School of Environmental Health, UBC

Wood dust, Formaldehyde and Noise Exposures in Vancouver Film Construction Shops

Summer Co-Op Term Report

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2010

Submitted to Dawn Brennan

Executive Summary

The primary objective of this summer Co-Op placement with the health and safety organization, Actsafe, was an Indoor Environmental Quality investigation and Noise evaluation of construction shops of film studios located in Vancouver. A questionnaire based survey was designed and data collected from construction shop workers about existing hygiene problems. Personal interviews were conducted to find out health symptoms that were potentially related to exposures at the workplace. Noise and wood dust were at the top of the hazard ranking process, thus selected for sampling. Formaldehyde was added to the sampling list because of symptoms reported by construction shop workers namely eye irritation, eye dryness, cough, skin irritation, which may have been related to formaldehyde exposure. Medium-density Fibreboard (MDF) was identified as a potential source of formaldehyde exposure.

The sampling strategy was a stratified convenient sampling that categorised workers from different construction shops into homogenous exposures groups: carpenters, metal fabricators, painters. Representative samples of identified exposure to these worker groups were taken from construction shops according to WorksafeBC guidelines and NIOSH methods. The number of workers sampled on a particular day ranged from 50% to all those working.

This hygiene investigation had a dual purpose: first, to find out the exposure levels for regulatory compliance purposes and second, to provide 2010 values for noise, wood dust and formaldehyde exposures because no previous evaluation data were available for these hazards in these construction shops. Personal samplers were used to measure individual exposure levels and the data thus collected were summarised to characterize group exposure levels.

70 % of noise measurements from carpenters (n=17) and 100 % from metal fabricators (n=3) were found to be out of compliance. Group noise exposure levels of carpenters (Lgroup = 86 dBA) and metal fabricators (Lgroup = 89 dBA) were over the WorksafeBC 8 hr-time weighted average (TWA) limit of 85 dBA. Formaldehyde concentrations (except one sample) were found to be within compliance levels. It must be noted that sampling was performed on less-than-average busy days; thus, a future comprehensive sampling, covering exposure variability among days, is needed for risk assessment with higher accuracy.

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I. Background on Actsafe

Actsafe (http://www.actsafe.ca/) was my employer for summer (2010) Co-Op term. Actsafe is a non-profit organisation dedicated to the promotion of health and safety in British Columbia's motion picture and performing arts industry. Its role is to provide arts workers and employees with the necessary support to ensure everyone is safe at the workplace. The Actsafe office is located in the city of Vancouver and is managed by staff comprising a General Manger, Creative Director, Office Manager, Outreach Director and a Health and Safety Consultant.

Actsafe is governed by the industry it represents. It operates through two standing committees that represent the motion picture and performing arts communities. Membership on these committees includes both employers and worker representatives from unions. Vancouver is known as Canada's 'Hollywood North' and has a vibrant film industry represented by huge film studios like Vancouver Film Studios, Bridge Studios, North Shore Studios and Mammoth studios amongst others.

Vancouver has been used as a filmmaking location for nearly a century, beginning with *The Cowpuncher's Glove* and *The Ship's husband*, both shot in 1910. British Columbia is the third largest centre for film and television production in North America. Apart from locations and facilities, BC has skilled crews, technicians and creative experts: Managers, painters, carpenters, heavy-machinery operators, metal workers, electricians, and artists that usually work 10 - 12 hour - 5 day shifts. According to BC Film Commission reports (7), in 2005 more than 200 productions were completed in BC that includes 63 feature films and 31 television series with film spending reaching at $ 1.2 billion in 2008.

According to a WorksafeBC reports (8), out of total 861 injury claims related to film and performing arts industry for the period 2005-2009, only **5** are related to toxic effects of gases, fumes or vapours inhalation and **2** are for high temperature exposure whereas the rest are safety related issues. Actsafe General Manager (Dawn Brennan) agrees that there is a strong possibility of a large number of hygiene related exposures going unreported. Occupational hygiene has not been at the core of Actsafe activities in past; however, now Actsafe is investing

resources to find out potential exposure hazards in the Film industry. This summer placement was one such step in the direction of identifying hazards in Film Construction shops. Actsafe expects to have some baseline data in place for noise, wood dust and formaldehyde exposure, from my project.

Actsafe Services

For workers in the motion picture or performing arts environment: Actsafe provides

Health and Safety Consultation for health and safety related questions or concerns.

Free Hearing Tests for workers in occupations deemed 'at risk' of noise induced hearing loss.

Free Respirator Fit Testing in situations where various air contaminants are present.

Safety Passport, Actsafe Safety Passport is a tool used by employers to verify certifications and identify workers who have the required health and safety training courses.

Industry Training, Actsafe offers training in the following courses

- Occupational First Aid Level 1
- WHIMIS (online)
- Film & Television Safety Awareness
- Performing Arts Supervisor Safety
- Transportation of Dangerous Goods (online)
- Introduction to Fall Projection
- Aerial Lift
- Counter Balanced Forklift

Ongoing Projects of Actsafe:

- Research and Development / Publications

  Stunt Safety, Actsafe is working with BC's stunt workers on issues related to fall protection and stunt safety.

Actsafe Forms, Actsafe offers a wide variety of OHS forms online for risk assessment and health and safety plans.

Posters, Actsafe produce industry specific posters addressing OHS issues. Available posters include emergency procedures, WHIMS, Fall Protection, Ladder safety, hearing conservation and safety in the sun.

- Communications / Promotions

  General promotion, Actsafe participates in Film and Performance industry trade shows and conferences and speaks to unions and various groups about related safety issues.

  Newsletters, Actsafe produces 9 newsletters a year and features health and safety issues of current interest.

  Website, Actsafe website is a great resource for film or performing arts worker or manager looking for current information on health and safety issues. The Actsafe online library is full of information on general safety issues encountered by industry.

II. Objectives

This project reports the investigation of construction shop worker's exposure to noise, wood dust and formaldehyde in local film studios. Comfort parameters: CO, CO_2, humidity, and temperature were recorded related to Indoor Environmental Quality. Actsafe is in the process of launching a Hearing Conservation program (HCP) in film construction shops and this study provides the 2010 measurements of individual and group noise exposures and compared to WorksafeBC compliance levels.

Formaldehyde exposure was suspected in shops from off-gassing from materials and wood dust originating from the commonly used medium-density fibre board (MDF) that is made using binder of formaldehyde resin. The target of formaldehyde sampling was to measure free concentration in air and formaldehyde in the wood dust - possibly released in the lung after wood dust is inhaled by shop workers.

This project was aimed to provide Actsafe with

1) Evaluation statistics for existing exposure levels of noise, inhalable wood dust and formaldehyde in construction shops. Data were representative for implementing appropriate controls.
2) Recommendations / Controls to bring the exposures within range as per the specification of regulatory authority, WorksafeBC.
3) Directions for future Industrial Hygiene investigations.

III. Rationale of Project

Hazards (Noise, Wood dust and Formaldehyde) investigated in this project were selected after site walkthrough and a questionnaire-based survey. Looking at the variety of worker complaints, it was decided to design a questionnaire and conduct interviews to collect information. A '4-page and 18-questions' survey titled 'Indoor Air Quality Survey' was designed

and data was collected from construction shop workers. Response to the survey was voluntary for workers.

'Q. 1 to 6' of the survey (Appendix III) referred to knowledge about Actsafe and bio-data of workers. Information about typical work-space and work-durations was collected in 'Q.7 to 10'. Response from 'Q. 11 to 16' were divided on a scale from -3 to +3 and workers were asked to rate Air Quality in their workplace. Information on existing noise levels was also collected. Under Q. 17, workers were asked about any existing health conditions or symptoms that get better when they are away from workplace. The last question was about worker's perception if the workplace air quality affects their work ability. Workers were asked for comments on any health and safety issue they thought was important in their workplace.

Results of the survey showed a higher level of dissatisfaction with Wood dust and Noise levels. A considerable percentage of workers reported Cough (29%), dry eyes (20%) and headache (14%) as workplace health symptoms; research in this direction found that construction shops use large amounts of Medium-density fibre (MDF) board. MDF is typically composed of 85-100% softwood and 0-15% hardwood (1). The urea-formaldehyde content of MDF board is normally 8-18 % and is 2-3 times higher than the normal particle board (6%) (4).

It was hypothesized that the upper respiratory tracts of workers might be receiving additional formaldehyde exposure from the deposition of formaldehyde containing wood dust particulate material in addition to the vapour phase formaldehyde that is possibly trapped inside particle board and released into air during wood-work in the construction shops. Moreover, Urea-Formaldehyde resin can also decompose to release formaldehyde due to heat generated during machining with tools.

Irritation of the eyes and respiratory tract are the first symptoms associated with formaldehyde exposure at concentrations ranging from 0.1 to 0.5 ppm (3), so formaldehyde was picked as third hazard for evaluation after Noise and Inhalable wood dust fraction. Wood dust in the construction shops is a mixture of airborne particulates from soft pine wood, MDF, Oriented Strand Board (OSB) and hardwood (Mahogany) ply. MDF is used to make shining walls in space-

ship shows, high-tech office and other science fiction location; OSB is used in deck and flooring while hardwood plywood is a favourable material for walls of film sets.

