

Silica Exposure in Artificial Nail Application Salons

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BACKGROUND

A nail salon patron contacted the Illinois Department of Public Health (Department) about the hazards of a white powder labeled “SILICA” used in the application of acrylic nails. Staff in the Department’s Occupational Diseases Registry (ODR) was not aware the industry used silica flour and visited a nail salon to identify the use and possible dust exposure that may exist in artificial nail salons.

Upon entering the nail salon, a strong chemical odor that was not nail polish or polish remover was noticeable and was later identified as an ethyl methacrylate polymer. An open bottle of an unnamed liquid, an opened jar of unnamed white powder, a buffing pad, an electric hand-held sanding machine and application brushes were on the technician’s work surface. The hand-held sanding machine was similar to an electric eraser fitted with a three-eighth inch sanding drum that rotated at a slow rate of speed estimated to be 150 revolutions per minute.

ODR staff needed to see how this white powder was used during the artificial nail application; therefore, a staff member volunteered to have artificial nails applied so that an entire nail application was observed. The nail technician, working on the staff member’s hands, placed a disposable isolation mask on her face before working on the customer’s hands. The mask covered her mouth and nose but did not seal against her face. One other nail technician used a similar mask while the third nail technician did not. When the staff member asked the technician why she wore a mask, she replied that she had a cold and did not want to give it to her customers. She gave no reason for the second staff member wearing a mask.

Original nails were first clipped to a manageable length, buffed and a thin piece of fiberglass was glued to the bottom side of the original nail. After the glue set, the nail technician applied the liquid and powder to the original nail and fiberglass by dipping the brush into the liquid and then into the powder. The technician built the artificial nail with approximately four layers of liquid and

powder. While the acrylic dried, dust exposure was nil, but the ethyl methacrylate polymer odor was quite noticeable during the liquid application.

During sanding of the nails, the technician's breathing zone was approximately 6 to 12 inches from the customer's fingernails for about for 20 to 25 minutes. This sanding was the major source of dust exposure. After the technician finished sanding the customer's nails, her own thumb, index and middle fingers were covered with a white dust that was a combination of acrylic monomers, fiberglass, an amorphous form of silica and crystalline silica.

When finished with the customer, the nail technician shook the towel that covered the top of the work surface causing the accumulated dust to become airborne. ODR staff noted the work station had an accumulation of fine white powder over its entire surface. The last step in the process was to polish the nails during which ODR staff noted no dust exposure.

After observing the process and contacting various artificial nail supply companies, ODR staff concluded that a potential for silica exposure was present. A study was undertaken to determine the amount of silica to which nail technicians are exposed.

The potential for chemical exposures exist because of a technician's proximity to the fingernail during application and shaping. Many salon technicians work a 10-hour day and more than five days per week to satisfy their customers' needs. With six to seven customers per day, technicians may be exposed to silica dust for up to five hours per day. Because of the time spent in this environment, it may be possible for technicians to exceed the recommended exposure limit for particular chemicals. Overexposure to ethyl methacrylate vapor is known to cause contact dermatitis and occupational asthma.¹ Silica overexposure is can cause silicosis, a fibrotic condition of the lung.²

At least 10 major companies manufacture or sell artificial nail products, and the amount of silica in the nail acrylic polymer varies from company to company. Silica content in one company's product may be 1 percent while another company's product may contain 10 percent.

The majority of nail technicians are not concerned about occupational chemical hazards. In a recent industrial survey only 37 percent expressed concern about chemical safety.³ Many nail technicians; therefore, do not use any device to protect themselves from harmful vapors or dusts.

Artificial nail salons differ in their method of reducing occupational exposures to hazardous vapors and dusts. Some use isolation masks, but these masks are not designed to eliminate dust and vapor exposures since they do not have a tight seal around the face and thus allow unfiltered air to enter the technician's respiratory system. Respirators approved by the National Institute for Occupational Safety and Health (NIOSH) may not be acceptable to nail technicians since they may deter customers from entering the salon. Also, NIOSH recommends that respirator usage be the last means for controlling dust and vapor exposures.

