

Executive Summary

The objective of this study was to perform an assessment of indoor air quality and ventilation efficiency of the hair and makeup trailers in the Vancouver motion picture industry. Motivation for the study arose from the use of volatile paints, aerosols, and solvents in small working environments, coupled with limited previous investigations. Carbon dioxide, carbon monoxide, volatile organic compounds, relative humidity and temperature were identified as potential indoor air quality issues from an initial walkthrough. Monitoring was conducted in 10 different trailers. Four trailers were monitored twice to assess day to day variability (N=14). Methods for measurements of gas concentrations and physical characteristics of air involved the placement of two direct reading instruments in each trailer. Concurrent observations were made on the tasks performed, number of occupants and opened or closed status of the door(s) and window(s). Results found that on average trailers had sufficient outdoor air exchange. However, 12 of 14 trailer visits experienced periods of insufficient distribution of outdoor air as indicated by levels of CO₂ above the study's 1000 ppm guideline level. Carbon monoxide levels were below regulatory exposure limits. Average total VOC concentrations were above 3 ppm comfort guidelines in 4 of the 15 trailers, and all trailers experienced elevated peak concentrations. Levels appeared highest during airbrushing, airbrush product cleanup and morning openings of the trailers. In conclusion, when CO₂ levels are above 1000 ppm or VOC average levels are above 3 ppm, it is recommended that trailers receive regular air exchanges with 100% fresh air to ensure the elimination of indoor air contaminants. Local exhaust ventilation, such as downdraft venting, is recommended for trailers undertaking regular airbrushing, as natural ventilation was not found capable of controlling the short bursts of high VOC concentrations sufficiently. Future personal sampling for paint particulate and airbrushing solvents is recommended in prosthetic trailers where total VOC levels were observed to be the highest.

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Definitions

15 minute STEL: means the time weighted average (TWA) concentration of a substance in air which may not be exceeded over any 15 minute period, as defined by section 5.1 of the Worksafe BC OHS regulation.

8-hour TWA limit: means the time weighted average (TWA) concentration of a substance in air which may not be exceeded over a normal 8 hour work period, as defined by section 5.1 of the Worksafe BC OHS regulation.

Aerosol: Microscopic liquid or solid particles suspended in air.

Atomization: The reduction of product into tiny particles or fine spray via pressurized air for use in airbrushing in the industry.

Local Exhaust Ventilation: A specific type of mechanical ventilation used for the control of contaminants at the source. Usually involves the pulling of air out of the working environment through ducts, hoods or slots, such as a down-draft room trailer.

Mechanical Ventilation: Also known as ‘forced ventilation’ employs an air handler connected by ductwork to intake and exhaust locations to control contaminants by dilution with outdoor air.

Natural Ventilation: The process of supplying and removing air through an indoor space by natural means. For example, opening a door and allowing pressure and gas concentration differentials to balance.

Off-gassing: The process of solids or liquids changing into the gas phase. For example, the movement of chemicals on a recently varnished table from a solid to a gas in air.

Parts per million (ppm): a measure of concentration equivalent to 1 mg mass per litre of air.

Volatile: Evaporating readily at normal temperature and pressures.

Standard Deviation (SD): A measurement of variability – a high standard deviation indicates values of the same measurement have a wide range around the average of the measurements. A low standard deviation indicates values closely cluster around the average of the measurements.

Synergistic Effect: An effect arising from two or more substances that produce an effect greater than the sum of the individual effects. For example when exposure to two chemicals at the same time is worse than exposure to each chemical separately.

Actsafe Background

The Occupational and Environmental Hygiene summer placement was undertaken in Vancouver, BC working for ActSafe. Actsafe is dedicated to the promotion of health and safety in British Columbia's motion picture and performing arts industries. Their role is to:

“Provide arts workers and employers with the necessary support to ensure everyone goes home safely at the end of the day. Actsafe is governed by the industries it represents. They operate through two standing committees that represent the motion picture and performing arts communities. Membership on these committees includes both employer and worker representatives. Their mandate includes providing subsidized training and free industry-related communication, education, services and advice”.

Actsafe staff include a general manager overseeing a health and safety consultant, communications manager, office manager and outreach and project coordinator.

Specific services provided include:

- **Health and Safety Consultation** – for film and television questions or concerns.
- **Safety Passport** – A streamlining tool for workers to verify their certification from completed health and safety training courses.
- **Free Hearing Tests** - For workers deemed ‘at risk’ of noise induced hearing loss to comply with WorkSafeBC Hearing Conservation Program requirements, section 7.8.
- **Free Respirator Fit Testing** – For workers in environments where airborne contaminants may be present to comply with Worksafe BC PPE program requirements, section 8.5.
- **Print and Online Resources** – Monthly newsletters, posters, info sheets, safety bulletins, forms, and additional resources.
- **Industry Training**
 - Aerial Platform for Experienced Participants
 - Aerial Platform for Inexperienced Participants
 - Aerial Platform over 80 ft
 - Counter Balanced Forklift for Experienced Participants
 - Counter Balanced Forklift for Inexperienced Participants
 - Fall Protection Training
 - Film and Television Safety Awareness
 - Firearm Safety Level 1
 - Introduction to Fall Protection
 - Live Performance Electrical Certificate
 - Occupational Health and Safety First Aid Level 1
 - Performing Arts Supervisor Safety
 - Rough Terrain Forklift Experienced
 - Transportation of Dangerous Goods (online)
 - WHMIS (online)

British Columbia is the third largest centre for film and television production in North America with over 246 motion picture projects and \$1.5 billion dollars on production spending in 2010¹. According to BC Film Commission statistics, 35,000 people in BC are employed in the film industry¹. The industry encompasses a wide variety of professions, including administration, carpenters, camera operators, painters, metal fabricators, heavy-machinery operators, hair and makeup professionals, electricians, and actors.

