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Occupational Health and Safety Surveillance

Task-Based Exposure Assessment of Hazards Associated with New Residential Construction

Alice Greife, Column Editor

Reported by Mark M. Methner, John L. McKernan, and James L. Dennison

Estimates of the number of workers employed in the construction industry range from six to eight million.⁽¹⁾ However, these estimates include all workers engaged in the many different facets of construction (e.g., commercial buildings, highway, etc.). Of particular interest is the new residential construction industry, classified as Standard Industrial Classification (SIC) Code 1521. This interest stems from the fact that virtually no exposure data exists for workers employed in this sector of the industry. According to the Bureau of Labor Statistics (BLS), the construction industry leads all other industries in the number of occupational injuries and illnesses.^(2,3) The average employment in the residential building construction industry in 1998 was 708,000 with an incidence rate of 7.6 total cases of occupational injuries and illnesses.⁽²⁾ These rates are based on employer injury and illness logs which may be influenced by changes in economic activity, working conditions and work practices, worker experience and training, and number of hours worked. In the past, research to identify occupational hazards associated with construction work has been conducted primarily in the general construction sector of this diverse industry.⁽⁴⁾ Hence, workers involved in residential construction have been understudied. This may be due, in part, to the fact that most of the residential construction work is performed by small subcontractors who employ nonunion workers. National survey data suggest that smaller contractors have greater fatal injury rates but lower nonfatal injury rates when compared to

larger contractors.⁽²⁾ Since subcontractors who often do not have health and safety programs comprise a large portion of all contractors engaged in residential construction, the need for hazard identification and task-based exposure assessment studies specific to this industry becomes very clear.⁽⁴⁾

According to the U. S. Department of Labor's Occupational Safety and Health Administration (OSHA), the most frequently cited OSHA standard at single-family residential construction sites was failure to have fall protection systems in place.⁽⁵⁾ Other violations frequently cited by OSHA include a lack of appropriate scaffolding and a written hazard communication program. Overall, OSHA citations are more aligned with safety issues than health issues. An analysis of the OSHA citation data available for construction indicates that health-related citations account for only four percent of the top 100 citations.⁽⁵⁾ Recently, OSHA endorsed a pilot program called HomeSafe in the Denver, Colorado area in response to seven deaths that occurred in residential construction. This ongoing program focuses on a 10 point list of potentially significant hazards on residential construction sites with the ultimate goal of educating workers and reducing injury rates.^(6,7) An evaluation of the effectiveness of this program has yet to be determined.

The impetus for this study stems from the initial findings of a qualitative assessment and identification of potential hazards associated with different trades involved in new residential construction.⁽⁸⁾ Each phase of new residential construction usually consists of multiple tasks, each with its own potential for exposure.

The purpose of this hazard surveillance effort was to estimate exposure of subcontractor trades to potentially hazardous agents. The following phases of residential construction were evaluated: excavation, concrete foundation pouring (including basement floor, garage floor, and driveway), carpentry, masonry, insulation, roofing, plumbing, electrical, heating, ventilation and air-conditioning (HVAC), drywall, painting, and flooring.

Methods and Materials

This study, conducted from May to July 1999, was a follow-up to an initial qualitative hazard assessment of residential construction sites in Ohio.⁽⁸⁾ The basic study framework included a review of all pertinent information on products used including Material Safety Data Sheets (MSDSs); observation of work practices; collection of duration of task and short-term (15 minute) personal breathing-zone air samples for chemical agents; limited sound level measurements; and an observational assessment of vibration hazards.

The initial phase of the study was to identify potential hazards at five different job sites. Twelve trades were evaluated during this study. For each trade, a listing of observed tasks and associated job titles and Bureau of Census (BOC) occupation codes is presented in Table I. Based on visual observations of work practices on a task-by-task basis, and work previously reported, an industrial hygienist utilized professional judgment when determining which tasks to sample.⁽⁸⁾ As the work was performed primarily by subcontractors, permission to conduct the study was initially obtained from the general contractor at each site. All of the general contractors and

their subcontractors who were contacted agreed to participate in the study.