Many salons use existing room air handling systems to reduce exposures. These systems, however, allow airborne dust to move past a technician's breathing zone before filtering the air. Some nail salons use down-draft tables that entrap vapors and dust within a filtering system. These should be effective if the exhaust is properly sized and the filters maintained. It is unknown whether these tables can control dusts effectively and be maintenance free.

Techniques in applying the silica-containing acrylic polymer differ slightly from salon to salon as do the preferred methods of filing nails (dental tools with metal bits, electric motors with sanding drums, and hand filing). In terms of exposure to dust, the method of filing the nails is important. Dental tools using burs generate dust over a longer distance as the burr's metal fins and the machine's rotary speed propel the dust. The sanding drum technique also throws dust, but a lesser

amount than the dental burr due to the drum's sand paper filling with dust and low rotation speed of the drum. Filing by hand probably does not throw dust into the technician's personal breathing zone but is more tedious and, therefore, not used as often.

INTRODUCTION

Studies have shown that airborne silica levels greater than the United States Occupational Safety and Health Administration's (OSHA) permissible exposure limit (PEL) or the NIOSH recommended exposure limit (REL) are hazardous to human health if the exposure occurs over an extended period of time.⁴ Such exposures can cause silicosis, a pulmonary disease. Certain industries can produce exposures above the OSHA and NIOSH limits, and they have been targeted for employee and company education to reduce silica exposure.

A new industry, artificial nail application or acrylic nails, has arisen that uses silica flour which can become airborne during filing of artificial nails. At present, no silica exposure studies in nail salons have been conducted to determine the rate of exposure. It is possible employees and employers maybe unaware of the health hazards posed by breathing silica dust into the lungs and of the fact that it may take 20 to 30 years of exposure before silicosis develops.

Although nail technicians may place their customer's hands in different positions to work on them, their personal breathing zone is within 6 to 10 inches of the dust generation source. Some nail technicians work on a client's hands while the client's hands are on the desktop, bending at the waist to get close to their work and to observe the grinding tool's location. This approach may generate complaints of backache. Other technicians hold the client's hands above the work surface, thereby eliminating bending for long periods. However, this position precludes the use of a down-draft table for dust control, since the client's hand is too far from the filtration system's air inlet.

The purpose of the study was to collect information on the following questions:

1. What is the exposure rate for silica in five artificial nail salons in Bloomington/Normal and Springfield, Illinois?
2. Will down-draft nail salon tables reduce the exposure rate for silica?
3. Will filing techniques produce a differential exposure to silica?

METHODS

The study design measured the silica exposure at five nail salons in the central Illinois area. Nail salons were selected by using the Bloomington/Normal yellow pages to identify all nail salons (n=18) in the area. A letter was sent to these salons describing the study and an inviting owners to participate. Follow-up telephone calls were made to each nail salon 10 days after the initial letter mailing. Of the 18 contacted, six nail salons did not have enough customers to conduct an adequate study, four salons did not work with artificial nails, two did not return telephone calls or letters, and two companies refused to be a part of the study.

This left four salons with a total of 10 technicians for the study. One of these salons wanted only one of its six technicians tested. Participating salons were visited to insure that the technicians created artificial nails, to enroll the salon's technicians in the study (by obtaining signed informed consents) and to observe if a down-draft table was used in the salon. Since none of these salons used a down-draft nail salon table, it was decided to contact two previously identified Springfield salons that did use these tables and ask them to enroll in the study. One salon in the Bloomington/Normal area was dropped to add the two down-draft table salons. Some salon owners did not want all technicians tested, and this reduced the technician sample size to 10 technicians.

Two of the salons did artificial nail application only; the rest were part of beauty salons. The salons employed from one to eight technicians. Three salons had one technician, while one had six,

and the fifth salon had eight technicians. Two of the nail salons, which accounted for six of the studied technicians, used down-draft tables, while three salons used conventional tables accounting four studied technicians. The five salons used three different vendors of acrylic products. All salons had a clientele that could generate at least six customers per eight-hour day to provide an adequate exposure duration for the day.

