzene	8.168	3.679	6.851	2.363	1.080	1.966	1.140	4.224	bdl	4.462	0.616	8.343
Total VOC	61.220	31.500	73.770	187.080	90.220	203.340	44.270	111.960	1.510	116.960	16.270	193.930

[a] bdl: Below detection limit (<0.001)

TABLE 74. SITE 3 HOURLY SPECIATED VOC CONCENTRATIONS IN M−34 DRIER GAS PRE−INCINERATOR (LOCATION 15) (MG/M^3).

Compound	Day 1						Day 2					
	09:12–10:07	10:07–11:06	11:06–12:05	12:05–13:08	13:08–14:06	14:06–15:07	09:05–10:07	10:07–11:08	11:08–12:06	12:06–13:06	13:06–14:09	14:09–15:08
n−Hexane	bdl[a]	bdl	1.042	bdl	bdl	bdl	bdl	bdl	bdl	115.406	7.897	0.327
Isopropanol	bdl	1.337	1.242	bdl	2.566	0.540	1.627	1.611	bdl	bdl	bdl	bdl
Benzene	1.166	2.322	1.398	2.712	2.641	1.447	3.493	1.585	1.757	2.077	1.528	0.095
Toluene	0.711	1.988	1.808	1.977	3.048	0.948	1.160	1.207	2.131	2.052	bdl	bdl
Ethylbenzene	0.534	2.499	1.266	1.967	3.110	0.393	0.321	1.377	2.116	2.055	0.893	bdl
p−Xylene	bdl	0.541	bdl	bdl	bdl	0.103	bdl	0.292	0.447	bdl	bdl	bdl
m−Xylene	0.128	bdl	0.311	0.520	0.755	0.156	bdl	bdl	bdl	0.478	0.204	bdl
Isopropylbenzene	0.175	0.939	0.332	0.743	1.096	0.212	0.159	0.485	0.795	0.644	0.366	bdl
o−Xylene	0.220	5.201	2.854	2.926	5.642	0.518	1.888	1.686	3.639	4.176	0.794	bdl
n−Propylbenzene	0.099	1.103	0.595	0.653	2.384	0.241	0.358	0.401	0.819	0.892	0.421	0.048
m&p−Ethyltoluene	0.626	3.153	3.892	2.291	3.634	1.193	4.140	1.297	3.063	7.205	1.922	0.236
Isobutylbenzene	0.277	1.604	bdl	0.742	3.538	1.169	bdl	0.371	0.726	bdl	0.482	bdl
1,3,5−Trimethylbenzene	0.282	2.463	1.763	1.024	1.139	0.653	1.096	0.572	1.316	1.866	0.699	0.062
o−Ethyltoluene	0.317	2.534	1.573	1.127	2.887	0.233	1.171	0.692	1.518	2.021	1.109	0.041
1,2,4−Trimethylbenzene	n.d.[b]	22.816	21.768	10.586	30.026	8.582	13.410	n.d.	10.461	n.d.	n.d.	n.d.
m−Diethylbenzene	1.235	12.060	10.625	3.904	bdl	bdl	3.859	2.407	2.904	9.614	0.947	bdl
p−Diethylbenzene	bdl	bdl	bdl	bdl	15.680	4.542	bdl	bdl	bdl	bdl	2.882	bdl
o−Diethylbenzene	4.218	32.192	32.196	18.810	bdl	15.707	18.331	10.080	12.812	27.819	bdl	bdl
1,2,3−Trimethylbenzene	1.462	8.315	10.395	4.996	31.311	5.178	5.973	3.407	3.000	8.957	10.141	0.857
Total VOC	30.390	208.820	183.400	131.080	285.860	90.410	75.610	84.560	105.660	416.170	98.870	15.510

[a] bdl: Below detection limit (<0.001)

[b] n.d.: no data – 1,2,4 TMB not included in lab report

TABLE 75. SITE 3 HOURLY SPECIATED VOC CONCENTRATIONS IN M–43 DRIER GAS PRE–INCINERATOR (LOCATION 16) (MG/M^3).