Chemical Agents

The chemical ingredients in each product were identified by reviewing labels on containers and obtaining MSDSs for all products. Most MSDSs were not

available at the site, but were obtained from product distributors and suppliers. In total, nearly 200 MSDSs were reviewed to identify chemical constituents for products used by workers. In a few cases, the hazardous ingredients noted on MSDSs were inconsistent with those listed on the label attached to the con-

tainer. This was particularly problematic for products containing volatile organic compounds (VOCs) such as toluene, xylenes, and isobutanol. To ensure that personal exposure samples were collected and analyzed for the appropriate agents, qualitative screening for VOCs was initially performed using a thermal

TABLE I
Work tasks evaluated by trade, job title, and occupation code

Trade	Task	Job title	BOC code ^A		
Excavation	Excavate the lot	Excavator	853		
	Install the perimeter drain				
	Backfill around the foundation				
Concrete	Pour footings and foundation	Concrete and terrazzo finishers	869		
	Preparation for flat work				
	Pour flatwork				
	Apply curing agent to flatwork				
Carpentry(framing)	Waterproofing	Floor and wall applier, liquid	599		
	Install redwood sill plate and floor decking	Carpenter	567		
	Frame walls				
	Install roof trusses				
	Install plywood roof panels				
	Install windows				
	Install siding				
Install gutters					
Carpentry(finish)	Install fireplace	Carpenter	567		
	Install interior trim				
	Install doors, handrails, and cabinets				
	Install counter tops				
	Install miscellaneous hardware				
Masonry	Complete masonry work	Brick mason	563		
Roofing	Apply shingles to roof	Rofer	595		
Plumbing	Install water, sewer, and gas lines	Plumber	585		
	Install rough plumbing				
	Install plumbing fixtures				
Electrical	Install rough electrical	Electrician	575		
	Install electrical fixtures				
HVAC	Install heating and air conditioning	Sheet metal duct installer	596		
Insulation	Install insulation	Insulation worker	593		
Drywall	Attach drywall to wall studs	Drywall installer	573		
	Apply joint compound to drywall				
	Texture drywall				
Painting	Paint interior	Painter	579		
	Paint exterior				
Flooring	Install vinyl flooring	Carpet and soft tile installer	566		
	Install carpet				
	Install wood flooring			Carpenter	567
	Install ceramic tile			Tile setter, hard	565

^AAlphabetical Index of Industries and Occupations, Bureau of Census, 1990, Hyattsville, MD; Centers for Disease Control and Prevention, National Center for Health Statistics.

desorption (TD) tube, in accordance with NIOSH Method 2549.⁽¹¹⁾ Any VOCs that appeared on the chromatogram in relatively high concentrations (peak heights were two to three fold higher than other peaks) were subsequently included in the sampling plan. All samples were obtained from workers who were instructed to conduct tasks as they normally would.

Several modifications to the sampling plan were made during the course of sample collection. These were necessitated by changes in the type of product used or the fact that selected tasks were not performed during the study period. This primarily affected sampling of contractors applying polyurethane to hardwood flooring as well as painters applying stain to woodwork. Hence, for these two trades, it was not possible to collect the desired number of samples (three) per

task. However, it should be noted that the limited number of planned samples precluded a statistically-based sampling strategy. Rather, this sampling effort was intended to provide exposure estimates on a task-by-task basis for each trade. An overall summary of the sampling strategy by trade, task, number of samples and analytes is presented in Table II.

All personal air samples were collected and analyzed in accordance with the appropriate NIOSH or OSHA sampling and analytical methods.^(11,12) Air sampling instrumentation consisted of two different types of battery-operated pumps depending on the desired flow rate; high flow Universal XR Sampler (SKC, Eighty Four, PA) or low flow HFS-113A (Sensidyne, Clearwater, FL). All pumps were calibrated with appropriate media in-line before and after each

sampling episode using an electronic calibrator (Gilian, St. Petersburg, FL). All postsampling flow rates were within +/- 1 percent of the presampling flow rate for each collected sample. Respirable particulates were sampled with an aluminum cyclone (SKC) calibrated at a flow rate of 1.7 liters per minute to yield an aerodynamic diameter cut point of 4 μm . Air sampling durations ranged from 5 to 240 minutes.