Silica exposure depended on the number of nail technicians, the arrangement of work tables, and the time spent at the work station. Diagrams 1 and 2 show the table layout in the two salons that had multiple technicians. Side by side table arrangements could result in dust exposures to a technician who sits at the work station during breaks, while the adjacent technician is filing nails and generating dust. Air movement and its subsequent dust may cause the technician on break to breathe dust contaminated air.

Diagram 1. SALON THREE TABLE ARRANGEMENT

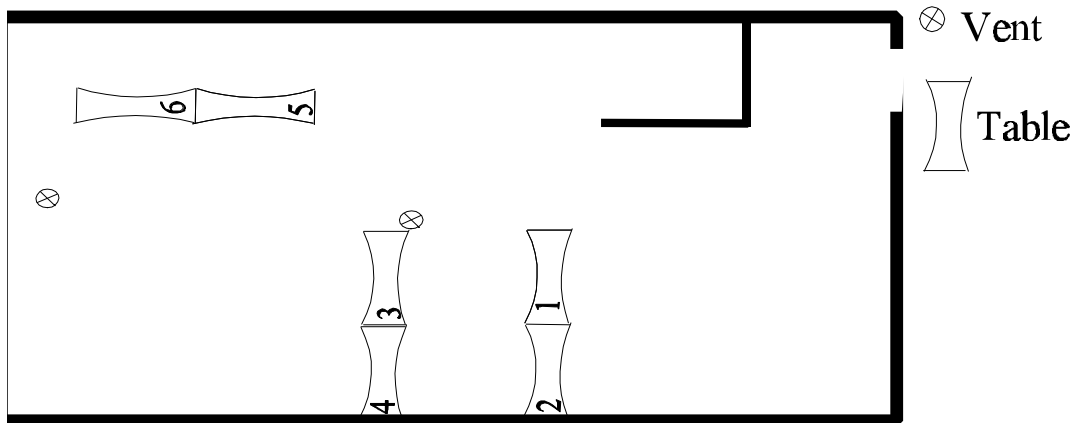
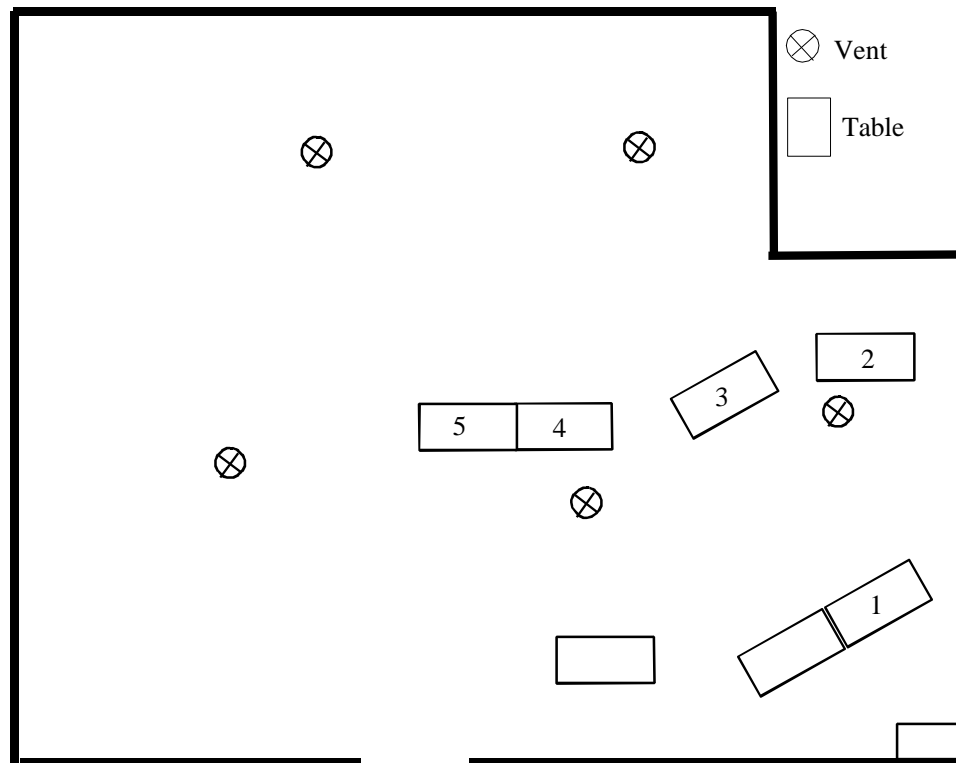