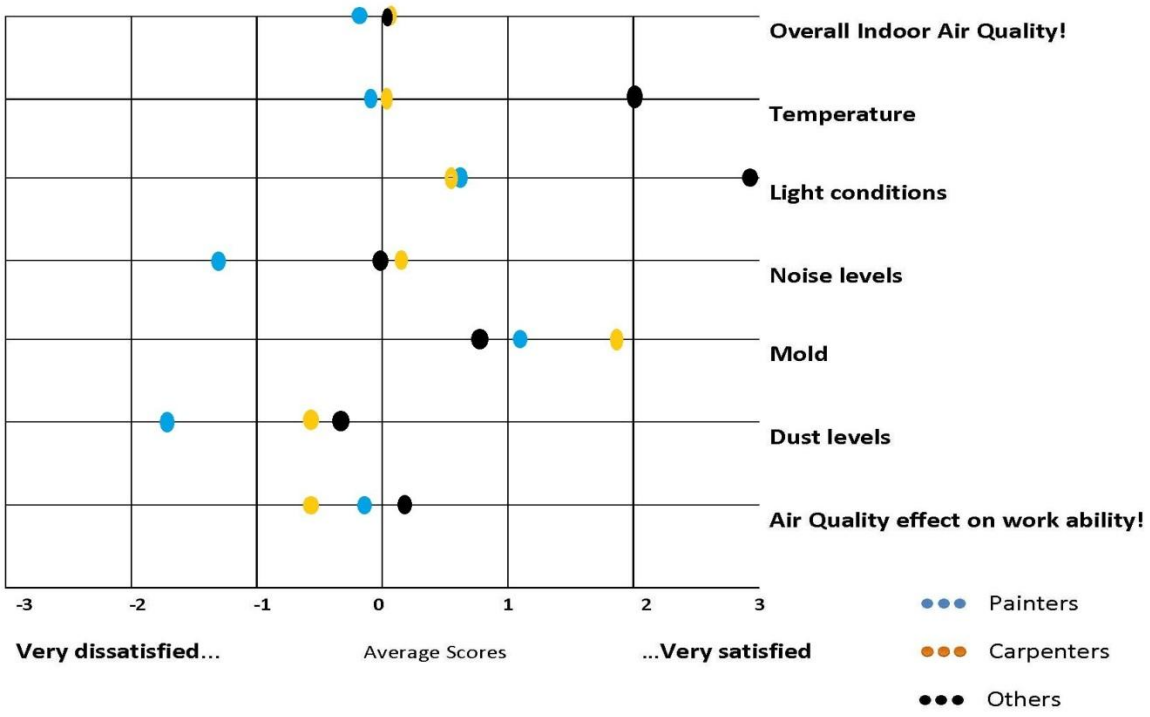


Fig. 1 Indoor Air Quality Survey (n= 34) at Film Studios (n=5) in Vancouver, May 2010

Apart from worker response to questionnaire, walkthrough observation of dusty shop conditions and overlapping of Formaldehyde and wood dust symptoms in workers formed base of the sampling plan; wood dust, with formaldehyde, can confound respiratory irritation and result in sensitization among exposed workers (3).

IV. Methods and materials

Sampling strategy: The goal of this project was to establish baseline exposure levels using personal monitoring methods and compare those with WorksafeBC compliance levels. There was no previous data available for the noise, wood dust levels or Formaldehyde exposure in construction shops. Three (3) high exposure occupational groups (HEG) were selected for sampling **:** carpenters, metal fabricators and painters; whereas, Cameramen, electricians,

assistant directors, actors and other set-crew were not on the sampling list because 1) they were not identified as high exposure group for the proposed hazards and 2) there were limitations associated with access to their work areas. The sampling days were dependent upon the studio permissions, availability to sample inside the construction shop for a particular day.

“Procedures for Measurement of Occupational Noise Exposure” (CSA Z107.56-94) was followed for group Noise Dosimetry. As given in the CSA standard, noise dosimeters were worn by a representative number of workers, calculate their group exposure and sample more workers, if needed, for the required precision. However, the study was expanded to sample a greater number of workers in more than one construction shop, even though CSA requirement might have been met after first round of sampling, mainly to look into noise variability present between different construction shops.

This approach was important, because the work intensity, as well as noise-dust-formaldehyde levels in construction shops, changes with each activity cycle which completes over a period of 30 days (TV shows) to 6 months (Feature Films). The only way to capture greater variability in a given time frame was to sample in shops which were in different phases of the activity cycle from “slow” to “busy” to “very busy”. The strategy was to collect a representative sample as in reality the same workers keep rotating between different construction shops. WorksafeBC instruction manual for “Noise Evaluation” was followed to collect all accessory information. Some direct observation and area noise sampling (Sound level Meter) was undertaken to measure octave band frequencies for characterisation of the noisy tasks and tools used in the construction shops.

NIOSH method 5700 was used for “gravimetric sampling” and “wood dust on formaldehyde” analysis. Sampling for free “formaldehyde” in the shop air was performed using calorimetric tubes as prescribed in NIOSH method 2016. Worker Exposure to formaldehyde concentrations was evaluated for combined concentrations of formaldehyde released by wood dust in laboratory conditions and free formaldehyde found in air. The mass of wood dust on individual samplers was used for inhalable dust concentrations. The sampling strategy did not

discriminate between the type and quantity of wood used in shop, but focused on the total dust produced in the shops that was being captured by samplers.

Sampling Devices: Airborne MDF board dust ,including other wood dust concentrations, were measured using 7–hole (SKC) personal dust samplers containing 25-mm, 5-µm pore size PVC filter and pumps (SKC) operating at flow rate of 2 L /min. Personal dust exposure samples were taken from workers' breathing zone. Filters were conditioned at 40 ± 5 % relative humidity, before and after sampling, for at least 48 hours to control humidity effects.

Gaseous formaldehyde concentration was found using DNPH (2, 4-dinitrophenylhydrazine) tubes (NIOSH method 2016); tubes were connected to SKC pumps running at 1.3 L /min flow rate. DNPH tubes were carried in an iced container at times other than sampling.

Q-track (TSI) air quality monitor was placed on a representative spot inside shop, data logging for the indoor air quality variables CO, CO_2, humidity and temperature was done; the last two parameters were essential to analyse the formaldehyde content of the wood dust. Spot checks for concentration of total volatile organic compounds (VOC's) was made using ppb-RAE (RAE systems).

CEL-350 dBadge dosimeters (Casella) were used for personal noise monitoring. WorksafeBC "Occupational Health and Safety Regulation" Part 7, Division-1 "Noise Manual" was followed to set up and operate dosimeters. WorksafeBC regulations follow CSA Standard Z107.56-94 and ANSI Standard S1.25-1991. Dosimeters were calibrated prior to sampling each day and set on the shoulders of workers facing upward, locked after start of data logging. Dosimeters were set to recommended WorksafeBC parameters for personal noise monitoring: *Weighting=A, Exchange rate=3dB, Time constant=slow, Criterion Level = 85dBA, Threshold level = off*. The Leq values as downloaded from noise badges were mathematically converted to Lex, 8hr TWA.

Area measurements for tools and tasks were completed using a Quest 2900 Integrating / logging Sound Level Meter. The SLM was calibrated every morning before sampling with integrated calibration tool kit. The SLM was used to characterise octave band frequencies of work tools used by carpenters and logged values at an averaging time constant of 1 second. The

SLM was kept at a distance 1 to 1.5 metres from noise source. Readings were also taken during breaks hours to find out baseline noise levels for each shop.

Sampling Information sheets were collected from workers at the end of shift in which they recorded their activities for the entire shift; also notes were taken for any special task that may influence result outcomes. Outlines of construction shops, location of tools were drawn.

Table 1. Table showing number of Samples, Workers, Trades and Construction shops

Similar Exposure Group (SEG)	Number of Construction Shops (ID)	Noise		Wood dust *		Free Formaldehyde*
		Workers (n)	Samples (personal) (n)	Workers (n)	Samples (personal) (n)	Samples (area) (n)
	5 = B, C, D, E, F	28	17	32	16	4
Metal Fabricators	**3**= A, E, F	4	3	0	0	0
Painters	4= A, B, C, D	1	1	4	2	2
Total		**33**	**21**	**36**	**18**	**6**

* *Wood dust and free Formaldehyde sampled on same day in same shops*

Sampling locations: The noise dose was measured in **5** construction shops located in 5 different film studios in Vancouver on various days of activity levels. Film Construction shops are huge buildings 10 to 20,000 square feet in size , have large areas designed for carpentry work and usually a small portion(2 to 3000 square feet) of the shop is left for metal fabrication and painting jobs. Except one, constructions shops used for wood dust and formaldehyde sampling

were the same as that for noise sampling. Personal noise samplers were used to record full shift noise dose (10 hours) in order to get a representative group noise dose (L_{group}). Wood dust and free formaldehyde sampling was done for half-shifts (5 hours) on carpenters and painters.

V. **Result, Noise:** As per CSA scheme, the results of individual noise Dosimetry on randomly selected representative number of "Carpenters" and "Metal Fabricators" gives:

Table 2. "Group Noise Exposure" Evaluation of Film Trades according to CSA Z107.56-06

Trade	Sample (Workers)	L group dBA	L C dBA	Precision (P) = L group - LC	Std. Dev.
1. Carpenters in 1st Shop	4 (6)	86.7	85	1.7 ≈ 2	0.96
Carpenters in 5 shops	17 (28)	86.3	85	1.3 ≈ 2	2.8
Result : Thus, Groups' mean Lex, 8hr for Carpenters is = 86 ± 2 dBA to 95 % confidence					
2.Metal Fabricators in 3 shops	3 (4)	88.6	85	3.6 ≈ 4	2.3
Result : Thus, Groups' mean Lex,8hr for Metal Fabricators is = 88 ± 4 dBA to 95 % confidence					

The group exposure levels in both "Carpenters" and "Metal Fabricators" were over WorksafeBC compliance levels of Lex, 8hr = 85 dBA (= Criterion Level or LC) ; thus, 12 out of 17 samples were out-of-compliance .One "Painter" badge gave noise dose = 82 dBA (Lex, 8hr).

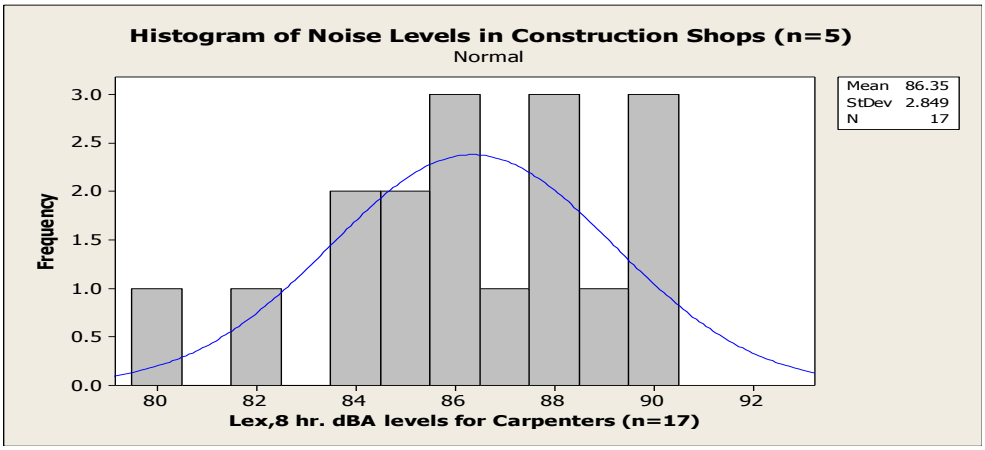


Figure 2. Histogram of Noise Levels (TWA) for Carpenters in Film Construction Shops.