Upon completion of the sample collection and data analysis, the measured concentrations of chemical agents were compared to NIOSH Recommended Exposure Limits (RELs),⁽⁹⁾ U.S. Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs),⁽⁹⁾ and American Conference of Governmental Industrial Hygienists (ACGIH[®]) Threshold Limit

TABLE II
Sampling strategy

Trade	Task	Number of samples collected	Sampled substance
Excavation	Excavate lot	3	Diesel exhaust
Carpentry	Cutting lumber for walls and subfloor	5	Wood dust
	Glue subfloor	4	Toluene, Stoddard solvent, benzene
Masonry	Mix mortar, cut brick	4	Respirable particulates, crystalline silica
Drywall	Sand joint compound	3	Respirable particulates
Insulation	Spray-on insulation between wall studs and roof rafters	3	Fibrous glass
	Seal gaps with polyurethane foam	3	Methylene bisphenyl isocyanate
Flooring	Install wood floors	2	Respirable particulates
	Install vinyl floors	3	Methylene bisphenyl isocyanate
	Apply polyurethane finish	1	Stoddard solvent
Painting	Install ceramic tile	3	Ethylene glycol
	Spray lacquer onto trim	4	Toluene, xylenes, isobutanol, Stoddard solvent, methyl ethyl ketone, Isopropanol, benzene
	Stain trim	1	Toluene, xylenes, isobutanol, Stoddard solvent, methyl ethyl ketone, Isopropanol
Concrete	Paint interior	3	Ethylene glycol
	Apply curing agent	3	Stoddard solvent
Plumbing	Apply asphalt-based waterproofing agent	3	Toluene, Stoddard solvent, benzene
	Solder copper pipe	3	Zinc chloride, ammonium chloride, tin, antimony, copper, silver
	Connect PVC pipe	3	Methyl ethyl ketone
	Total	54	

Values (TLV[®]s).⁽¹⁰⁾ In cases where the REL, PEL, and TLV were different, the most stringent criterion was used to assess exposure, and hereafter is referred to as the occupational exposure limit (OEL). Nineteen of 24 15-minute duration air samples were collected to compare exposure values with applicable 15 minute short-term exposure limits (STELs). The remaining samples, including five 15-minute duration samples collected for substances lacking STELs, reflected the duration of a particular task, and were compared to the 8-hour time-weighted average exposure limit.

For workers who were monitored for two or more substances which exhibit similar toxicologic effects, (e.g., toluene and methyl ethyl ketone), exposure to the mixture was evaluated using the OSHA E_m calculation.⁽¹³⁾ The E_m is essentially a unity calculation that divides the exposure result for each analyte by the applicable OEL and then sums all of the resultant fractions for all of the analytes in the mixture. If the sum of the fractions exceeds unity (1.0), an over-exposure is indicated.

Noise

Noise measurements were obtained using a calibrated CEL 383 Sound Level Meter (CEL Instruments, Milford, NH) during tasks where noise levels appeared to be substantial. Specific equipment identified as having the potential for excessive noise exposure (i.e., >85 dBA) was monitored by placing the meter near the workers' ear and recording the result on the field data sheet. Also noted was the type of noise (i.e., continuous, intermittent, impact). All noise measurements were taken in peak or slow mode (dBA), depending on the duration of the task.

Vibration

Observations of potential vibration hazards were made during initial qualitative walk-through evaluations of the five project sites. Workers were observed during normal work practices using equipment that could potentially result in exposure to vibration. Notations

were made on the field data sheet as to whether the equipment imparted vibration to the entire body, the hand-arm region, or both. A detailed quantitative assessment of vibration hazards was outside the scope of this study.

Results

This study revealed a wide range of exposures, which reflect time-weighted averages over the sampling period or task (Table III). Results are presented for each trade based on the physical state of the agent: particulates (Table III.a) and organic solvents (Table III.b). This level of categorization is based on chemical constituents in the products used as well as hazards generated by a particular task (e.g., wood dust).

Chemical Agents

Drywall workers. Three samples were collected for respirable particulates while sanding walls and ceilings after the application and drying of joint compound. Exposure values ranged from non-detectable (ND) to 3.3 mg/m³. By comparison, the TLV-TWA for this agent is 3 mg/m³.

Insulation workers. Three samples were collected for workers who sprayed fibrous glass wool insulation between wall studs, attic rafters and floor joists. Exposure values ranged from 0.41 to 1.3 fibers/cc (f/cc); one sample exceeded the most stringent OEL of 1.0 f/cc. During this task, exposures typically lasted one hour with about an hour between exposures. Hence, the operators may receive exposure for approximately half of their eight-hour workday. On occasion, workers were observed wearing dust masks during the task.