Diagram 2. SALON FOUR TABLE ARRANGEMENT



Ceiling mounted exhaust fans in each of the salons were not adequate to remove the ethyl methacrylate vapors that were evident during the observation. If the exhaust vents could not remove the vapors, it is very possible that the dust, which is heavier, was not removed. The exhaust vents were not positioned properly to allow air movement in a vertical column. The ceiling height was too high to allow laminar air flow from floor to ceiling; therefore, turbulent air flow caused the airborne vapors and silica dust to mix throughout the room.

Bids were asked from environmental engineering companies to provide air monitoring of the nail salons participating in the study. The companies were asked to conduct personal air samples and air monitoring samples within the salon. A company was chosen on the lowest bid basis, ability to conduct the study in the time needed, and method of study technique.

STUDY DESIGN

Nail salon technicians were instructed two weeks before the test day to schedule a full work day in order for the testing to represent a maximum exposure. In addition, the technicians were instructed to use normal work techniques; technicians and owners were told that no special cleanup of the salon was necessary.

On the day of the test, project staff calibrated the test instruments, placed them in the proper position and instructed the nail technicians on the proper use of the instrument. ODR staff monitored the test apparatus, and noted nail technicians' activities and work habits.

Results of the study were based on the air monitoring of the individual nail technicians, along with staff observations. Air sampling was conducted using the same industrial hygienist to calibrate, place, and instruct the nail technicians.

TEST PROCEDURES

The nail technicians and test instruments were monitored throughout the four-hour period. At the end of four hours, the industrial hygienist returned, shut the machines off and secured the filter membranes.

On the day of the test three of the work sites had a single nail technician working within the salon. One nail salon had five nail technicians in the study, and one salon permitted two of six technicians in the study. Most customers of one salon were walk-ins, while the other salons used appointments to schedule their clients. One salon's test pump battery failed during the test period and required a new test apparatus. This salon's test procedures were repeated to provide a positive test for this location.

The test pumps used during the nail salon study were Sensidyne Model BDX 530. The quantitative test used NIOSH 7500 procedures. This procedure uses a 10-millimeter nylon cyclone

and five micrometer PVC membrane. Pumps were set to 1.7 liters per minute air flow by means of a test flow meter. Test volume was 400 liters per minute of air passing through the pump. The pump inlet tube was positioned approximately 6 to 8 inches above the work surface and in line with the normal work positions. This allowed the personal breathing zone air to be monitored, left the technician able to work, and did not disturb the test apparatus. The pumps were left on and not disturbed during the four-hour testing process. Nail technicians did their normal work tasks during the test.

Technicians were monitored at 15 minute intervals to observe specific job tasks. In addition, those technicians that worked at work stations incorporating the down-draft fans were monitored for fan usage. These data provide an exposure time. A list of tasks that a nail technician may do while in the salon include applying acrylic, filing nails, buffing nails, polishing nails, cleaning, and taking breaks. When observing the technician's tasks and time allotments, filing of nails might be the major source of dust emission.

RESULTS

Nail technicians are not always busy during the work day. The air monitoring test was based on a normal work day. Salon Four's technicians double as cosmetologists and may work at other tasks when not working on nails. Salon Three does not take appointments and depends on walk-in trade. Thus the nail technicians may have breaks between customers as reflected in the work task analysis (Table 1) for all nail technicians.