Objectives

This project reports on the air contaminants, ventilation and comfort parameters of hair and makeup trailers in the Vancouver motion picture industry during the summer of 2011. Area monitoring of carbon dioxide, carbon monoxide, VOCs, humidity and relative temperature were completed to provide quantitative results on indoor air quality conditions.

Goals of the project:

- 1) Provide an evaluation of the effectiveness of ventilation in the hair and makeup trailers by monitoring a minimum of 7 trailers.
- 2) From the results and observations gained, make recommendations to ensure worker health and regulatory compliance with WSBC OHS regulation.
- 3) Assess and identify need for specific personal exposure sampling and future occupational hygiene evaluations.

Literature Review

No previous studies on the indoor air quality of motion picture hair and makeup trailers were located, nor were studies of chemical exposures of the workers. For hairdressers in general, literature has established some associations of the occupation with dermatitis², asthma³, respiratory sensitization⁴ and reproductive effects⁵.

Only a handful of studies have described chemical exposure levels of hairdressers in salons⁶⁻⁹. The majority of these have assessed volatile organic compounds (VOCs) in air such as isopropanol, formaldehyde, ethanol and persulphates. Interestingly while health effects have been established in the previously mentioned studies, overall concentrations of actual airborne contaminants were found to be well below occupational exposure limits in each of these studies. Potential synergistic effects between low concentrations of a wide variety of chemicals, in addition to exposure through dermal absorption are possible explanations for this discrepancy⁷.

A single study on dermal exposure in hairdressers was located that concludes hairdressers' skin is exposed to allergenic compounds during hair dyeing. The donning of disposable gloves was strongly recommended prior to mixing the dyes, but no further conclusions as to exposure levels were drawn¹⁰.

Literature addressing make-up workers or other cosmetologist chemical exposures and health effects was not located.

Rationale

Hair and makeup workers regularly use a wide variety of chemicals to create and maintain the desired “look” of actors. The majority of the work is undertaken in mobile trailers ranging from 25 to 50 feet long, while touch ups of actors are performed on set. Some of the trailers are equipped with mechanical ventilation to ensure fresh air is circulated by forced air supply and exhaust. An informal survey of trailer stock suggested that new trailers, especially on feature films, are more likely to be fitted with mechanical ventilation, while older trailers on lower budget productions rely strictly on natural ventilation.

Many of the chemicals used by workers in the trailer are volatile or are aerosolized during regular use, creating potential for worker inhalation of the chemicals. Furthermore some of the frequently used chemicals found in the trailer such as isopropyl myristate and octamethylcyclotetrasiloxane (244 fluid) have potentially adverse health effects. However, they are not controlled under WHMIS legislation and do not have validated methods for determining concentration in air, nor published occupational exposure limits. Considering the products used, it is important to assess if mechanically and naturally ventilated trailers are effective in exhausting air potentially containing these chemicals. .

Gases and Physical Characteristics of Air Monitored

Carbon Dioxide (CO₂) – As per section 4.72 of the OHS regulation, An adequate supply of outdoor air must be provided to the workplace in accordance with Table 2 of *ASHRAE Standard 62-1989*. The assessment of ventilation rates is a complex and meticulous process; an approximation of these rates can be gained by using occupant generated CO₂ levels as an indicator of fresh air exchange.

Outdoor CO₂ levels are approximately 350 ppm varying according to urbanization of the area and weather conditions. Indoor levels greater than 650 ppm above outdoor levels requires an assessment of the ventilation rates as per as per section 4.79(2)(a) of the OHS regulation. In this study CO₂ levels was assumed to be an appropriate indicator of ventilation and as such, concentrations above 1000 ppm indicate that insufficient fresh air was supplied to the workplace. Carbon dioxides concentration of 1000-5000 ppm are not toxic, but are an indicator of the inability of the ventilation system (natural or mechanical) to dilute contaminants in workplace air.

Carbon Monoxide (CO) – CO is an odourless gas, which is generated when combustion is incomplete. It is present in cases of improperly vented combustion appliances, tobacco smoke, and combustion engine exhaust.

The hair and makeup trailer is one of many trailers positioned within the filming location. The trailers, catering trucks and other automobiles when running or idling can produce carbon monoxide, which may accumulate in the hair and makeup working environment. Additional sources of carbon monoxide may include the operation of mobile generators or nearby smoking. Carbon monoxide is dangerous because it inhibits the blood's ability to carry oxygen to vital organs such as the heart and brain. Acute health effects arising at high concentrations include headaches, fatigue, nausea, dizziness and eventually death¹¹.

It can also be transported across the placental barrier, and exposure in utero constitutes a special risk to the fetus¹¹.

Volatile Organic Compounds (VOCs) – VOCs are classified as organic compounds (e.g. solvents) that have a boiling point roughly in the range of 50 to 250 °C. The ability of these chemicals to cause health effects depends on the specific chemicals present, from those with no known health effect to those that are highly toxic. Some potential health effects include eye, skin and respiratory tract irritation and cancer. Potential sources of VOCs in the trailers include the airbrushing of paints with alcohol or silicone based thinner, the use of aerosol and colouring hair sprays, and offgassing of other volatile hair and makeup products. In addition, the materials used in the construction of the trailers may offgas VOCs.