Painters. Painters were exposed to a variety of organic solvents including those in lacquers, stains, paints, and cleaning compounds. Staining and lacquering were generally performed sequentially, so combined exposures to these products typically occurred. In the homes that were being built during this study, few were being treated with both stain and lacquer, so the samples collected are not representative of exposures

when both products are used. Painters who sprayed lacquer resulted in the highest solvent exposures. Of the two non-STEL samples collected, one indicated overexposure to toluene while two indicated unity values of 1.2 and 2.5 for the mixture. Of the two STEL samples, one exceeded the unity calculation (1.5) while the other was 0.5. The painters who performed these tasks did not wear a respirator. The single 60 minute sample collected during staining work indicated an exposure to toluene of 69 mg/m³ (40% of the TLV), with a unity value of 0.84 for the mixture. The latex paint product used for interior walls of the homes was labeled as containing ethylene glycol. Three short-term (duration-of-task) samples collected for ethylene glycol during the application of paint indicated exposures were less than the limit of detection, suggesting that exposures to this substance were negligible.

Plumbers. Soldering copper pipe was performed by plumbers using a soldering wire that contained elemental tin, antimony, copper and silver. The two samples collected for metal fume indicated one over-exposure to silver and copper (three and four times the OEL, respectively) while the other indicated very low exposures occurred for all four substances. Plumbers also used paste flux (containing ammonium chloride and zinc chloride) while soldering copper pipe. Since the OELs for these contaminants have STELs, samples were collected for 15 minutes. The single STEL sample collected indicated no detectable amount of either substance. Plumbers also used pipe cement containing methyl ethyl ketone to secure polyvinyl chloride (PVC) pipe connections. Three samples collected during this task revealed exposures less than 10 percent of the OEL.

Carpenters. During structural framing, carpenters were monitored for wood dust while cutting lumber. During this task, exposures ranged from none detected to 0.75 mg/m³ (OEL = 1 mg/m³). Carpenters also used a subfloor adhesive that contained various solvents, including toluene, Stoddard solvent, and benzene. Four short-term air samples

TABLE III.a
Task-based air sampling exposure data (mg/m³)—Particulates

Trade	Task	Sample time (mins)	Sample volume (L)	Diesel exhaust	Wood dust	Respirable PNOC	Respirable crystalline silica	Zinc chloride	Ammonium chloride	Tin	Antimony	Copper	Silver	Fibrous ^(A) glass
Excavation	Excavate lot	240	504	0.006										
		240	504	0.006										
		242	553	0.008										
Carpentry	Cutting lumber	240	480		0.31									
		71	121		0.58									
		117	199		0.75									
		57	112		0.45									
		80	157		<0.13									
Masonry	Mix mortar/cut brick	161	274			0.62	<0.11							
		182	309			0.29	<0.10							
		186	329			0.21	<0.09							
		186	316			0.10	<0.10							
		57	97			<0.21								
Drywall	Sand joint Cpd	70	119			3.30								0.41
		28	48			2.30								1.30
		98	216											0.68
Insulation	Blown-in insulation	87	174											
		65	150											
		60	102			<0.20								
Flooring	Sand wood floors	238	405			0.37								
	Cut wood floors	15	30											
Plumbing	Solder pipe	83	166											
		15	30											
	ACGIH—TLV			0.05	5	3	0.05					0.004	0.002	1
	NIOSH—REL			N/A	1	5	0.05					0.1	0.01	3
	OSHA—PEL			N/A	15	5	^c					0.1	0.01	N/A
	TLV—STEL							2	20	2	0.5	0.1	0.01	
	REL—STEL							2	20	2	0.5	0.1	0.01	

PNOc: particulates not otherwise classified.

TLV: Threshold Limit Value.

REL: Recommended Exposure Limit.

PEL: Permissible Exposure Limit.

STEL: short term exposure limit.

Values in **bold** exceed the occupational exposure limit for the duration of the task.

< indicates sample was below the limit of detection.

^AFibers/cc of air.

^BShould be compared to STEL.

^CPEL = 10/%silica+2.

^DCeiling limit.

MEK: methyl ethyl ketone.

MDA: methylene bisphenyl diisocyanate.

N/A: not applicable; no more than one substance measured above most stringent OEL.

