Applied Occupational and Environmental Hygiene
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/uaoh20

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Published online: 30 Nov 2010.

Applied Occupational and Environmental Hygiene
Volume 15(12): 890–895, 2000
1047-322X/00 $12.00 + .00

Construction

Development of a Hazard Surveillance Methodology for Residential Construction

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Introduction

Currently, there are between six and eight million workers employed in the U. S. construction industry.[1] When compared to all other goods-producing industries, construction leads in the number of occupational injuries and illnesses.[2] This industry consists primarily of small contractors, each employing fewer than 10 workers. Small contractors employ 30 percent of all construction workers, and represent 82 percent of the total number of construction establishments.[3] Small contractors are not subject to the Occupational Safety and Health Administration's (OSHA) injury and illness reporting requirements, which are mandatory for employers with more than 10 employees. Considering that small establishments represent such a large segment of construction employers, it is likely that the injury and illness statistics for the industry are underestimated. Recent articles have identified potential chemical and physical hazard exposures in construction environments.[4,5,6] Specifically identified are exposures to hazardous solvents, wood dusts, noise, vibration, and temperature extremes, which are more common in construction than in other more traditional work environments.[5,6]

Beginning in January and continuing in May through July 1999, the National Institute for Occupational Safety and Health (NIOSH) investigators and their contractors conducted pilot studies in Columbus, Ohio and Denver, Colorado. The studies were conducted during different phases of residential construction performed by six general contracting companies and their subcontracted tradesmen. Investigators visited 20 residential construction sites (i.e., lots), consisting of different house floor plans. This surveillance research effort was initiated to develop a methodology for the identification and quantification of chemical and physical hazards in residential construction, an industry with a high percentage of small contractors. This report is intended to inform the reader of the chemical and physical hazard evaluation methodology developed by NIOSH for use on residential construction sites, and how it has been successfully applied within the recently completed pilot studies.

Methods/Results

Unlike many other industries, residential construction is very dynamic. Work sites can change daily, even many times daily. The diversity in tools, tasks, materials, workers, and workplaces makes chemical and physical hazard evaluations challenging in this work environment. Evaluation methods used in this industry need to reflect the flexibility and mobility of the workforce. Therefore, the NIOSH pilot studies utilized a task-based exposure assessment model (T-BEAM).[7] T-BEAM incorporates the idea that each occupation is potentially exposed to a unique combination of chemical and physical hazards that are inseparably associated with a defined task. The elements of the methodology developed within the T-BEAM include: (1) performing preliminary walk-through surveys, (2) investigating the frequency and magnitude of the identified or potential hazards, and (3) quantifying the identified or potential hazards.

Preliminary walk-through surveys were conducted on 20 residential construction sites encompassing different phases of construction. The walk-through surveys provided valuable information on:

1. Types and quantities of potential chemical and physical hazards by task,
2. Specific information on all products present on work sites (MSDSs, product labels),
3. Identification of exposed groups and personal work practices,
4. Length of time needed to complete tasks and how often that task was repeated, and
5. Whether any controls were in place to reduce or eliminate exposure to potential hazards.

Information gathered during the preliminary walk-through surveys was used to select specific potential hazards for further evaluation. This selection was based on the recognized health effect associated with the hazard[8,9] and the frequency of use or quantity of the hazard. From this selection process, a preliminary list of potential hazards by occupation and task was developed.

A sampling strategy was then developed to evaluate these potential hazards at the 20 residential construction sites. Collection of personal and area air samples, noise dosimetry and observational ergonomic and vibration risk factor data was planned for those occupations and tasks that exposed workers to the identified chemical and physical hazards. To quantify hazards more efficiently, they were grouped into four categories: solvents, particulates, noise, and ergonomic and vibration risk factors.

Solvents

Methods for sampling and analyzing solvents were identified using the NIOSH *Manual of Analytical Methods* (NMAM). To minimize the number of samples collected, the analytical laboratory was consulted to determine which methods could be combined or modified to enable the quantification of several solvents from a single sample. Table I lists those NMAM methods that were "combined" into a single method, which could then be used for quantifying multiple analytes from the same sample.