Result, Formaldehyde:

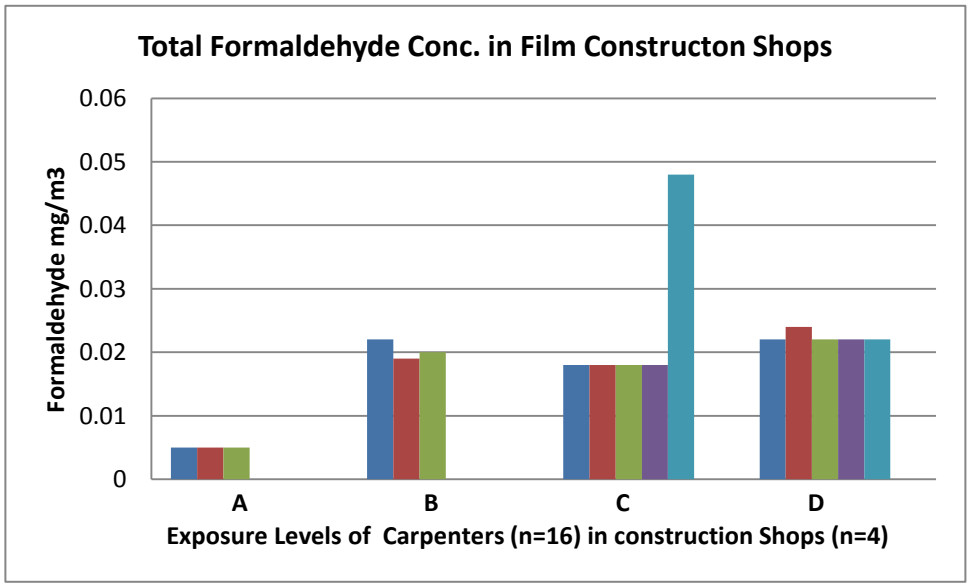


Figure 3. Histogram showing Total (Wood dust + Free Air) Formaldehyde levels

Total concentration of Formaldehyde in construction shop is constituted by free amount present in the air captured with sorbent tubes and the concentration of formaldehyde measured by extracting the dust sample in warm water (37^{o} C). Reported levels of Formaldehyde are in compliance with WorksafeBC Exposure Limit and ACGIH ceiling of 0.3 ppm 8 hr-TWA. Observed values are close (at and over) NIOSH Recommended Exposure Limit (REL) of 0.016 ppm 8 hr-TWA in three construction shops.

Table 3. Formaldehyde Exposure of Carpenters at Construction Shops (n=4)

Construction Shop ID	A	B	C	D	Average of All 4 shops
Average Conc. (ppm)	0.004	0.016	0.019	0.017	0.015
Average Conc. (mg/m^3)	0.005	0.020	0.024	0.022	0.019

WorksafeBC TWA for Formaldehyde = 0.3 ppm

Result, Gravimetric Wood dust:

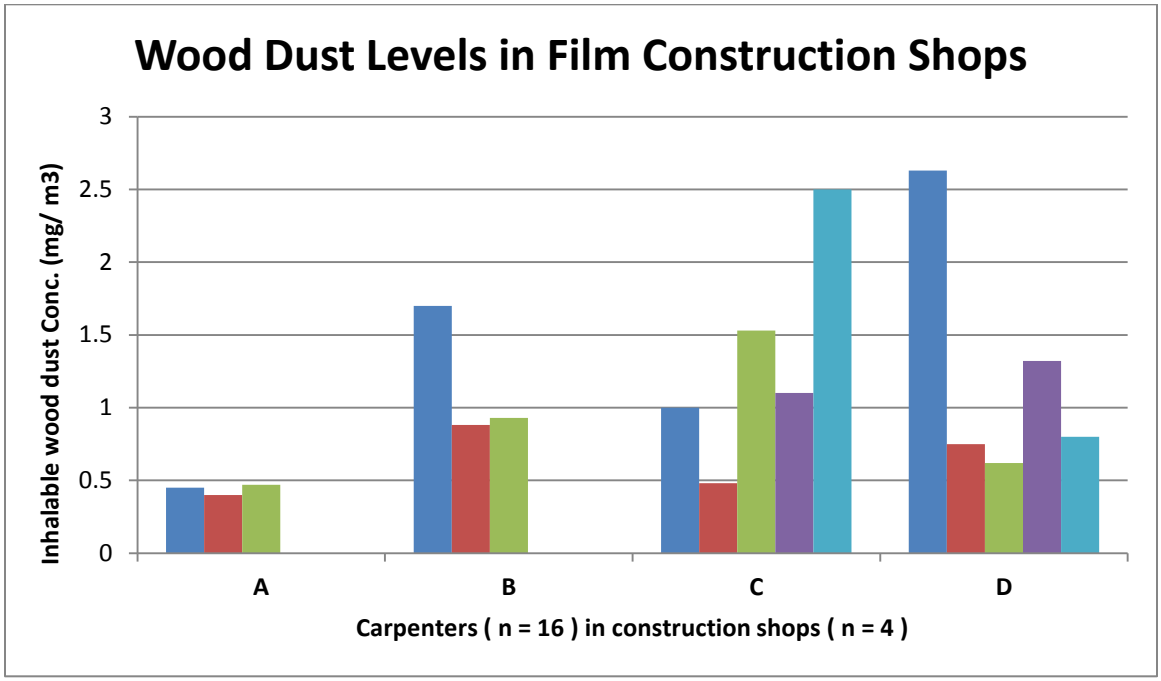


Figure 4. Histogram showing Wood Dust levels in Film Construction Shops.

Table 4.Wood Dust Exposure of Carpenters at Construction Shops (n=4)

Construction Shop ID	A	B	C	D	Average of all 4-shops
Average Conc. (mg/m3)	0.42	1.17	0.84	1.17	0.9

A direct comparison between wood dust sampling results and WorksafeBC TWA exposure levels (EL) is not possible because WorksafeBC exposure limits are different for Allergenic species and Non-allergenic Hardwood (1 mg/m^3) and Non-allergic softwood (2.5 mg/ m^3), whereas my sampled wood dust has all three of these mentioned in unknown fractions . However, taking a conservative approach for associated health outcomes and considering 1 mg/m^3 as exposure limit, 7 out of 16 carpenter samples were out of compliance.

According to information collected from workers, on average 40 % softwood, 40 % hardwood ply (mostly Mahogany), 15 % MDF and 5 % of paper based ply board and some plastic / flexi glass sheets are used in construction shops.

VI. Discussion Total Formaldehyde exposure levels found was lower than expected in all construction shops. Formaldehyde concentrations were observed in all 16 air samples, whereas only 4 wood dust samples showed some levels of formaldehyde that could be released at conditions similar to the human respiratory tract. One reason could be comparatively low use of MDF during sampling days, although MDF was found to be, more or less, used during all sampling days. Construction shop workers reported about days when they use MDF > 90 % of all other woods during a shift continuously for days, especially when the sets are being made for science fiction based feature or show.

The MDF supplier MSDS sheets (9) list 7-10% Urea-Formaldehyde content in the particle board, this content (plus other unknown source of formaldehyde) result in 0.015 ppm (average of all shops) formaldehyde exposure levels to construction shop workers. In my opinion, these levels are lower than actual average levels because most of my sampling days were of a minimum use of MDF board as none of the shops were constructing MDF based sets for science fiction. Workers informed me about fuming boards and plywood when supplies arrive in construction shops. Supplies were over a week old during the days of sampling. Supplies are dependent on the levels of activity going on in the construction shops and all sampling days were below average busy days, according to the perceptions/experience of shop workers.

All carpenters in a construction shop were found to be working on one or other wood type (including MDF) at one time or other during sampling. There are no specific tasks or jobs restricted for one type of carpenters, the lead carpenters provide directions to new ones for almost similar tasks they were doing, so it was hard to generalise differences in exposure levels among carpenters based on their activity. Some carpenters moved between shops and film sets; I could not identify other sources of formaldehyde emission on sets for them.

Chronic exposure to wood dust has been reported to result in allergic reactions, chronic respiratory disease, and nasal-sinus cancer; formaldehyde is also known to cause nasal cancer in rodents (2). Formaldehyde is known to cause eye and nasal irritation at concentrations exceeding 0.3 ppm, the concentrations found in this investigation are far below this level, yet 47% of construction workers reported some type of dry eyes/ irritation, cough or headache symptoms which are experienced at work only (3).

Inhalable wood dust captured by 7-hole sampler in this investigation represent levels of particulates that can settle anywhere along the respiratory tract of workers. European SCOEL recommends a health based exposure limit of 0.5 mg/m^3 for wood dust based on allergenic and non-allergenic respiratory manifestations (6), it becomes significant when 50% of collected wood dust samples show concentrations over 1 mg/m^3. According to information collected, 60% of the times wood other than softwood is used in the shops. The exposure levels of wood dust are thus capable of generating allergenic symptoms especially among health compromised workers, moreover when 57 % of surveyed workers belong to 41-60 years age group (According to IARC, Mahogany is a suspected human carcinogen-A2).

Almost all table saws in construction shops had either local exhaust hoods or inbuilt vacuum suctions to reduce wood dust emissions. One table saw per shop was found to be in use at a time during this sampling, however, wood dust levels can be perceived to be higher during busy or very busy periods when most of the tables are in use at a time. Carpenters were consistent in switching vacuum suction 'on', even while working on a table saw for shorter periods. Chop-saws also had local vacuum suction systems in all except one shop. Workers confirmed that wood dust levels corresponded to activity level in the shops, which was not high during this sampling.

70% of carpenters and 100% of sampled metal fabricators were found to be exposed to noise levels above compliance levels of WorksafeBC. Interestingly, the reported rate of noise, in survey, as a workplace problem was higher in painters compared to workers. One possible reason is that all carpenters use ear protection especially while working with noisy tools or noisy jobs whereas their poor cousin painters who work on the other side of a plywood

partition don't need ear protection for the type of tasks they do, eventually end up exposed to noise levels more than carpenters; one dosimeter on a painter recorded a significant (action level) sound pressure level of 82 dBA. About 95 % of carpenters used custom-made hearing protection devices that are known to provide better protection than ear plugs or muffs. 47 % of carpenters recorded noise peak levels over 140 dBC resulting mostly from working on one type of staple/nail guns. Carpenters in construction shops use these guns more frequently than any other tool because the film sets are structures of temporary nature that need joining wood pieces together to a particular shape or design. Staple / nail guns are most handy for the purpose and a repeated use of this tool is a necessary evil. Levels higher than recorded are expected during busy periods when 3 or more carpenters use these guns simultaneously.

VII. Recommendations:

1) **Eliminate use of pressurised air for cleaning gear, it generates additional airborne dusts.**

   Carpenters were found to use pressurised air to take dust off their clothes before breaks and at the end of the shift. This practice creates additional airborne inhalation hazard of the wood dust. Carpenters are advised to completely eliminate this practice.