TABLE III.b^A
Task-based air sampling exposure data (mg/m³)—Organic solvents

Trade	Task	Sample time (mins)	Sample volume (L)	Toluene	Xylenes	Isobutanol	Stoddard solvent	MEK	Isopropanol	Ethylene glycol	Benzene	MDI	Unity calculation for mixture	
Carpentry	Glue subfloor	15	3	1.2 ^B			<8.4 ^B				<0.67 ^B		N/A	
		15	3	0.6 ^B			<8.3 ^B				<0.67 ^B		N/A	
		15	3	<0.63 ^B			<7.8 ^B					<0.63 ^B		N/A
		15	3	0.8 ^B			<8.3 ^B					<0.67 ^B		N/A
Insulation	Foam insulation	15	16									<0.01 ^B		
		15	16									<0.01 ^B		
		15	16									<0.01 ^B		
Flooring	Install vinyl floor	6	6									<0.02 ^B		
		9	9.3									<0.01 ^B		
		5	5.2									<0.01 ^B		
Painting	Apply polyurethane	15	3				179 ^B							
		15	30											
	Install ceramic tile	15	30											
		15	30											
		15	30											
Painting	Spray lacquer	99	3.2	288	55	81	<7.8 ^B	31	149				2.5	
		240	38	121	38	50	12	21	21	37				1.2
	Apply stain	15	3	507 ^B	55 ^B	96 ^B	<8.3 ^B	17 ^B	272 ^B					1.5
		15	3	142 ^B	33 ^B	30 ^B	24 ^B	2.8 ^B	76 ^B					0.5
		60	12	69	26	22	19	50	75					0.84
Interior paint	Apply curing agent to flatwork	13	25											
		15	30											
		15	30											
		15	30											
Concrete	Apply curing agent to foundation	15	3				7.1 ^B						N/A	
		5	1				7.4 ^B						N/A	
		5	1				16 ^B						N/A	
		15	3	<0.68 ^B			6 ^B					<0.68 ^B	N/A	
Plumbing	Connect PVC pipe	15	3	<0.67 ^B			8 ^B						N/A	
		15	3	<0.78 ^B			16 ^B						N/A	
		15	3					76 ^B						
		15	3					81 ^B						
Plumbing	ACGIH—TLV	15	3					19 ^B						
		15	3	188	434	152	573	590	492	100 ^D				1
		15	3	377	434	152	350	590	983	N/A ^D				N/A
		15	3	754	434	303	2863	590	983	N/A ^D				1
		15	3	565	651	455	1718	885	983	8			0.15	
Plumbing	REL—STEL	15	3	565	651	N/A	1800	885	1229				0.2	
		15	3											

^A See footnotes to Table III.a.

collected during this task showed that toluene was the only solvent detected, at a concentration less than one percent of the OEL. The low exposure was not unexpected since the adhesive was used in an area that was well ventilated due to the lack of walls, roof and windows.

Flooring workers. Two samples were collected to assess flooring subcontractors' exposure to wood dust during cutting and sanding hardwood flooring. One sample obtained while cutting floor material indicated an exposure of 0.37 mg/m^3 (OEL = 3 mg/m^3) while the other sample (collected during sanding) was below the analytical detection limit ($< 0.20 \text{ mg/m}^3$). Also, due to the fact that finished wood floors were not common in the subdivisions sampled, only one short-term sample was collected during the task of applying polyurethane finish to the installed wood floor. This sample indicated that exposure to Stoddard solvent was approximately 10 percent of the OEL. Only a small section of the floor was being treated (i.e., $< 100 \text{ ft}^2$). Higher exposures to Stoddard solvent may occur when polyurethane is applied to larger areas, especially if the area is not well-ventilated.

Flooring contractors were also responsible for installing ceramic tile in bathrooms with mastic that contained ethylene glycol. Three short-term samples collected did not detect this contaminant. Similar negative results were

obtained for MDI samples collected while flooring contractors installed vinyl flooring using a small amount of an isocyanate-containing glue.

Excavation workers. Excavation workers were monitored for exposure to diesel exhaust. A total of three samples were collected, two for a backhoe operator and one for a worker assisting in the excavation who operated a laser grading device. All three samples indicated that exposure to elemental carbon, a surrogate measure for exposure to diesel exhaust, were approximately 0.01 mg/m^3 , less than 20 percent of the OEL of 0.05 mg/m^3 .