Table 1. NAIL TECHNICIAN TASKS VERSUS TIME IN HOURS

Task	Salon 1	Salon 2	Salon 3		Salon 4					Salon 5
	Op 1	Op 2	Op 3	Op 4	Op 5	Op 6	Op 7	Op 8	Op 9	Op 10
Break	1.00	1.00	1.25	1.50	1.25	2.00	2.25	3.25	1.25	1.00
Acrylic application	0.50	0.50	0.50	0.50	1.00	0.25	0.25	0.50	0.50	0.75
Filing	0.75	1.25	1.00	1.00	1.00	1.00	0.75	0.25	0.75	1.50
Buffing	0.75	0.75	0.75	0.50	0.25	0.25	0.25	0.00	0.75	0.00
Polishing	1.00	0.50	0.50	0.50	0.50	0.50	0.50	0.00	0.75	0.75
TOTAL	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00

Op = Operator

Source: Illinois Department of Public Health

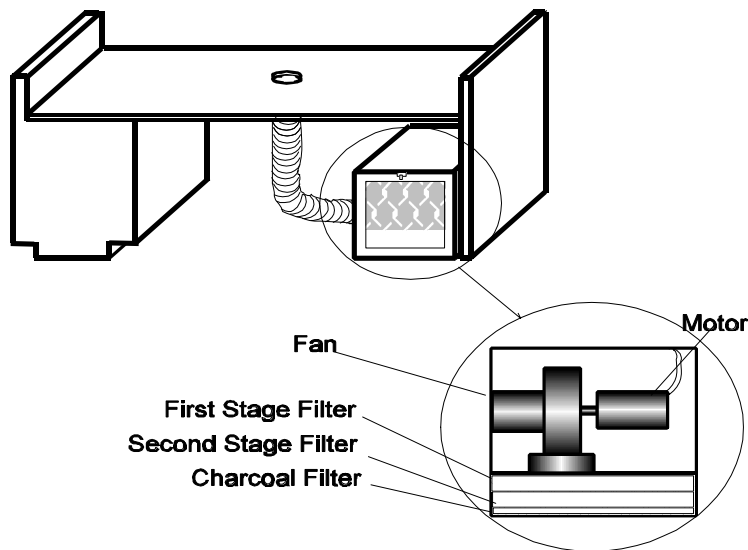
Technicians were requested to book as full a day for nail salon activity as possible. A nail application takes about 1 to 1.25 hours to complete. Work breaks and other duties kept technicians from applying nails for the entire four-hour period. These breaks in work activity were not noticed when the ODR staff observed the initial nail salon to identify if a possible dust exposure occurred.

At Salon One, which has a single nail technician, the battery failed in the air monitor pump during the initial test period and the test had to be repeated. All other tests were accomplished during the first test period without incident. All technicians used some type of powered file, whether emery wheels or metal burrs, except the operator at Salon One, who used manual files and buffers when working on the nails.

Salons Four and Five used down-draft work tables as illustrated below (Diagram 3). The exhaust fan is rated at moving 144 cubic feet of air per minute. The manufacturer states that the fan's exhaust blows through a three-stage filter. One stage removes dusts, the second stage removes fine dusts that passed through the first stage, and the third stage is an activated charcoal filter to remove organic vapors. Exhaust air flows into the salon. After receiving permission to open the boxes to read

the fans' flow rates, staff found that the charcoal filters were missing. Without this charcoal filter, organic vapors from the acrylic application are not entrapped and thus enter the room's air system. In addition, most nail technicians cover the table's hole with a terry cloth towel. The purpose of this towel is unclear. Possible purposes for the towel are to keep the table top clear of acrylic build up, to reduce the fan's flow rate and prevent the acrylic from drying too fast, or to provide comfort for the client's hands.