2) **Substitute to Hand held sanders with inbuilt suction vacuum.**

   Hand held sander was observed to produce dust close to the inhalation zone of carpenters. Hand held sanders with in-built suction vacuum, available in market, should replace the existing sanders. This change can be brought in a phased manner.

3) **Substitution of old staple/nail guns by new less noisy versions.**

   Staple guns were measured to be main source of impulsive noise in the construction shops. Less noisy new versions of guns should replace the noisy old versions.

4) **Isolation of Planer and Table router, most noisy machines in shop, by noise barriers.**

   Planer and table router are main static sources of noise in a construction shop. These sources can be isolated by noise barriers. The shape, design and installation of noise barrier will be specific to the lay out of the shop. Professional advice for installation of acoustic enclosures is available.

5) **Isolate paint shop from construction shop by noise barriers.**

Painters have higher levels of dissatisfaction with the noise levels produced by carpenter tools. Paint shops were observed to be separated by barriers that do not stop the secondary noise exposure. Paint shops need to be isolated from the other construction shop by effective noise barriers to prevent noise leaks.

6) **Implementation of a Hearing Conservation Program for construction shops**.

   A hearing conservation program should be implemented at all construction shop with following elements:

   - Comprehensive and periodic sound survey
   - Engineering and administrative controls that may include acoustical modifications.
   - Worker education
   - Hearing protection devices
   - Audiometric monitoring of the workers

7) **Evaluation of dilution ventilation systems in construction shops.**

   Ventilation system of construction shops needs an evaluation for their efficiency if they provide enough dilution to keep the wood dust concentration below the exposure levels. Similarly, ventilation systems of paint shops and paint spray booths need an evaluation.

8) **Comprehensive survey of film construction workers for workplace health symptoms**.

   The survey designed for this project needs to be expanded to have a comprehensive outlook of the existing health symptoms in the workers.

9) **Substitution of formaldehyde containing MDF by non-formaldehyde MDF**.

   Formaldehyde containing MDF should replace by non-formaldehyde containing form of MDF which is available in the market.

10) **Evaluate exposure levels during glue (Sta'-put) application.**

    Construction shop workers were concerned about the use of sta'-put glue. It is a recognised respiratory irritant and may have a synergistic effect with wood dust and formaldehyde. It needs to be replaced.

VIII. Limitations

This sampling and analysis is entirely based on carpenters and painters working inside construction shops. They also work on film-sets for considerable periods of times but sampling was not done for film sets. It is possible that there are other significant sources of exposures on sets, not identified during this project, which may synergistically add-up to give similar health effect as formaldehyde. The number of carpenters working with staple guns is also higher on film-sets as it is final stage of object installation. In construction shops, painters are separated from carpenters by partitions but on sets they work next to each other where carpenters complain of cross-exposures from fuming paint materials, and painters of noise from tools like staple guns. Exposure on film sets could not be recorded and evaluated.

Our sampling days represent lower than average busy days of work in construction shops. Wood dust levels, as well as formaldehyde exposure levels, are probably higher than those identified by this investigation. In future, sampling can be done for a complete period of feature or show construction in one shop. It will definitely give better assessment of exposure levels.

Acknowledgements

My sincere thanks to

- **Catherine Roome** for her kindness and encouragement.
- **Dawn Brennan** for giving me an opportunity to work in Actsafe.
- **Marty Clausen** for taking me to studios and meeting with people from Film industry.
- **Maureen Kaake** for listening to my boring technical talks on Industrial Hygiene.
- **Ed Brisson** for entire computer and other support.
- **Cris Barzen and Winnie Chu** for laboratory support.
- **All Workers and Supervisors** in film construction shops.
- **And Dr. Karen Bartlett** for making this project possible.

References

1. Priha E, Pennanen S, Rantio T, Uitti J, Liesivuori J. Exposure to and acute Effects of Medium-Density Fiber Board Dust. Journal of Occupational and Environmental Hygiene 2004 Nov 1;11:738-744

2. Bender JH, Mullin LS, Graepel GJ, Wilson WE. Eye Irritation Response of Humans to Formaldehyde. Journal of American Industrial Hygiene Association. 1983 44:463-465

3. Ruth JH. Odor Threshold and Irritation level of Several Chemical Substances: A review. 1986. 47: A 142- A 151.

4. Chung KYK, Cuthbert RJ, Revell GS, Wassel SG, Summers N. A Study on Dust Emission, Particle size Distribution and Formaldehyde Concentration during Machining of Medium Density Fibreboard. Annals of Occupational Hygiene. 44; 6: 455-466.

5. Formaldehyde on Dust (Textile or Wood).NIOSH Manual of Analytical Methods (NMAM), Fourth Edition.1994

6. Scientific Committee on Occupational Exposure Limits (SCOEL): Recommendations from the Scientific Committee on Occupational Exposure Limits for Wood Dust. June 2002.

7. BC Film Commission. Reports. [Online]. [cited 2010 Oct 01]. Available from URL : http://www.bcfilmcommission.com/

8. WorkSafeBC. Statistics for Performing Arts and Film.[Online].2010.[cited 2010 Oct 01].Available from URL : http://www2.worksafebc.com/Portals/ArtsAndFilm/Statistics.asp

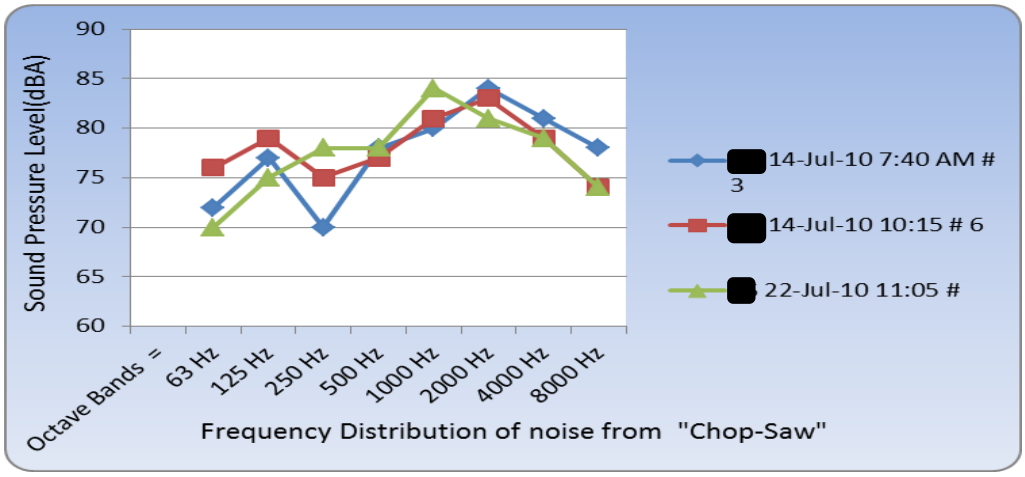
9. FIBERBOARD II. Material Safety Data Sheet. Glacier Green MDF. Plum Creek MDF, Inc. 265 Meadow Lake Blvd Columbia Falls, MT 59912.

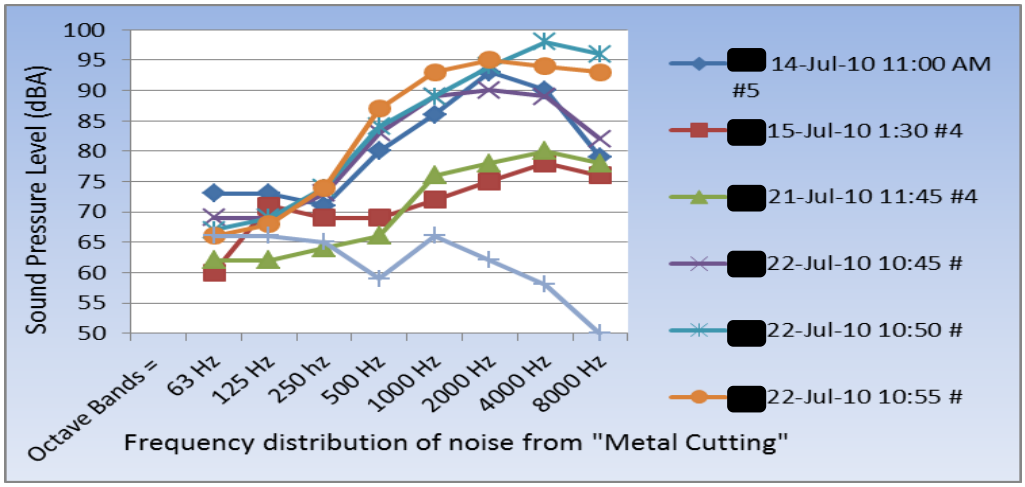
Appendix I

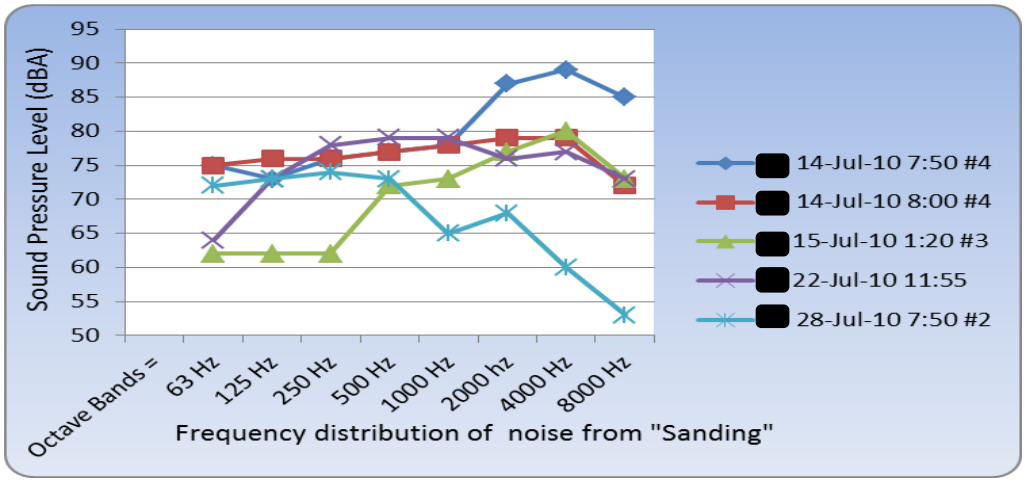
Table 5: Noise levels in Film Construction Shops