Masons. Masons were sampled for respirable particulate while mixing mortar, and for respirable crystalline silica while cutting brick. Initially, the intent was to collect separate samples for silica exposure from the masons while they mixed mortar and cut brick. However, it was not possible to effectively separate these two tasks so each sample collected was analyzed for both respirable particulates and respirable crystalline silica. Exposure values for the respirable particulates during mortar mixing ranged from 0.1 to 0.6 mg/m^3 (OEL = 3 mg/m^3). Respirable crystalline silica was not detected and was due to insufficient sample air volume as a result of the short duration of the task.

Concrete workers. During concrete work, a curing agent containing Stoddard

solvent was sprayed onto the surface of the newly-poured concrete. Exposure to Stoddard solvent ranged from 7 to 16 mg/m^3 , which, by comparison, is less than one percent of the OEL. This may be because a small quantity of product was used in outdoor areas. During water-proofing of poured concrete foundation walls, a paint roller was used to apply an asphalt-based coating to the exterior face of the foundation walls. Exposure to benzene and toluene were below the detectable limit while exposure to Stoddard solvent ranged from 6 to 16 mg/m^3 (less than one percent of the OEL).

Insulation workers. Isocyanate-containing foams were applied using an aerosol canister to seal gaps in the foundation and around windows and doors. The product label indicated the presence of methylene bisphenyl isocyanate (MDI). However, no samples collected showed any appreciable level of MDI.

Noise

Sound level measurements were obtained for those tasks that necessitated the use of noise producing tools and equipment as identified during the walk-through phase of this study (Table IV). Measurements ranged from 90 to 115 dBA. Given the high sound levels measured and the duration of exposure, it is likely that some of the worker exposures would exceed the OEL when measured on an 8-hour TWA basis. Therefore, it is

TABLE IV
Sound level measurements by trade and task

Trade	Task	Type of noise	Source	Duration	Average noise level (dBA)
Concrete	Cutting concrete expansion joints	Continuous	Concrete cutter	45 minutes	105 ^A
Carpentry	Securing siding	Impact	Nail gun	< 1 second	115 ^B
	Cutting trim material	Intermittent	Circular saw	3-5 seconds	90
	Moving supplies	Continuous	Bobcat material loader	1 hour	93
	Cutting siding	Intermittent	Circular saw	3-5 seconds	103
	Cutting lumber	Intermittent	Circular saw	3-5 seconds	103
Roofing	Installing roof shingles	Impact	Nail gun	< 1 second	115 ^B
HVAC	Installing/assembling sheet metal ducts	Impact	Sheet metal riveter	< 1 second	99
Flooring	Cutting ceramic tiles with wet saw	Intermittent	Circular saw	3-5 seconds	97

^ANIOSH REL indicates this task can be performed for 4 minutes, 43 seconds at this level.

^BNIOSH REL indicates this task can be performed for 28 seconds at this level.

TABLE V
Vibration hazards by trade and task

Trade	Task	Equipment used	Type
Excavation	Excavate/backfill	Backhoe/loader	Whole body
Carpentry	Cut/secure lumber	Circular saw, nail gun	Hand-arm
Masonry	Cut concrete	Concrete saw	Hand-arm
Roofing	Secure shingles	Nail gun	Hand-arm
Plumbing	Drill lumber to run pipe	Electric drill	Hand-arm
Electrical	Drill lumber to run electrical cable	Electric drill	Hand-arm
HVAC	Rivet sheet metal	Rivet gun	Hand-arm
Drywall	Drive drywall screws	Drill/screw gun	Hand-arm
Painting	Spray paint walls/ceilings	Airless sprayer	Hand-arm
Flooring	Cut floor planks	Circular saw	Hand-arm

clear that personal noise dosimetry should be performed to better characterize exposure in these trades.

Vibration

Numerous vibration hazards were apparent in the trades observed, as indicated in Table V. Hand-arm vibration hazards were the most common, predominantly from the use of power tools. Whole body vibration hazards also existed, such as those experienced by operators of heavy excavation equipment.