Diagram 3. DOWN-DRAFT SALON TABLE WITH FILTER BOX



Air monitoring samples were sent to a laboratory in Salt Lake City, Utah, for analysis. This analysis produced a gross weight of silica converted to a time weighted average. The NIOSH recommended exposure limit is defined at 50 micrograms of silica per cubic meter (mcg/m^3) as a time weighted average for up to 10 hours/day during a 40-hour work week, while OSHA's permissible exposure limits are defined by the percentage of silicon dioxide in the dust. The current OSHA PEL

for respirable dust containing crystalline silica (quartz) is calculated using the following formula.⁵

$$\text{PEL} = 10,000 \text{ mcg/m}^3 \div (\% \text{ silica} + 2)$$

Thus, if the sample was identified as having 25 percent silica content, the PEL would be–

$$\text{PEL} = 10,000 \text{ mcg/m}^3 \div (\% \text{ silica} + 2)$$

$$\text{PEL} = 10,000 \text{ mcg/m}^3 \div (25 + 2)$$

$$\text{PEL} = 10,000 \div 27$$

$$\text{PEL} = 370 \text{ mcg/m}^3$$

greater percentage of silica in the sample will decrease the PEL.

Time weighted averages (TWA) for the nail technicians are provided in the Table 2.

Table 2. OPERATOR S CRYSTALLINE SILICA AND TOTAL DUSTS EXPOSURE

Operator Number	Work Surface	Nail Filing Technique	Silica Exposure*	Total Dusts** (includes acrylics) micrograms/cubic meter
1	Flat	Hand files	not detectable	150
2	Flat	Motorized drums	not detectable	420
3	Flat	Motorized drums	not detectable	300
4	Flat	Motorized drums	not detectable	120
5	Down Draft	Motorized burrs	not detectable	170
6	Down Draft	Motorized burrs	not detectable	420
7	Down Draft	Motorized burrs	not detectable	250
8	Down Draft	Motorized burrs	not detectable	250
9	Down Draft	Motorized burrs	not detectable	250
10	Down Draft	Motorized burrs	not detectable	120

*Not a health risk for any operator

**Exposure levels for acrylic dusts have not been determined by Occupational Safety and Health Administration (OSHA) or National Institute for Occupational Safety and Health (NIOSH); however, ethyl methacrylate, a component of acrylic nails, is a potential health risk for an asthma condition and contact inflammatory skin conditions.

Source: Illinois Department of Public Health

The first question the study sought to answer was what exposure rate for silica existed in five artificial nail salons in Bloomington/Normal and Springfield, Illinois. None of the nail technicians exceeded the NIOSH REL or the more stringent OSHA PEL as the respirable silica dust exposures were not detectable. Ventilation within the salon, manicuring technique, and percentage of silica within the acrylic polymer were some of the reasons silica dusts were not detectable.

As to whether down-draft nail salon tables reduce the exposure rate for silica, none of the monitors on the nail technicians exceeded the NIOSH REL or the more stringent OSHA PEL for silica dust exposures. The total dust rate can be classified into two groups. The flat tables, with four operators in three salons, produced an average of 28 mcg/m³ of respirable dusts; the down-draft tables, with six operators in two salons, produced an average of 24.3 mcg/m³ of total respirable dust. Using down-draft tables, therefore, produced less respirable dusts.

The down-draft table's manufacturer states that the table's fan is designed to run continuously without affecting the warranty. Nail technicians were observed using the fans intermittently during the day. Three used the fan continuously while one did not turn the fan on at all. Two technicians turned the fan on during filing and turned it off after the filing was completed. If the down-draft fans were used continuously, it would be expected that average respirable dust exposure would go down. For this type of down-draft table to be effective, however, the filters must be maintained and the fan must be running. Filters should be the type made specifically for the fan box and replaced when stated by the manufacturer. Elimination of even one filter element circumvents the air purification system.