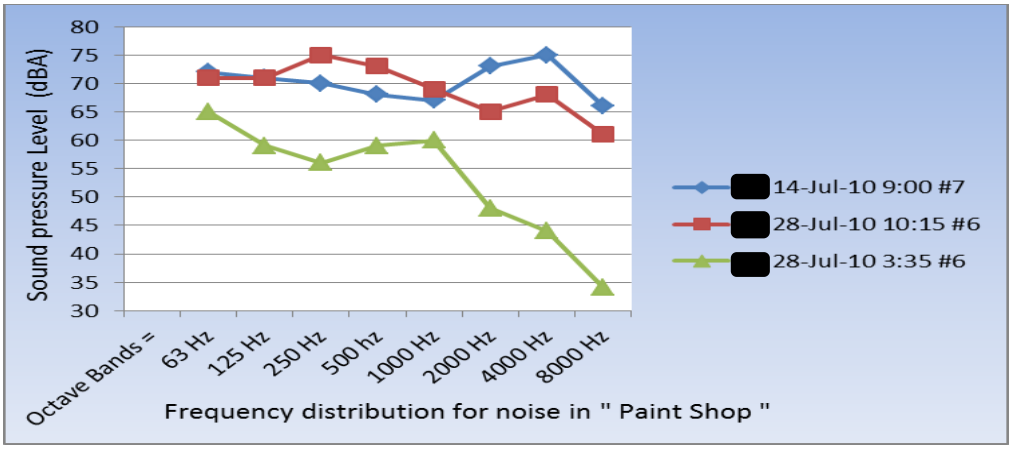
Similar Exposure Group	Worker ID	Samples	LA eq , dB(A)	Shift durtion (hours)	Lex, 8 hr dB(A)	Peak level dBC (max)	OK with BC Regs? Yes / No	L group
Carpenter	B-C1	17	87	10:33	88	139.5	N	86.3
	B-C2		85	9:40	86	139	N	
	B-C3		86	10:29	87	143.5	N	
	B-C5		85	9:41	86	137.3	N	
	E-C1		89	10:06	90	143.5	N	
	E-C3		83	9:58	84	134.5	Y	
	F-C1		84	10:12	85	143.1	N	
	F-C2		85	10:01	86	143.5	N	
	F-C3		81	10:11	82	139.6	Y	
	F-C5		79	10:22	80	128	Y	
	A-C1		87	10:29	88	137.1	N	
	A-C3		83	10:24	84	136.1	Y	
	A-C4		88	10:19	89	143.5	N	
	A-C5		89	10:11	90	143.5	N	
	C-C3		89	10:28	90	143.5	N	
	C-C4		84	10:22	85	138.4	N	
	C-C5		87	10:13	88	135.3	N	
Metal Fabricator	E-M2	3	89	10:07	90	135.8	N	88.6
	F-M4		85	10:00	86	131.1	N	
	A-M2		89	10:31	90	135.7	N	
Painter	B-P4	1	81	10:04	82	106.7	Y	

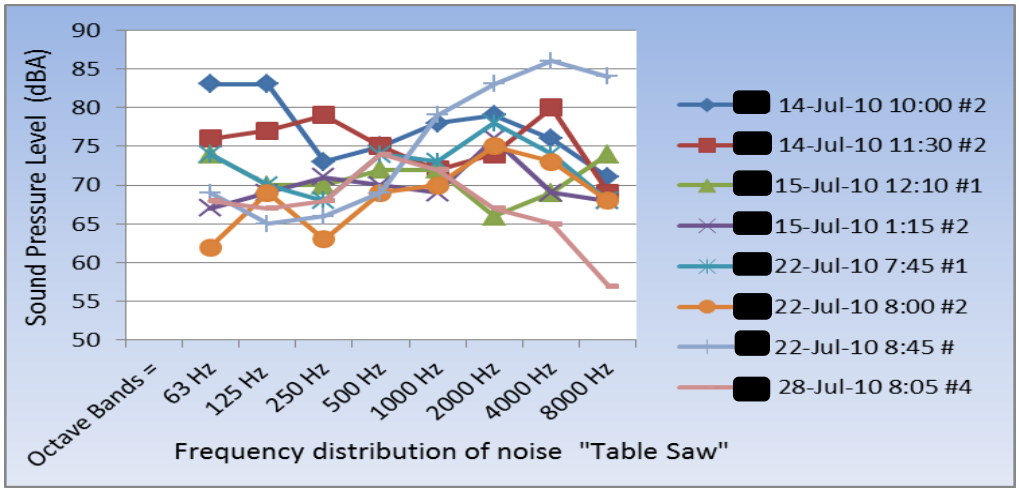
Figure 5. Noise Characterisation of Tools and Tasks in Construction Shops

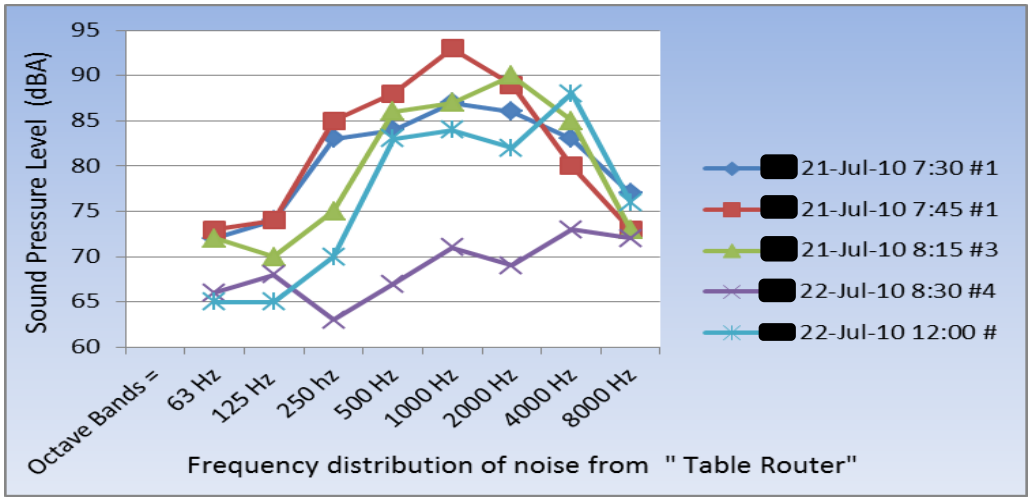


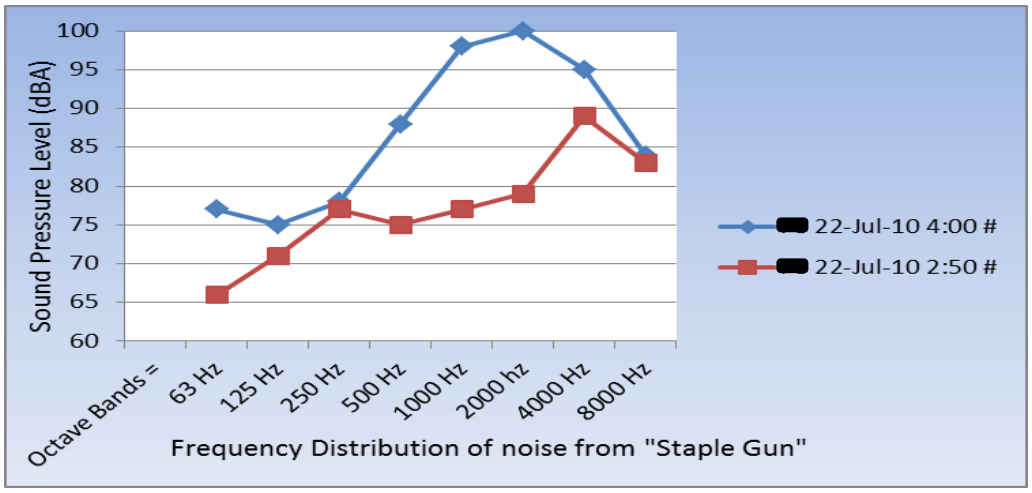



Sound Pressure Level (dBA)
95
90
85
80
75
70
65
60
55
50
Octave Bands =
63 Hz
125 Hz
250 Hz
500 Hz
1000 Hz
2000 hz
4000 Hz
8000 Hz
14-Jul-10 7:50 #4
14-Jul-10 8:00 #4
15-Jul-10 1:20 #3
22-Jul-10 11:55
28-Jul-10 7:50 #2
Frequency distribution of noise from "Sanding"


Sound pressure Level (dBA)
80
75
70
65
60
55
50
45
40
35
30
Octave Bands =
63 Hz
125 Hz
250 Hz
500 hz
1000 Hz
2000 Hz
4000 Hz
8000 Hz
14-Jul-10 9:00 #7
28-Jul-10 10:15 #6
28-Jul-10 3:35 #6
Frequency distribution for noise in " Paint Shop "


Sound Pressure Level (dBA)
90
85
80
75
70
65
60
55
50
Octave Bands =
63 Hz
125 Hz
250 Hz
500 Hz
1000 Hz
2000 Hz
4000 Hz
8000 Hz
14-Jul-10 10:00 #2
14-Jul-10 11:30 #2
15-Jul-10 12:10 #1
15-Jul-10 1:15 #2
22-Jul-10 7:45 #1
22-Jul-10 8:00 #2
22-Jul-10 8:45 #
28-Jul-10 8:05 #4
Frequency distribution of noise "Table Saw"


Sound Pressure Level (dBA)
95
90
85
80
75
70
65
60
Octave Bands =
63 Hz
125 Hz
250 hz
500 Hz
1000 Hz
2000 Hz
4000 Hz
8000 Hz
21-Jul-10 7:30 #1
21-Jul-10 7:45 #1
21-Jul-10 8:15 #3
22-Jul-10 8:30 #4
22-Jul-10 12:00 #
Frequency distribution of noise from " Table Router"


Sound Pressure Level (dBA)
100
95
90
85
80
75
70
65
60
Octave Bands =
63 Hz
125 Hz
250 Hz
500 Hz
1000 Hz
2000 hz
4000 Hz
8000 Hz
22-Jul-10 4:00 #
22-Jul-10 2:50 #
Frequency Distribution of noise from "Staple Gun"