Discussion

Overexposures, as they relate to the appropriate OEL, were found for workers involved in sanding drywall joint compound (particulate), installing insulation (fibrous glass), lacquering (toluene), and soldering (elemental silver and copper). Respiratory protection was observed to be in use sporadically for drywall and insulation trades only (dust masks). Other forms of PPE, with the exception of leather gloves used by carpenters when handling lumber, were not evident. The fact that neither the general contractor nor the subcontractors had a formal, written respiratory protection program was also noted.

Detectable, but low exposures were noted for workers exposed to diesel exhaust (excavation), mortar and brick dust (mason), solvents in a concrete curing agent and waterproofing products (concrete), pipe cements (plumber), subfloor

adhesive (carpenter), and polyurethanes (flooring).

The major advantage of this type of study lies in the fact that estimates of task-specific exposure can be used to identify potentially hazardous jobs, and work practices that warrant better characterization of exposure. Another advantage was that specific tasks can be assigned an exposure value which can be used to determine how long a particular task can be performed before the OEL is exceeded. An example of this involves the painter who sprayed lacquer onto woodwork inside a home. Because the air sample indicated an exposure to mixed solvents of 2.5 over a period of 1.7 hours (the duration of the task), the amount of time the painter could conduct this task at the same exposure level before the OEL of unity (one) is exceeded would be three hours. Such an example only applies to tasks that result in an exposure greater than the OEL. Finally, appropriate control measures can be identified and implemented along with follow-up studies aimed at determining their effectiveness.

The task-based exposure assessment approach has been used previously to characterize worker exposure during welding and thermal cutting.⁽¹⁴⁾ However, that study examined more workers engaged in longer duration tasks than those presented here. Due to the fact that intra/inter day variability in work practices may have some effect on ex-

posure levels, it is unlikely that the limited number of samples collected during this study adequately reflect the range of worker exposure for most of the evaluated tasks. Thus, it is difficult to conclude from these results that over-exposures do not occur at other times. Another limitation of this study involved the mobility of the workforce and the logistical difficulty associated with tracking workers across job sites. Finally, it was noted that some short duration tasks did not allow the collection of sufficient sample volume to adequately quantitate exposure. In one case (masonry, cutting brick), the environmental limit of detection (laboratory detection limit divided by sample volume) for crystalline silica exceeded the OEL.

Overall, the level of cooperation on the part of the contractors was extremely good. In fact, the majority of the general contractors, subcontractors, supervisors, and employees indicated an interest in knowing what their exposure levels were and how they relate to the OEL; this information was provided to each group studied. While most contractors and subcontractors were aware of the safety hazards associated with their work (e.g., slip/trip/falls, electrocution, etc.), each voiced little concern over health hazards. This suggests that chemical and noise hazards have gone relatively unrecognized in this industry and warrant further investigation.

Conclusions

The limited sampling data acquired during this study indicate that selected subcontractor trade workers engaged in single-family home construction are overexposed to chemical agents during the execution of specific tasks. Potential exposure to noise and vibration hazards exists as well, based on sound level measurements and a qualitative assessment, respectively. Additionally, statistically-valid monitoring efforts are needed to develop a better understanding of specific tasks that pose the greatest health risk from exposure. However, the highest priority for additional monitoring should

be given to those trades and tasks where over-exposures occurred.

Avoiding and controlling exposures at the source is difficult for the workers studied here because they are mobile and often work under variable environmental conditions (i.e., open windows versus closed). Hence, the utilization of appropriate PPE is very important in reducing exposures. The majority of exposures fall into two categories: particulates and organic solvents. Therefore, selecting, using and maintaining the appropriate respirator for these hazards will effectively reduce exposure. For those workers exposed to noise, appropriate hearing protection will prove useful in reducing exposure to an acceptable level, especially in the concrete, carpentry, roofing, HVAC, and flooring trades. With respect to vibration hazards associated with the use of specific equipment (primarily hand-held power tools), efforts should be made to quantify the magnitude of exposure, especially in the excavation, carpentry, masonry, roofing, plumbing, electrical, HVAC, dry-wall, painting, and flooring trades.

In general, the results presented here should be interpreted with caution because of the low number of samples per task. This factor indicates that additional sampling is needed to better characterize exposure despite the fact that many samples were below OELs. However, this study also indicates that exposure to some contaminants may be above OELs. Thus, this range-finding study

helps identify some exposures of concern in addition to providing evidence that other previously unrecognized exposures are present at these types of construction sites.

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