Relative Humidity and Temperature – Physical characteristics of air selected to assess comfort, as work in trailers is often conducted outside of regular hours, and at various locations or altitudes. Relative humidity levels below 20% are associated with increased discomfort and drying of the mucous membranes. High humidity can spur mould growth in the trailers.

Standards and Regulation

Table 1. Gases to be monitored.

Gases	WSBC Regulation	Section	Monitoring Instrumentation
Carbon Dioxide	Insufficient Ventilation: 1000 ppm^A , 8 hr TWA: 5000 ppm 15 min STEL: 15000 ppm	4.79(a) 5.48	Q-Trak
Carbon Monoxide	8 hr TWA: 25 ppm 15 min STEL: 100 ppm	5.48	Q-Trak
VOCs	None ^B	-	miniRAE

^ARequires assessment of ventilation rates

^BWorkSafeBC does not currently regulate total measurements of VOCs, as it is the measurement of a total concentration of a large number of chemicals whose interactions and health implications do not indicate a threshold effect. Instead total VOCs are considered an As Low as Reasonably Achievable (ALARA) substance, in which efforts should be made to drive worker exposures to as low as is practicable¹². In addition, the European community has prepared a target guideline value for TVOCs < 0.3 ppm¹².

Physical Characteristics of Air (Relative Humidity and Temperature)

WorkSafe of British Columbia stipulates environmental criterion for work places. Indoor air quality standards set out by *ASHRAE Standard 62-89*, Ventilation for Acceptable Indoor Air Quality are accepted by the WSBC as an approved standard for indoor air quality.

Table 2. Recommended guidelines for physical characteristics of air.

Season	Relative Humidity	Temperature (°C)
Summer	30%	23-27
	50%	23-26
	60%	23-26
Winter	30%	20-24
	50%	20-24
	60%	20-23

ASHRAE-Standard 55-1992: Thermal Environmental Conditions for Human Occupancy specifies conditions or comfort zones in which 80% of sedentary or slightly active individuals find the environment thermally acceptable. The values apply to people wearing typical summer or winter clothing.

Methods

Interviews were conducted with IATSE 891 Department Chairs and Co-chairs as an initial foray into identifying the air quality concerns of each department. Issues were prioritized according to perceived need and extent of current knowledge on the hazard. Concerns not addressed by this study were documented for future investigation.

An initial assessment of a movie hair and makeup trailer was conducted to identify potential indoor air quality issues. Carbon dioxide, carbon monoxide, VOCs, temperature and relative humidity were selected considering their potential to cause adverse health effects or discomfort and the monitoring practicality of each.

Air monitoring of the hair and makeup trailers was conducted between late July and early August. The July 12, 2011 British Columbia Film Commission Film List was downloaded and all productions (Feature films, Movie of the Weeks and TV Series) listed as shooting during July were contacted via telephone. If permission was obtained from both the production office and the makeup or hair head of department, a trailer visit was arranged.

During a trailer visit, initial spot measurements of gases and physical characteristics of the air were made outside the trailer. The two direct reading monitors were then placed against the mirrors, within the station rails of each trailer. Both instruments were set to datalogging mode with a 1 minute interval for continuous monitoring of levels. Trailer dimensions were measured and rough layouts were sketched on sampling information sheets for each trailer. Observations were also made periodically on the presence of mechanical ventilation, the number of occupants in the trailer, whether door(s) and window(s) were open, closed or ajar, and on the use of aerosol sprays and airbrushing.

The two test instruments and the parameters the equipment sampled for are:

Q-Trak (TSI) – samples and measures for carbon monoxide, carbon dioxide and records temperature and relative humidity.

MiniRAE 2000 PID (RAE Systems) – utilizes photo ionization detection to sample for total volatile organic compounds yielding concentration in ppm (toluene equivalents).

In addition, three trailers before day shoots were monitored in the morning during the initial opening of the doors by transport workers. Instruments were placed within the station rails at either ends of the 3 trailers. VOC levels and the introduction of fresh air over time, as indicated by CO₂ levels, were monitored.

The survey data from each trailer was compiled and examined to determine factors associated with indoor air quality. Microsoft Excel 2007 was used for assessment of basic descriptive variables (average, max, min, standard deviation) and generation of bar graphs and tables.

Results

Three major areas of concern were consistently identified through interviews with IATSE 891 department chairs and co-chairs (Table 3):

- Smoke and Fogs on set
- Medite (Medium Density Fibreboard) dust in construction shops
- Hair and Makeup products in trailers

In consultation with the ActSafe General Manager, Hair and Makeup products were selected as the focus of the study because of the lack of previous indoor air quality assessment of the trailers. The potential toxicity of some of the sprays, paints and solvents used, paired with limited controls and ventilation, made the working environment ideal for an initial evaluation.

Table 3. Summary of Interviews

Interview Statistics	Survey Interviews
Chairs or Co-chairs Interviewed (N)	14
Departments Represented (#)	10
Average Shift Length of Interviewee (h / SD)	12 +/- 2.1
Years of Experience (yr / SD)	18.5 +/- 6.5

Monitoring was conducted for 9 different productions in 10 different trailers located throughout Greater Vancouver (Table 4). Four of the trailers were monitored on two separate visits to identify day to day variability.

Table 4. Number and type of trailers visited.

Sampling Description	Trailers
Total Trailer Visits (N)	14
Trailers Monitored Once (#):	6
Trailers Monitored Twice (#):	4
Standard Hair and Makeup Trailers Visited (#):	9
Prosthetic Trailers Visited (#):	1
Trailers with Local Exhaust Ventilation (#)	2
Trailers without Local Exhaust Ventilation (#)	8
Median Trailer Length (ft / Range)	36 (22-50)
Median Chairs (# / Range)	6 (4-8)

Carbon Dioxide

Thirteen of 14 trailers had average CO₂ levels below 1000 ppm indicating the majority of trailers had sufficient distribution of outdoor air. However, 12 of 14 trailers had peak levels of CO₂ above the 1000 ppm guideline level, indicating periods of insufficient distribution of outdoor air (Fig 1).