The study's third question, as to whether filing technique affects silica exposure, could not be addressed. None of the nail technicians exceeded the OSHA PEL or the more stringent NIOSH REL. Filing techniques yielded different dust rates. The hand file method, used by only one operator, produced 15 mcg/m³ of respirable total dusts. The motorized sanding drum method, employed by

three operators in two salons, produced an average of 28 mcg/m³ of respirable total dusts, and the motorized burr method produced an average of 24.3 mcg/m³ of respirable total dusts. The average dust quantity generated by motorized burrs may have been affected by the use of the down-draft tables. The two operators that used the fans 100 percent of the time had the lowest total dust weight, and the operator who did not use the fan had the highest rate. Staff monitoring the test observed that motorized burrs threw dust farther than the motorized drum and the manual file did not throw any dusts. Because of their capacity to throw dusts over a greater distance, motorized burrs may be able to throw dusts into a technician's personal breathing zone. The motorized sanding drums produce dust, but much of it is imbedded in the drum. While the dust generated by a motorized sanding drum was observed not to travel as far when thrown, some could enter a technician's personal breathing zone.

DISCUSSION

Presently, three nail filing methods are used in the nail salon industry. No effort has been undertaken to determine which method protects the nail technician while still allowing the technician to be productive. Further studies should examine down-draft ventilation tables with the use of slow speed motorized drums and motorized burrs. Slow speed motorized drums and motorized burrs should be used with flat tables. The two filing methods should be compared for dust generation, and the two types tables could be compared to determine the effectiveness of down-draft tables. Air flow quantity through a down-draft table's fan should be measured during the study and compared with the manufacturer's specification. At the end of the study, a comparison of equipment would show the equipment to use to reduce total dust exposure.

During the course of this study into silica exposure, other possible public health hazards within the nail salon industry were noted. Some habits affect only technicians, while others may affect their

customers. Many technicians work very close to their client's hands, some bending at the waist for long periods of time. A study should address the lower back stress that such a position may cause and determine a correct posture for nail technicians.

Bleeding around a client's cuticles can occur whenever a nail technician hits the cuticle with a burr, drum or file, and blood pathogens may contaminate the tool. Many nail technicians do not change instruments between clients. A study should address tool usage from one client to another and should address the nail technician's role in stopping the cuticle bleeding. Technicians should provide cotton gauze to the client with instructions to hold the gauze in place. The technician should not hold the gauze personally without the use of protective gloves.

Personal breathing zone silica exposure was not above the NIOSH REL. Ventilation systems to limit dust exposure and organic vapors emitted during nail application, however, are important for nail technicians. A good ventilation system should keep vapors and dusts from entering the technician's personal breathing zone and remove the vapors and dusts from the room. Nail salon technicians, though, should not have to remember when to change the filters. Having the air exhausted to the outside of the building is more practical, as the table's down-draft fan would need no filter; thereby requiring no maintenance.

REFERENCES

1. Gosselin RE, Smith RP, Hodge HC. *Clinical Toxicology of Commercial Products*. Williams and Wilkins Press, Baltimore, Md. 1984; II-409.
2. Spencer AB, Estill CF, McCammon JB, Mickelsen RL, Johnston OE. Control of Ethyl Methacrylate Exposures During the Application of Artificial Fingernails. *American Industrial Hygiene Association Journal*, 1997 Mar, 58(3) 214-218.
3. Spencer AB, Estill CF, McCammon JB, Mickelsen RL, Johnston OE. Control of Ethyl Methacrylate Exposures During the Application of Artificial Fingernails at Moore's University of Hair Design, Cincinnati, Ohio: U. S. Department of Health and Human Services, Public Health Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Engineering Control Technology Branch. Report No.: ECTB 171-22a.
4. Spencer AB, Estill CF, McCammon JB, Mickelsen RL, Johnston OE. "Control of Ethyl Methacrylate Exposures During the Application of Artificial Fingernails". *American Industrial Hygiene Association Journal*, 1997 Mar, 58(3) 214-218.
5. NIOSH [May, 1996]. Preventing Silicosis and Deaths in Construction Workers, Cincinnati. Ohio: U. S. Department of Health and Human Services, Public Health Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, NIOSH Report No.: 96-112.

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