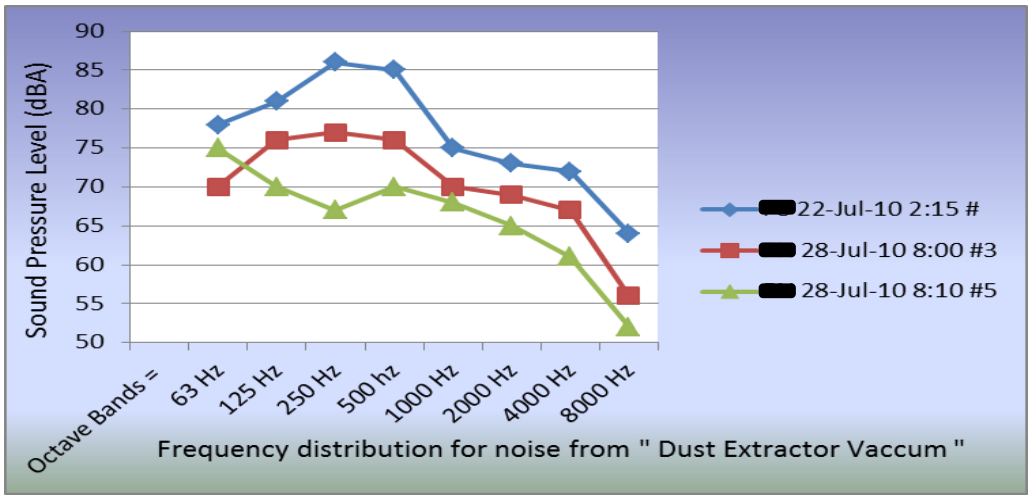

Sound Pressure Level (dBA)
90
85
80
75
70
65
60
55
50
Octave Bands =
63 Hz
125 Hz
250 Hz
500 Hz
1000 Hz
2000 Hz
4000 Hz
8000 Hz
22-Jul-10 2:15 #
28-Jul-10 8:00 #3
28-Jul-10 8:10 #5
Frequency distribution for noise from " Dust Extractor Vaccum "

Table 6. Peak Frequencies produced in Construction Shops by Tools / Tasks

Tool or Task	1/1 Octave Band (Hz)			Observed Peaks (Hz)
	Lower	Centre	Upper	
Chop Saw	2800	**4000**	5600	3000
Metal Cutting	5600	**8000**	11200	6000
Sanding	5600	**8000**	11200	6000
Table Saw I	180	**250**	355	200
Table Saw II	5600	**8000**	11200	6000
Table Router	1400	**2000**	2800	1500
Staple Gun	2800	**4000**	5600	3000
Dust Extractor Vacuum	180	**250**	355	250

Surveyed using Sound Level Meter (SLM)

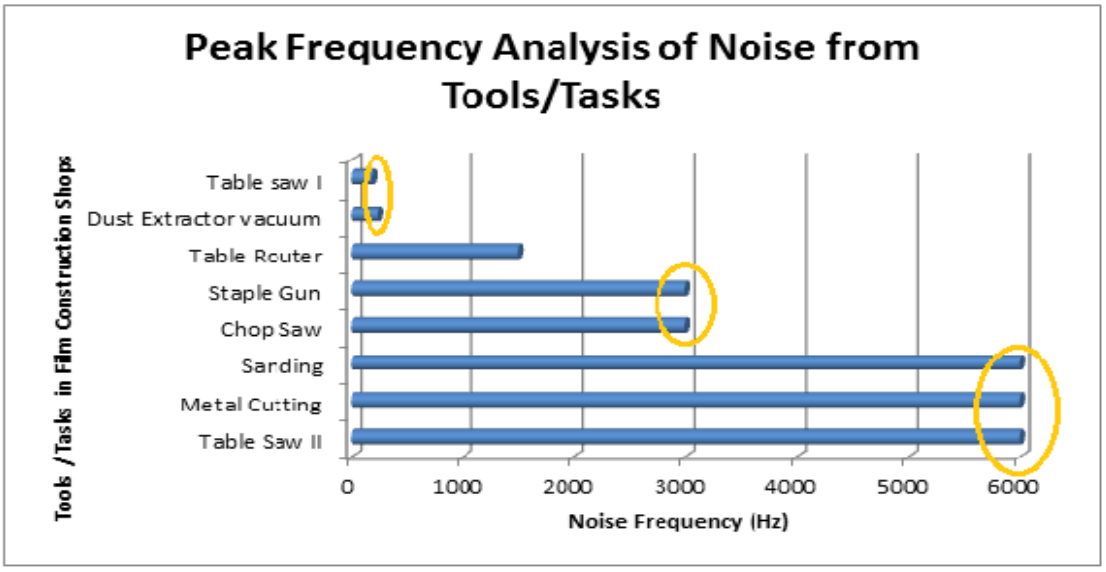


Figure 6. Frequencies Analysis by Sound Level meter for Tools / Tasks in Construction Shops

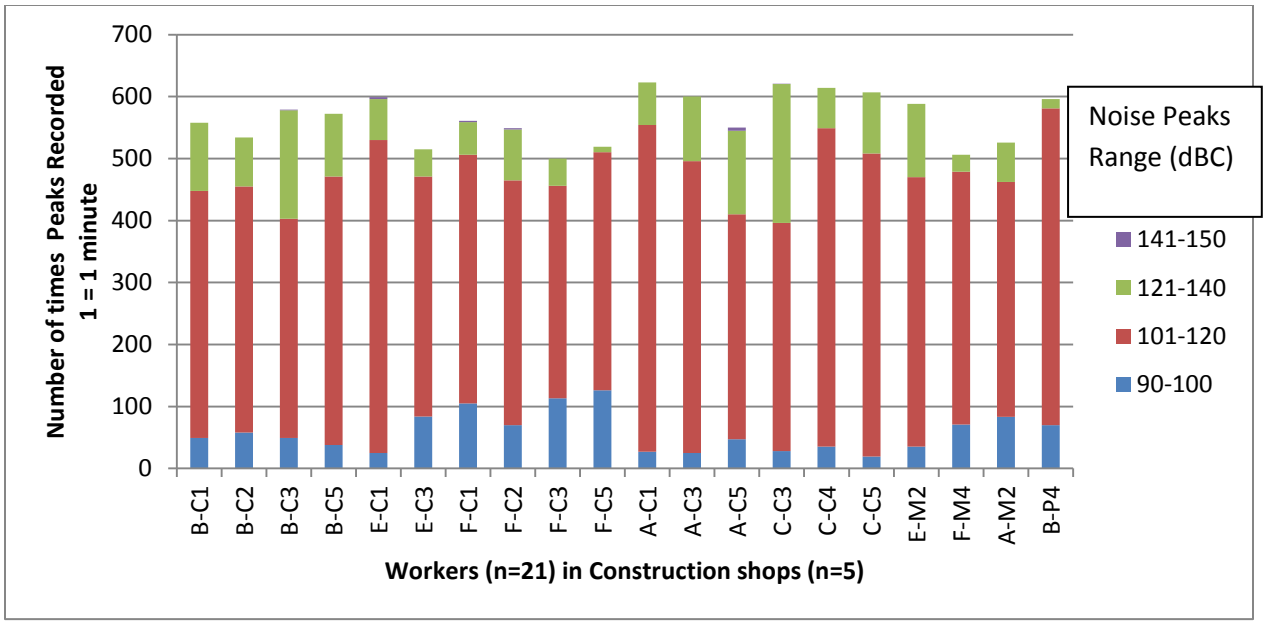


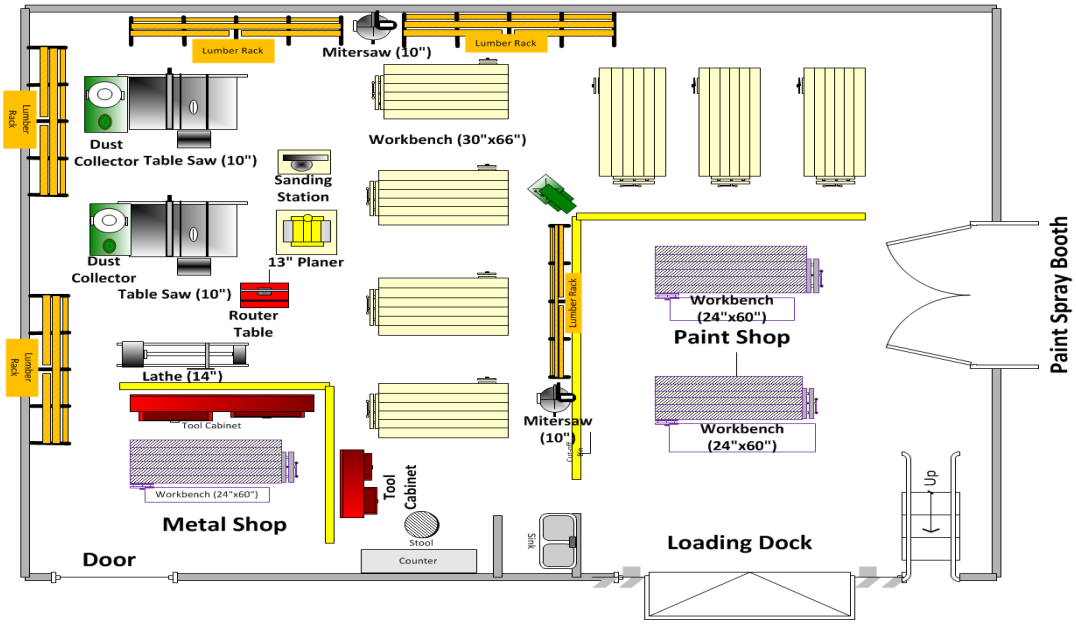
Figure 7. Range of Noise peaks (dBC) recorded by Construction Workers for full-shift

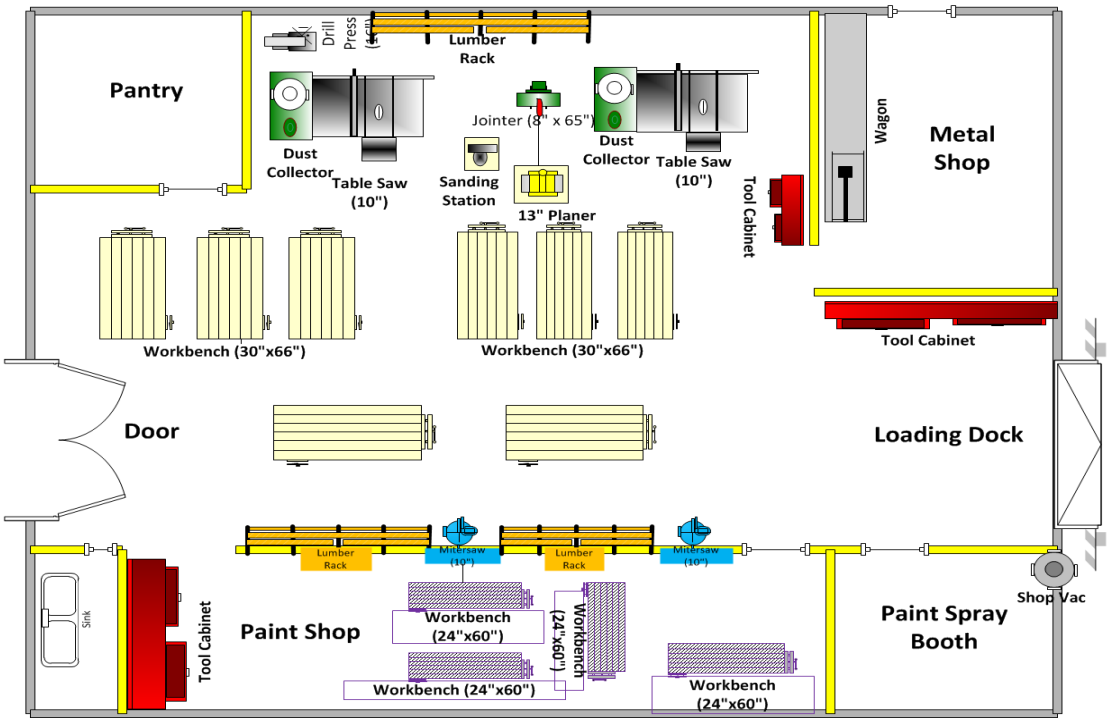
Table 7. Table showing Noise Peaks (dBC) ranges for Construction Workers