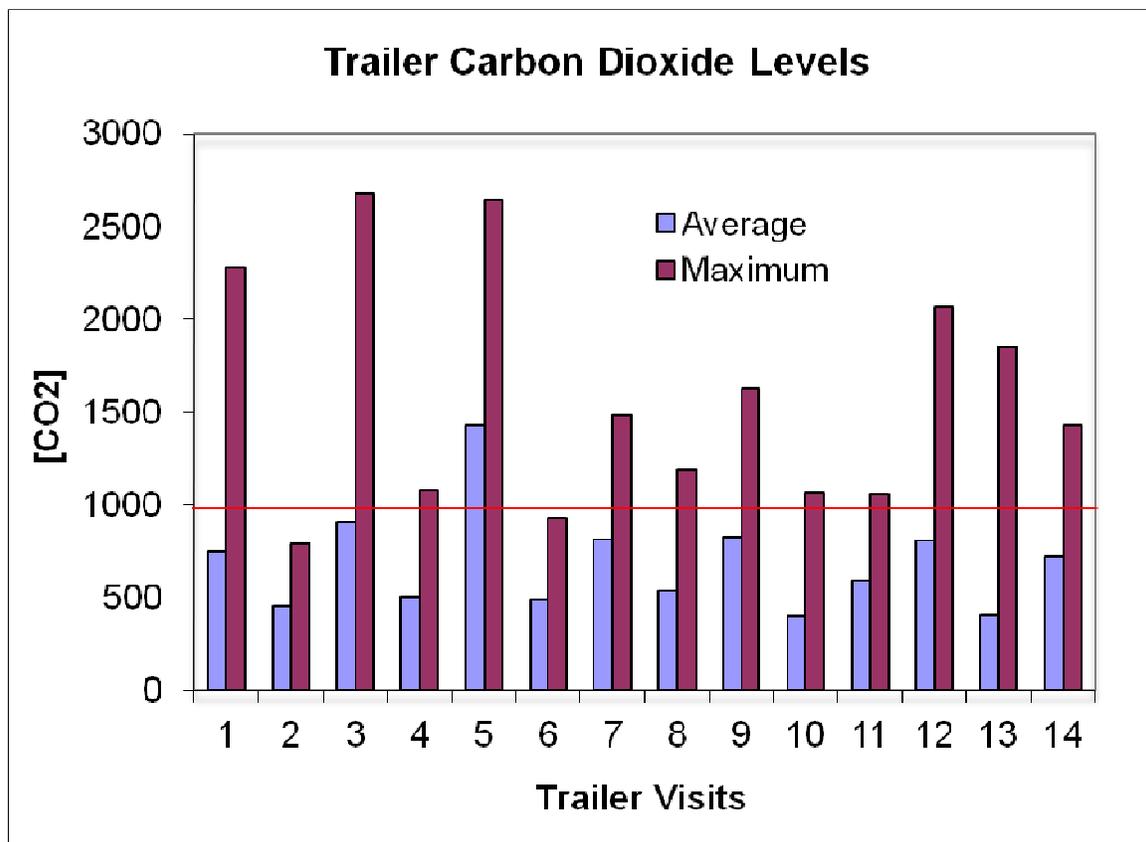


Fig 1. Bar graphs of trailer carbon dioxide levels for each trailer visit. The red line represents the 1000 ppm CO₂ indicator of sufficient ventilation. Blue bars represent the values averaged over the entire visit, purples represent the peak value recorded.

The CO₂ average level for the 14 trailer visits was 690 ppm, while the average of the peak values experienced during each visit was 1585 ppm (Table 5). Higher levels were associated with increased number of occupants and open or closed status of the doors and windows. This indicates that many trailers in the industry experience a substantially insufficient supply of outdoor air for short periods of time daily. 17% of total sampling time observed insufficient ventilation as indicated by CO₂ levels above 1000 ppm.

Table 5. CO₂ Trailer Levels.

Trailer Visit	Sampling Duration (hh:mm)	Average CO2 (ppm)	Maximum CO2 (ppm)	Standard Deviation	Time above 1000 ppm CO2 (hh:mm)	% Time above 1000 ppm CO2
1	5:16	752	2284	416	0:49	23%
2	4:38	458	790	85	0:00	0
3	4:31	914	2677	587	1:11	26%
4	5:09	505	1081	60	0:10	~0%
5	9:21	1431	2641	476	7:15	76%
6	6:07	488	928	103	0:00	0%
7	4:10	816	1487	328	1:30	36%
8	11:30	539	1187	116	0:02	~0%
9	9:37	826	1632	352	2:41	28%
10	7:50	399	1069	178	0:15	3%
11	11:41	595	1063	165	0:12	1.7%
12	13:20	810	2070	454	4:11	31%
13	13:27	406	1850	214	0:27	3.3%
14	7:10:00	721	1429	398	1:06	15%
Average	8:07	690	1585	281	1:24	17%

Carbon Monoxide

All trailers monitored experienced average and maximum area sample levels below WorkSafeBC personal exposure 8 hour TWAs and 15 minute STELs (Fig 2). Average values represent exposure over an entire working day and are therefore better compared to the WSBC 8 hr TWA (**lower blue line**), while maximum values represent brief periods of exposure that are better compared to the WSBC 15 min STEL (**upper red line**).