	Day 1						Day 2					
Compound	09:12–10:07	10:07–11:06	11:06–12:05	12:05–13:08	13:08–14:06	14:06–15:07	09:05–10:07	10:07–11:08	11:08–12:06	12:06–13:06	13:06–14:09	14:09–15:08
n–Hexane	bdl[a]	bdl	bdl	bdl	0.187	0.142	bdl	bdl	0.783	539.996	bdl	bdl
Isopropanol	4.906	bdl	bdl	bdl	bdl	1.481	bdl	bdl	bdl	bdl	1.049	bdl
Benzene	10.041	5.492	2.315	2.036	0.301	1.100	bdl	bdl	bdl	3.004	1.220	1.606
Toluene	4.207	4.180	4.174	1.572	bdl	bdl	bdl	bdl	0.117	4.643	1.901	1.459
Ethylbenzene	8.398	9.357	2.120	2.150	0.065	0.515	bdl	bdl	bdl	2.269	1.533	2.113
p–Xylene	bdl	bdl	0.477	0.392	0.021	0.119	bdl	bdl	bdl	0.787	0.416	0.472
m–Xylene	bdl	bdl	0.229	bdl	bdl	bdl	bdl	bdl	bdl	1.375	0.532	bdl
Isopropylbenzene	bdl	bdl	0.148	bdl	bdl	0.092	bdl	bdl	bdl	2.155	1.328	5.362
o–Xylene	17.767	16.971	4.180	2.780	0.167	bdl	bdl	bdl	bdl	6.763	4.986	bdl
n–Propylbenzene	4.460	3.452	1.574	1.067	bdl	0.017	bdl	bdl	bdl	2.040	2.594	1.085
m&p–Ethyltoluene	13.824	15.845	5.751	6.004	0.342	0.222	bdl	bdl	bdl	9.398	7.560	4.907
Isobutylbenzene	bdl	bdl	bdl	bdl	0.111	0.083	bdl	bdl	bdl	0.595	3.386	3.436
1,3,5–Trimethylbenzene	6.109	7.044	1.590	1.528	0.132	0.156	bdl	bdl	bdl	3.739	2.006	3.073
o–Ethyltoluene	7.002	7.728	1.730	1.553	0.156	0.104	bdl	bdl	bdl	4.041	3.619	40.515
1,2,4–Trimethylbenzene	65.459	n.d.[b]	bdl	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	33.636	29.754	bdl
m–Diethylbenzene	34.793	39.210	3.721	9.880	bdl	bdl	bdl	bdl	bdl	18.513	bdl	15.499
p–Diethylbenzene	bdl	bdl	bdl	bdl	0.965	0.715	bdl	bdl	bdl	1.086	15.272	42.738
o–Diethylbenzene	114.006	124.798	14.668	33.192	3.253	2.675	bdl	bdl	bdl	48.505		18.882
1,2,3–Trimethylbenzene	34.744	36.695	4.810	10.342	1.141	0.988	bdl	bdl	bdl	16.697	30.247	12.607
Total VOC	723.460	767.120	1222.340	190.080	17.660	26.220	1.430	1.140	1.290	794.960	253.620	256.840

[a] bdl: Below detection limit (<0.001)

[b] n.d.: no data – 1,2,4 TMB not included in lab report

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PROFESSIONAL EXPERIENCE:

1989 to Present University of Illinois at Chicago, Environmental and Occupational Health Sciences

Research Specialist (1991 to Present)
Coordinated field experiments for NIOSH funded research project. Collected and analyzed air pollution data for project. Supervised other students working on same project. Taught portions of university and continuing education classes in air pollution and industrial hygiene. Lectured on general industrial hygiene practice, analytical chemistry, industrial ventilation, ambient air pollution monitoring, and air pollution source testing.

Research Assistant (1989 to 1991)
Developed and maintained a gas chromatography lab for cryogenic analysis of trace volatile organic compounds in ambient air. Trained other students on sample collection and analysis. Member of team that collected eighty, twelve hour multimedia ambient air samples including

PROFESSIONAL EXPERIENCE: (Continued)

VOC, semi-volatile organics, PM_{10}, atmospheric anions and cations, criteria pollutants and meteorology as part of an EPA sponsored air toxics research project.

1988 to 1989 Illinois Institute of Technology Research Institute

Assistant Biologist
Developed and monitored test atmospheres (organic and particulate) for inhalation toxicology studies for National Toxicology Program studies.

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Assisted faculty in preparation and teaching of general and upper divisional biology laboratory courses.

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CONFERENCE PAPERS:

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