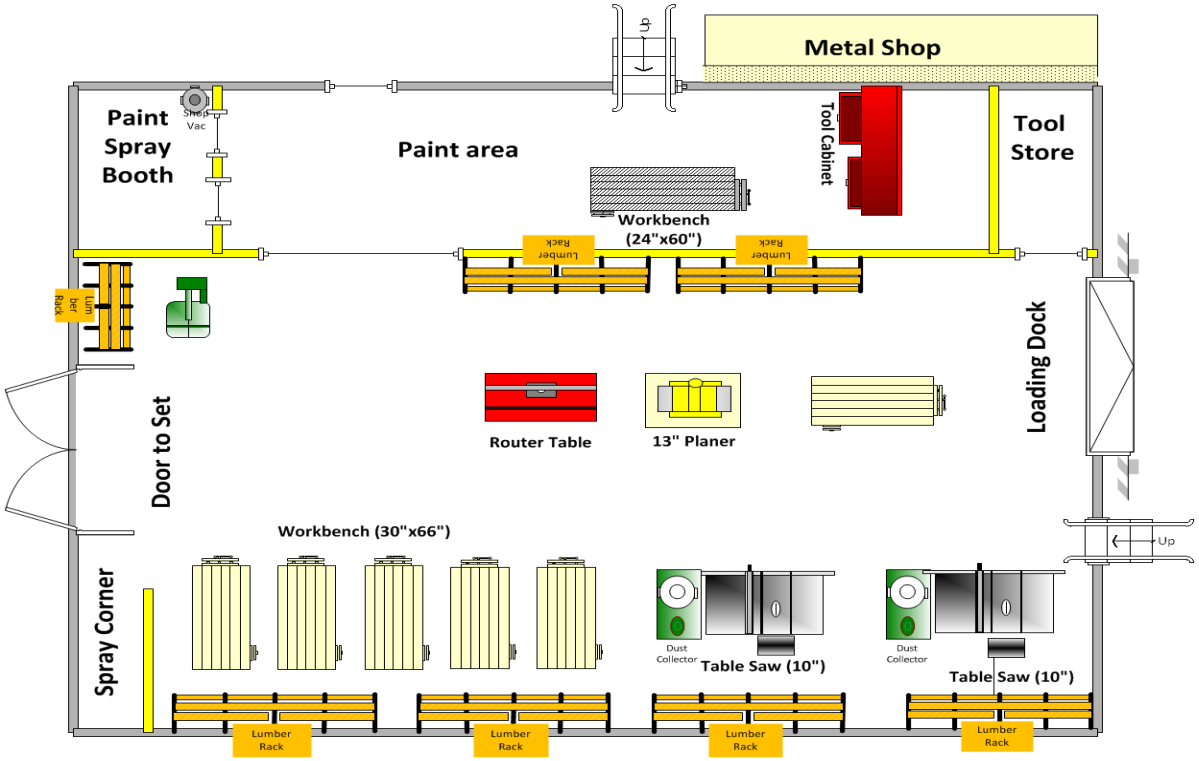
Workers	Noise Peak Range (dBC)			
	90-100	101-120	121-140	141-150
B-C1	49	399	110	0
B-C2	58	397	79	0
B-C3	49	354	175	1
B-C5	38	433	101	0
E-C1	25	505	66	3
E-C3	84	387	44	0
F-C1	105	401	53	2
F-C2	70	395	82	2
F-C3	113	343	44	0
F-C5	126	384	9	0
A-C1	27	527	69	0
A-C3	25	471	104	0
A-C5	47	363	135	5
C-C3	28	368	224	1
C-C4	35	514	65	0
C-C5	19	489	99	0
E-M2	35	435	118	0
F-M4	71	408	27	0
A-M2	82	379	64	0
B-P4	70	511	15	0

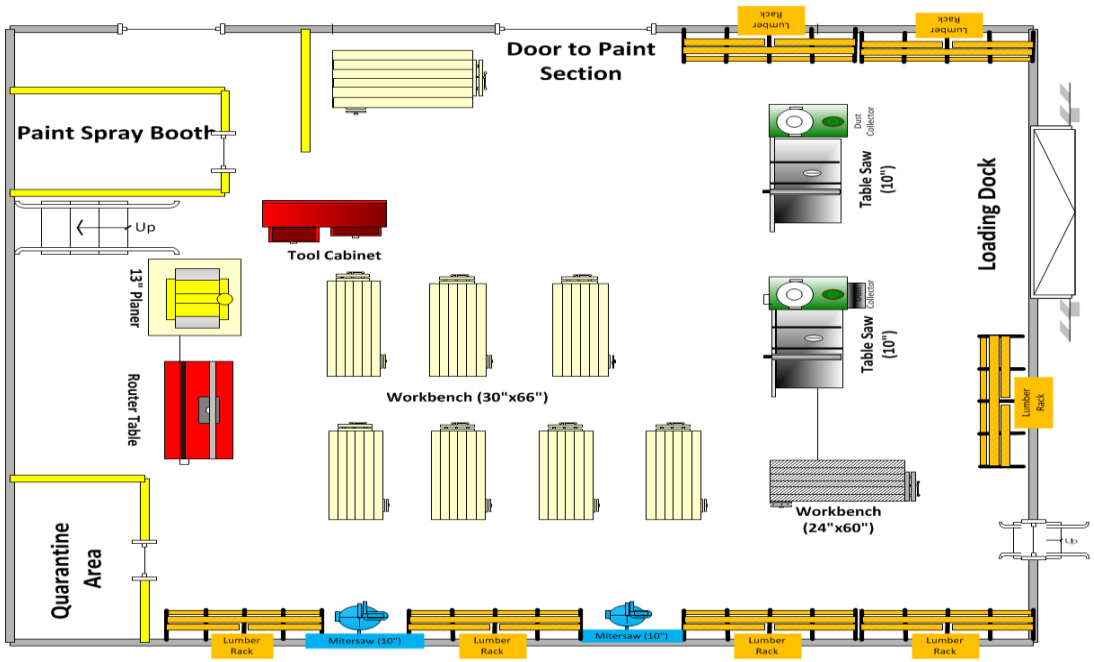
Appendix II

Fig. 5 Construction Shop outlines, in-order from First to Last: B, E, F, A






Metal Shop
Paint Spray Booth
Shop Vac
Paint area
Tool Cabinet
Tool Store
Workbench (24"x60")
Lumber Rack
Lumber Rack
Lumber Rack
Door to Set
Router Table
13" Planer
Loading Dock
Workbench (30"x66")
Up
Spray Corner
Dust Collector
Table Saw (10")
Dust Collector
Table Saw (10")
Lumber Rack
Lumber Rack
Lumber Rack
Lumber Rack


Door to Paint Section
Lumber Rack
Lumber Rack
Paint Spray Booth
Up
Tool Cabinet
13" Planer
Router Table
Workbench (30"x66")
Dust Collector
Table Saw (10")
Loading Dock
Dust Collector
Table Saw (10")
Lumber Rack
Workbench (24"x60")
Quarantine Area
Lumber Rack
Mitersaw (10")
Lumber Rack
Mitersaw (10")
Lumber Rack
Lumber Rack

Appendix III

Indoor Environmental Quality Survey (SAMPLE)

Location: **Date:**

1) Are you familiar with **ActSafe**?

Yes	No

2) What, if any, services you use of **ActSafe**?

3) What, if any, services would you like **ActSafe** to offer?

4) How would you describe the work you do?

Admin. Support	Technical	Supervisory	Professional	**Please Specify**

5) What is your age?

20 or under	20 to 40 yrs	41 to 60 yrs	Over 60

6) What is your gender?

Male	Female

7) Which of the following best describes your workspace?

Enclosed Office	Open Plan Office	Large Studio Space	Other

8) How long have you been working in your present workspace or occupation?

Less than 1	1- 2 yrs	3 - 5 yrs	More than 5 yrs

9) In a week, how many hours you spend at your workplace?

Less than 10 hrs	10 - 20 hrs	21 - 40 hrs	More than 40 hrs

10) In a day, how many hours you spend at your workplace?

Less than 2 hrs	2 – 4 hrs	4 – 8 hrs	More than 8 hrs

11) How satisfied are you with the air quality in your workplace (stuffy / stale air, odors, cleanliness)?

Dissatisfied			Neutral			Satisfied
-3	-2	-1	0	1	2	3

12) How is the temperature at your workplace?

Too Cold			Just Right			Too Hot
-3	-2	-1	0	1	2	3

13) Are you satisfied with the lighting in your workplace: amount of light, visual comfort (glares, reflections, contrast)?

Dissatisfied			Neutral			Satisfied
-3	-2	-1	0	1	2	3

14) How satisfied are you with the noise levels in your workplace?

Dissatisfied			Neutral			Satisfied
-3	-2	-1	0	1	2	3

15) Do you ever see or smell mold in your workplace?

Yes, often	Yes	Sometimes	Don't Know	Heard about it	No	Never
-3	-2	-1	0	1	2	3

16) How satisfied are you with the dust levels in your workplace?

Dissatisfied			Neutral			Satisfied
-3	-2	-1	0	1	2	3

17) Do you have symptoms that are worse when you are at work than when you are at home or on weekends? If yes, circle the symptom :

Headache	Dry eyes	Skin problems	Coughing
Chest tightness	Nausea	**Others (Specify)…**	

18) Does the air quality in your workplace interfere or enhance your ability to get your job done?