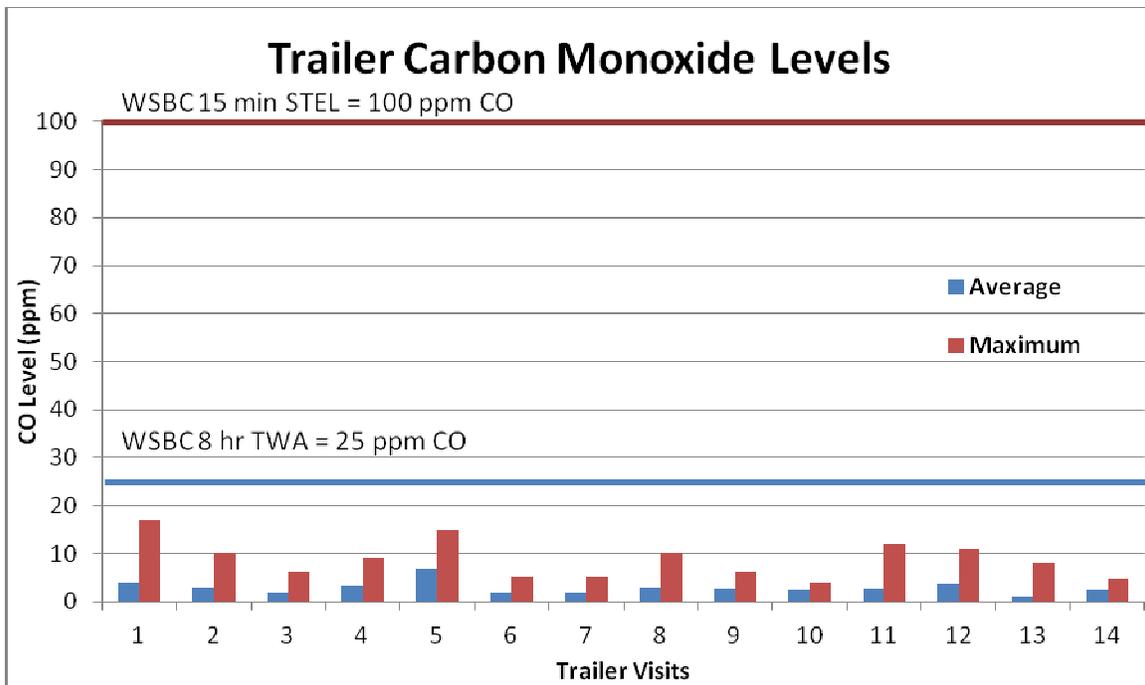


Fig 2. Bar graph of trailer carbon monoxide levels. Blue bars indicate daily values averaged over the entire sampling day for the trailer. Red bars indicate the maximum daily value recorded during the trailer visit.

The CO average area sample for the 14 trailer visits was 3.0 ppm which is comparable to outdoor ambient levels and is below the 25 ppm 8 hr TWA (Table 6). The average maximum values in each trailer was 8.8 ppm, This is below the 100 ppm 15 minute STEL, but does indicate nearby sources of carbon monoxide, from where the gas can enter the trailer working environment.

Table 6. CO Trailer Levels

Trailer Visit	Sampling Duration (hh:mm)	Average CO (ppm)	Maximum CO (ppm)	Standard Deviation
1	5:16	4.1	17.4	4.0
2	4:38	3.2	10.0	1.8
3	4:31	2.0	6.5	1.2
4	5:09	3.3	9.1	1.6
5	9:21	7.3	15.0	2.9
6	6:07	2.1	5.3	0.9
7	4:10	2.2	5.2	1.2
8	11:30	3.0	10.1	2.4
9	9:37	2.8	6.4	1.9
10	7:50	2.4	4.5	0.8
11	11:41	2.7	12.1	1.2
12	13:20	3.7	11.4	2.5
13	13:27	1.2	7.9	2.2
14	7:10	2.5	4.8	1.3
Total	8:07	3.0	8.8	1.9

VOCs

Average VOC levels for 4 of the 15 trailers were above 3 ppm, while all trailers experienced maximum readings above 0.3 ppm (Fig 3).