Dissatisfied			Neutral			Satisfied
-3	-2	-1	0	1	2	3

List any occupational health issues you encounter frequently at work:

Results of Questionnaire based Survey

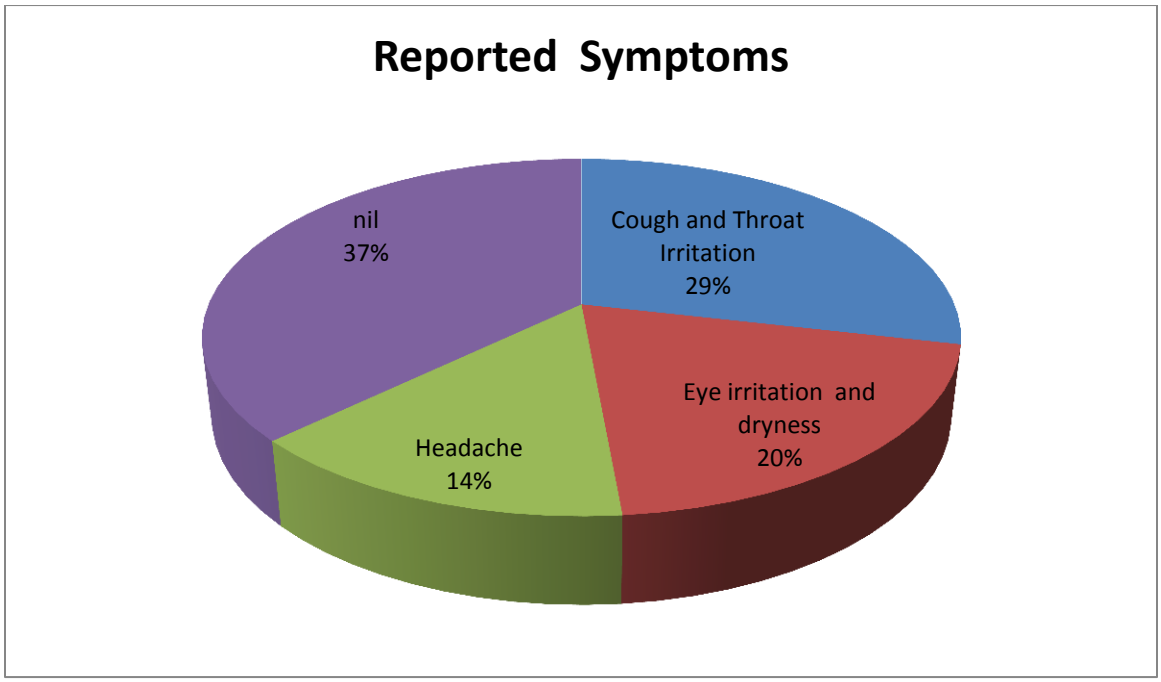


Figure 2. Pie chart showing Symptoms as reported by Vancouver Film workers (n=34)

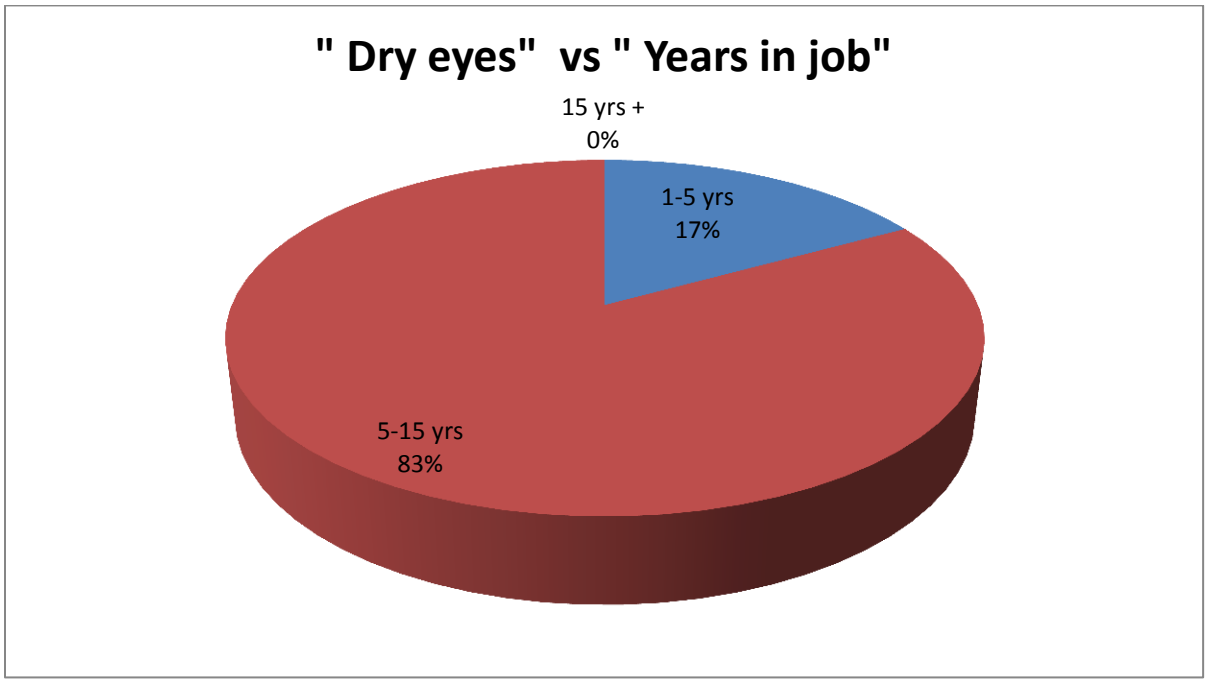


Figure 3. Pie chart comparing Dry Eye symptoms to Years in job

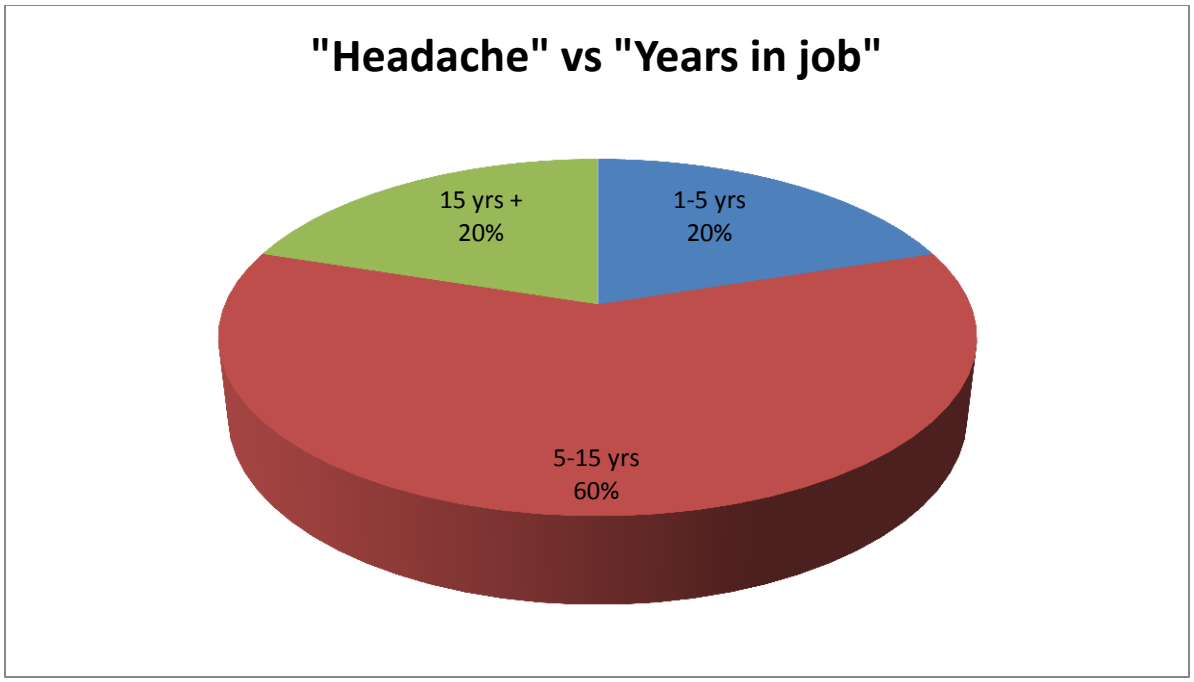


Figure 4. Pie chart compares Headache symptom to Years in job

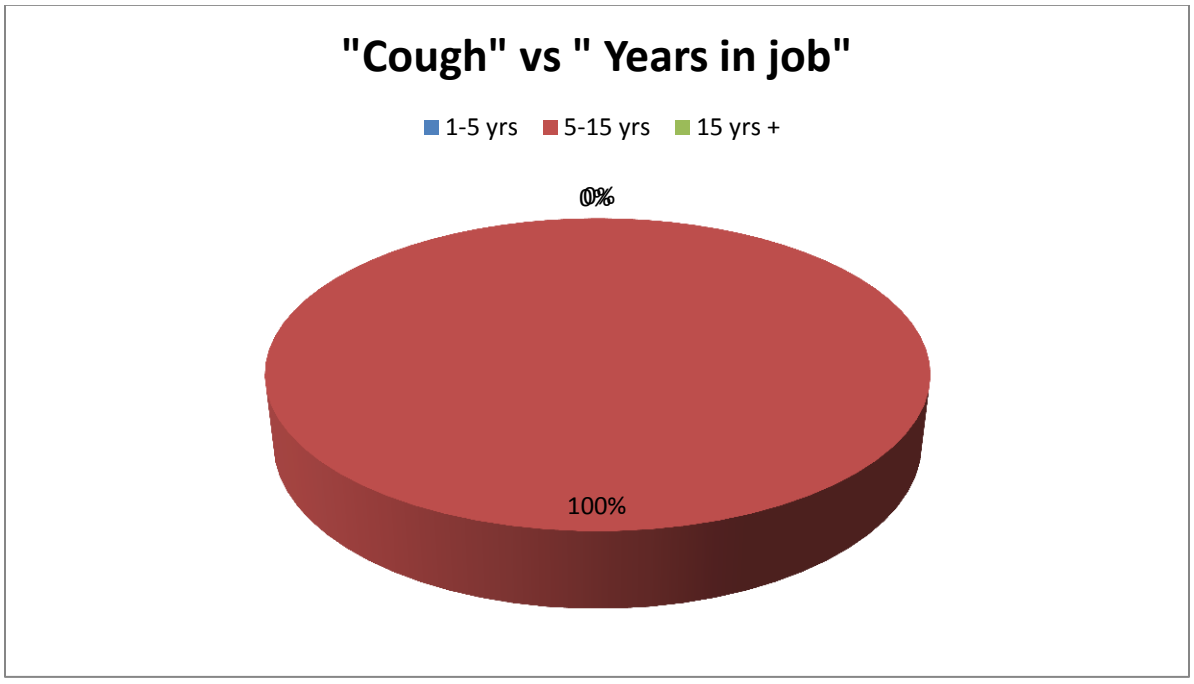


Figure 5. Pie chart compares Cough symptoms to Years in job