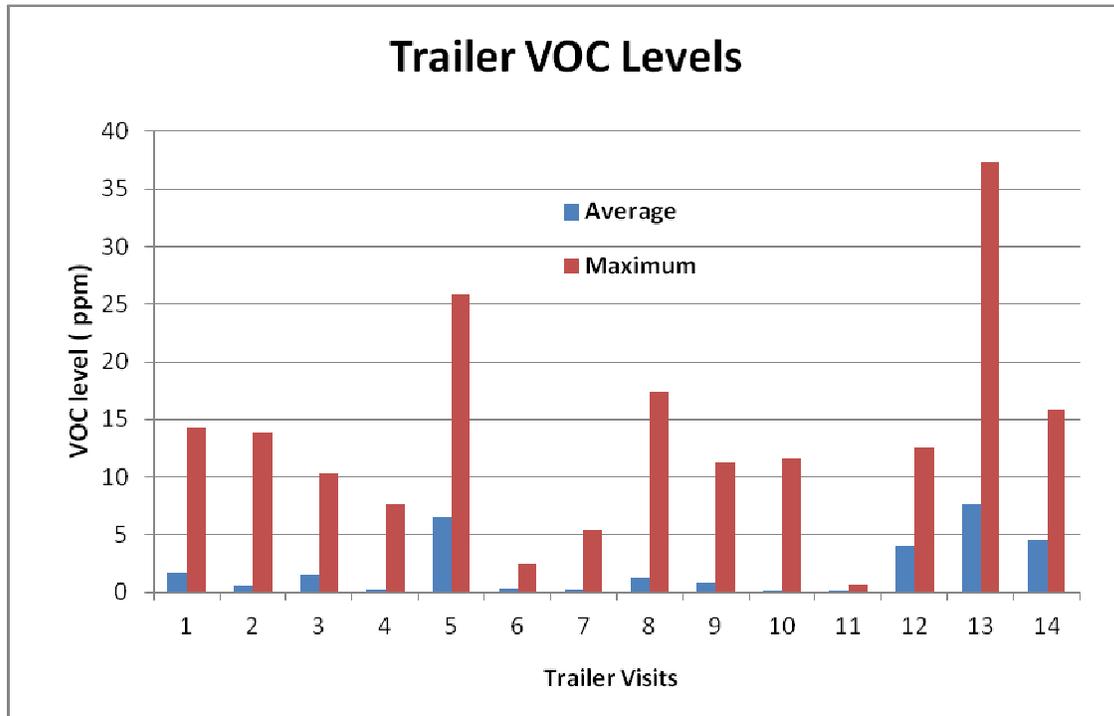


Fig 3. Bar graph of trailer VOC levels. Blue bars indicate daily values averaged over the entire sampling day for the trailer. Red bars indicate the maximum daily value recorded during the trailer visit.

The overall VOC average area sample for the 14 trailer visits was 2.1 ppm (Table 7). The average of the maximum value for all trailers was 13.3 ppm. Both represent concentrations higher than outdoor levels and European guidelines.

Table 7. Trailer VOC Levels

Trailer Visit	Sampling Duration (hh:mm)	Average VOC (ppm)	Maximum VOC (ppm)	Standard Deviation
1	5:16	1.70	14.3	3.2
2	4:38	0.63	13.8	1.71
3	4:31	1.60	10.3	1.51
4	5:09	0.22	7.6	0.77
5	9:21	6.50	25.9	4.46
6	6:07	0.34	2.5	0.52
7	4:10	0.31	5.4	0.5
8	11:30	1.28	17.3	2.3
9	9:37	0.76	11.3	1.22
10	7:50	0.10	11.6	1.7
11	11:41	0.01	0.7	0.06
12	13:20	3.96	12.6	3.07
13	13:27	7.69	37.3	8.45
14	7:10	4.5	15.8	3.56
Total	8:07	2.11	13.3	2.36

In addition, three trailers before day shoots were monitored during the first opening of the doors in the morning by transport workers. VOC levels and the introduction of fresh air over time were monitored. Overnight the trailer is unoccupied, however, potential sources of VOCs include volatilization of hair and makeup products kept within the trailer and products used in the construction of the trailer itself. As fresh air was introduced to the trailer through the open doors, total VOCs took 57 minutes to reach levels comparable to outdoor levels in one 40 foot trailer, and 60 minutes in a 36 ft trailer (Fig 4). In a third 37 ft, single door trailer, no build-up of VOCs was observed and no period of opening time was necessary to reach levels comparable to outdoors. The cause of this variation was not determined, however, the products stored, the effectiveness of the product seal, and the age and construction materials of the trailers are likely contributing factors.

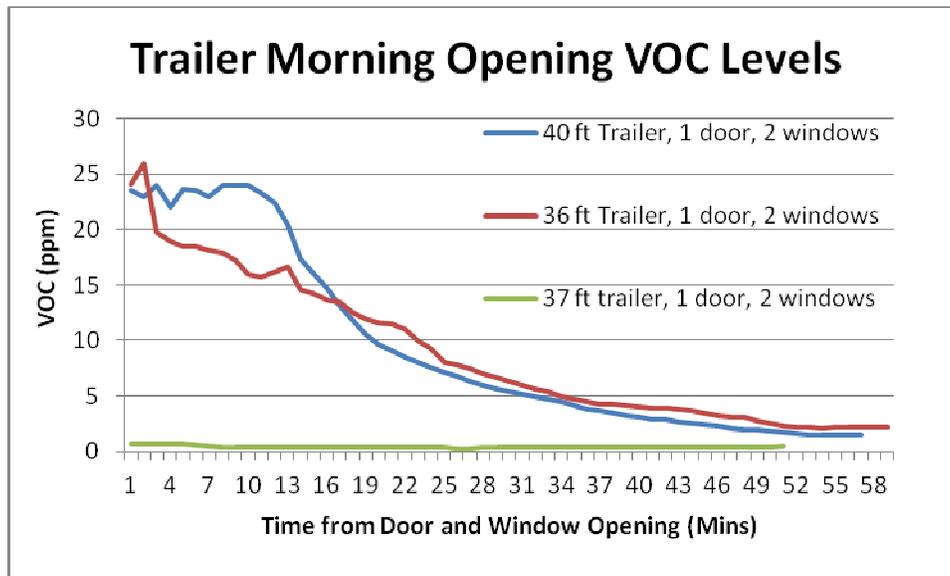


Fig 4. Line plot of VOC levels during the initial opening of 3 trailers in the morning for day shoots.

Relative Humidity and Temperature

Average relative humidity and temperature for all trailers monitored were within regulatory comfort guidelines (Appendix 1).

Discussion:

Trailer ventilation was seen to vary widely from highly effective to insufficient. Trailers relying upon natural ventilation were frequently observed to provide adequate outdoor air when doors and windows remained opened, as indicated by CO₂ levels well below the 1000 ppm threshold. All trailers, from large (40+ ft) with 1 door to small trailers (30 ft) with 2 doors, generally saw CO₂ levels comparable to outdoor levels in this case. However, when doors and windows were closed, dilution of trailer air with fresh air was effectively eliminated as indicated by accumulating CO₂ and VOC levels. Only upon opening of the door(s) were levels seen to begin decreasing to ambient conditions.

This is a concern because for a large portion of the year hair and makeup workers must keep doors and windows closed for reasons such as inclement weather, cold temperatures, lighting issues and general cast comfort. Workers reported conditions necessitated the door(s)/window(s) of the trailer to be closed 60-70% of the year.

For trailers with minimal airbrushing or aerosol spraying this is a concern of comfort, with poor indoor air quality potentially impacting workers through increased fatigue, irritation and a general feeling of 'stale' air. For productions with substantial airbrushing or aerosol spraying, the concern is of particulate and chemical exposure. Airbrushing and aerosol spraying were associated with increased total VOC levels.

Application of paint or makeup products to actors via airbrushing in trailers is a task unique to the industry. During airbrushing, paints must be thinned with solvents before they can be aerosolized: use of isopropanol (99% alcohol), octamethylcyclotetrasiloxane (244 fluid) and water were observed as standard thinners in the industry. Airbrushing pushes both these carriers and the pigments into the air where they can be inhaled by the makeup worker, cast member or anyone else in the trailer. This increases the level of airborne particulates and VOCs in the air. Prolonged inhalation of particulate generated by the airbrushes poses a risk to health, potentially causing respiratory irritation and pulmonary tissue damage.

In the single prosthetics trailer monitored, the observed issues of increased VOC levels appear compounded, as all stations possessed and operated airbrushes. This airbrushing combined with use of aerosol sprays is believed to be the cause of the highest average and maximum level of VOCs that was observed in the study. Natural ventilation in the trailer appeared effective with CO₂ average levels observed at 406 ppm, however, the highest VOC average levels of the study at 7.8 ppm were registered. This clearly indicates that relying on natural ventilation to control the bursts of high concentrations of VOCs created by the use of airbrushes and aerosol sprays is insufficient.

Many of products used in the trailers are highly volatile, and the trailers were seen to be small workplaces with periods of inadequate fresh air that may serve to exacerbate airborne chemical levels. The fact that cosmetic products are limited in their regulation contributes to inadequate product labelling and limited safety information for hair and makeup professionals, which may in turn lead to higher exposure through inappropriate use. Furthermore, the presence of numerous chemical compounds in trailers is likely to be continuous and mixed, the synergistic and chronic effects of which are largely unknown. Low exposure levels for individual compounds have been established in related fields, but multiple chemicals and multiple routes of exposure (inhalation, skin absorption and ingestion) combined with the inadequate ventilation underscore the value to be gained from assessment of the department.

Recommendations

Employer (Production)

1. When CO₂ levels are above the guideline of 1000 ppm or VOC average levels are above outdoor conditions, it is recommended that trailers receive regular air exchanges with 100% fresh air to ensure the removal of indoor air contaminants. Achieving this strictly through dilution ventilation (opening of doors/windows) was not found to be consistently possible or practicable in this study. Use of mechanical or local exhaust ventilation are possible solutions.
2. In trailers where one or more airbrushes are consistently used, local exhaust ventilation is highly recommended as prolonged exposure to the aerosolized particulate can cause respiratory irritation and chronic pulmonary tissue damage. In addition, exposure to the two most commonly used thinners, isopropyl alcohol and 244 fluid, can cause eye, skin and respiratory tract irritation – both MSDSs recommend use with local exhaust ventilation.

- Permanent solutions include use of trailers with exhaust hoods or downdraft vents. When this is not practicable, temporary solutions include using portable exhaust fans set up next to airbrush or aerosol spraying stations that exhaust to the outside through flexible ducting.

3. Opening of standard and prosthetic trailer doors before the initiation of a shooting day for a minimum of 1 hour prior to worker entrance is recommended as a precautionary action. Monitoring of initial morning openings found that trailers in which VOCs had built-up from offgassing during non working hours took a minimum of 1 hour to reach average levels.

- Minimum airing out periods will clearly vary according to trailer construction materials, trailer size, opening sizes and products contained.

4. Ensure that air conditioning and ventilation systems in the trailers are regularly maintained, in particular the cleaning and replacing of filters.

- As per Section 4.78 Preventative maintenance in the OHS regulation.

5. Hair and makeup products are generally perceived as benign and unregulated, however controlled substances under WHMIS are used in the trailers. Knowledge of health effects and methods of controls for each product is crucial in protecting worker health. It is recommended that MSDSs are provided for all such products. Common examples include, isopropanol (99% alcohol), ethanol (70% alcohol) and ethanol with a denaturing agent (SD alcohol 40).

- As per Section 5.16(1) in the OHS regulation, an employer must ensure that a copy of an MSDS required by sections 5.14 or 5.15 is made readily available

Supervisor (HODs or Keys)

1. Health and safety orientations of all individuals to each new trailer as they move between productions. Of particular importance is the controls of the ventilation system if it is present, such as the use of extractors below station tables or downdraft vents – even experienced workers were occasionally observed to be unfamiliar with the controls. Removal of contaminants is crucial for worker health, but won't be effective if it is not used properly and consistently.

- As per WSBC section 3.23(1) an employer must ensure that before a young or new worker begins work in a workplace, the young or new worker is given health and safety orientation and training specific to that young or new worker's workplace.

2. Request MSDSs for cosmetic products. Cosmetic products do not require MSDSs, however some manufacturers will still provide them. It is encouraged for workers to show a strong preference for products that supply them. Increased ingredient transparency and accountability from the manufacturers will help give workers the knowledge to use hair and makeup products safely.

- Sections 2, 4 and 8 of the 16 section format MSDS (Potential Health Effects, First Aid Measures and Exposure Controls/Personal Protection), in the investigators

opinion, provide the most relevant and readable information for hair and makeup worker health.

Workers (1st Assistant, 2nd Assistant, Day Calls) See Appendix 2 for Airbrushing Tips

1. Minimize the usage of temporary colouring hair sprays as much as possible as they contain products that can cause mild to moderate irritation of the eyes, skin and respiratory tract. The desired effects can be achieved with topically applied products.
2. To reduce VOC levels from offgassing, ensure all hair and makeup products in the trailer are securely capped, and cleanup is prompt when work with actors is finished. See Appendix 2 for airbrushing best practices.
3. Remove obstructions from air condition and ventilation systems. Hair and makeup workers must make the most out of working in tight confines in the trailers, however these systems are greatly reduced in efficiency when they are obstructed by equipment placed in front of or on top of air intakes or discharge points.

Limitations:

Trailer visits were not randomized, but were dependent on permission from production offices and hair or makeup heads of department, as well as busyness of the shooting schedule. In addition, the majority of days sampled were reported as lower than average level of activity days in the trailer. As a result, gas concentrations in the trailers monitored may not be representative of all trailers industry wide during the summer in Vancouver, and may underestimate gas concentrations.

Future studies should randomly assess indoor air quality of the trailers to capture a representative number of slow, medium and high work activity days. Sampling in the winter would provide data for comparison to the summer values. Winter VOC levels are anticipated to be greater, and fresh air exchange to be lower, due to the decreased ability of workers to maintain doors and windows open. Within trailer variation was not effectively assessed in this study, as the majority of trailers were monitored for a single day.

Access for monitoring only one prosthetic trailer was gained. These trailers appear at highest risk for poor indoor air quality. Personal sampling in additional prosthetic trailers for particulate and specific exposures arising out of airbrushing with alcohol or silicone thinners is recommended now that it is established VOCs can offgas in the trailers.

Acknowledgements

I would like to sincerely thank Dawn Brennan, General Manager of ActSafe for the opportunity to work in this fascinating industry. I would also like to thank Marty Clausen, the health and safety consultant for showing me the ropes, along with the rest of the Actsafe staff for their support. Thanks to UBC faculty advisor Karen Bartlett for providing continual feedback during the placement, and to Jeff Nichol and Winnie Chu

for laboratory support. Finally thanks to all the production companies and kind hair and makeup professionals for allowing me to conduct the research.

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Appendix 1 – Relative and Humidity Statistics

Trailer Visit	Sampling Duration (hh:mm)	Temperature (°C)			Relative Humidity (%)		
		Avg	Min	Max	Avg	Min	Max
1	5:16	25.7	20.6	28.8	29.7	22.9	46.5
2	4:38	25.7	19.4	27.9	48.5	42.7	76.4
3	4:31	26.1	20.6	28.5	46.4	40.8	70
4	5:09	23.2	19.3	43.4	54.5	44.7	69.2

5	9:21	23.3	20.3	25.8	54.3	41.2	65.2
6	6:07	24.4	21.8	33.2	41.2	35.2	52.4
7	4:10	24.5	20.7	26.5	44.9	38.8	63.6
8	11:30	25	19.8	28.8	40.6	27.4	53.6
9	9:37	23.9	28.5	27	46.1	39	61.2
10	7:50	26.2	23	27.9	38.2	33.9	56.4
11	11:41	27.3	24.2	29.5	40.1	31.9	49.7
12	13:20	23.1	18.9	27.9	48.5	34	71.3
13	13:27	26.4	19.4	30.2	37.3	24.6	58.2
14	7:10	26	21.8	27.3	48	42.7	63.6
Total	8:07	25.06	21.31	29.48	44.16	35.70	61.24

Appendix 2 - Airbrushing Best Practices:

- Use the lowest pressure level possible to achieve the desired effect
 - The higher the pressure the smaller the aerosols created by the airbrush become, which poses a health risk for two reasons.
 1. Smaller droplets take longer to settle out of the air, and therefore have a greater likelihood of being inhaled.
 2. The smaller a droplet is the further it penetrates into the lungs, where it is more difficult for the body to eliminate particulate .
 - The higher the pressure the more paint ‘bounce back’ or overspray is created, resulting in less paint on the cast and more in the trailer air.
- Use an airbrush cleaning pot or cleaning station to minimize VOCs created in the trailer.
 - When cleaning the airbrush with alcohol or 244, spray the excess solvent into a cleaning pot, sometimes referred to as a cleaning station. The cleaning station has a filter system that helps to trap VOCs so they are not introduced into the trailer air.
- Use as little paint possible to achieve the desired effect.
 - Experienced airbrushers report being able to use less paint for the same effect: use double action airbrushes that enable greater control when the task allows.
- Use of paint products that can be thinned with water are recommended to achieve a desired effect whenever possible, as water is the most benign.
- If it is awkward to adjust the pressure on the regulator of the compressor, and the compressor can’t be moved, consider substituting for airbrushes that are now available equipped with a regulator built in near the front of the brush.
- When airbrushing with isopropanol (99% alcohol) or 244 fluid ensure there are no nearby ignition sources as both solvents are flammable.
- Above all, airbrushing, especially body spraying or other substantial spraying, should be undertaken in the presence local exhaust ventilation (ie extractors or downdraft vents).