Other factors were considered before analyzing personal samples collected for a given occupation and task. These included estimates of the concentration of chemical contaminants in the work environment and the suspected presence of analytes based on MSDS information and survey observations. To help in making decisions about sample analysis, thermal desorption (TD) tubes were collected in the vicinity of workers sampled for solvents. The TD tube, using NMAM 2549, allowed for the identification of volatile organic compounds (VOCs) up to a molecular weight of 350. The TD tube analysis provided semiquantitative data on the concentration of VOCs in the sampled air to assist in selecting the most appropriate analysis methods for the personal samples collected. Compounds detected on the TD tube were also compared to the list of identified or potential chemical agents prepared during the walk-through surveys. This comparison ensured that chemical hazards were not overlooked when analyzing samples, and was useful in determining the presence of hazardous chemicals in the workplace, especially when MSDSs or product labels lacked this information. A flow chart detailing the methodology for sampling chemical agents is provided in Figure 1.

Particulates

When performing walk-through surveys, tasks that had the potential to generate dusts were identified, especially those that generated visible particulate "plumes." A real-time particle-sizing instrument (Grimm Technologies, Model 1.100) was used to determine the mass and size ranges of particulates generated for each task before selecting a sampling method to quantify personal exposures. The proper particulate sampling method (i.e., respirable or total) was selected using the mass and size range data from the real-time instrument. When the mass median diameter (MMD) for sampled particulates using the real-time instrument was 4 μm or less, respirable sampling using a 10-mm cyclone (NMAM 0600) was conducted.[10,11] If particle size ranges exceeded a MMD of 4 μm or could not be narrowly characterized, total particulate sampling (NMAM 0500) was utilized. On worksites where specific types of particulate matter, such as diesel exhaust or crystalline silica, were known or suspected to be present, the specific collection and analytical methods (NMAM 5040 and 7500, respectively) were used.

Noise

Construction tasks have been found to generate sound pressure levels (SPLs) in excess of 85 decibels (dBA) with peak SPLs of 130 dBA reported for certain tasks.[12] For this reason, noise exposure evaluations were included in the T-BEAM evaluation. During the walk-through surveys, a sound level meter was used to measure SPLs near workers performing noise-generating tasks. Workers performing tasks with SPLs above 85 dBA were subsequently sampled for the duration of the task using personal noise dosimeters. Workers monitored for noise exposure included those using impact tools, saws or cutting tools, compressed air, and combustion-powered equipment.

Ergonomic and Vibration Risk Factors

Ergonomic and vibration risk factors by occupation and/or tasks were also recorded in the NIOSH surveys. All occupations were evaluated for work postures, limb manipulation and transport movements, lifting postures, and vibration. No data on applied force or number of repetitions were collected. Data collection was limited to onsite observations, and questionnaires were administered while workers performed their tasks. As ergonomic hazard data were collected, it was differentiated into nine categories:[13]

1. Passive postures—stationary standing or sitting;
2. Awkward postures—bending, contorting, or deviating limbs of the body for prolonged periods to perform a work task;
3. Lifting postures—frequent bending of the torso or back to lift materials;
4. Arm transport movements—moving small or light objects with the arms;
5. Shoulder transport movements—similar to arm transport, except force from the torso is involved;
6. Hand and wrist manipulation—using the hand and wrist primarily to perform tasks;

TABLE I
Combined analytical methods for solvents

NMAM methods	Analytes
1403, 1450, 1500, 1501, 1550	Butyl cellosolve, isobutyl acetate, isobutyl isobutyrate, stoddard solvent, toluene, xylene
1300, 1301, 1500, 1609	Acetone, tetrahydrofuran, toluene, cyclohexanone
1500, 1501, 1550	Toluene, xylene, stoddard solvent, trimethylbenzene
1400, 1401	Ethyl, tert-butyl, isopropyl, and isobutyl alcohol
1300, 1609	Cyclohexanone, tetrahydrofuran

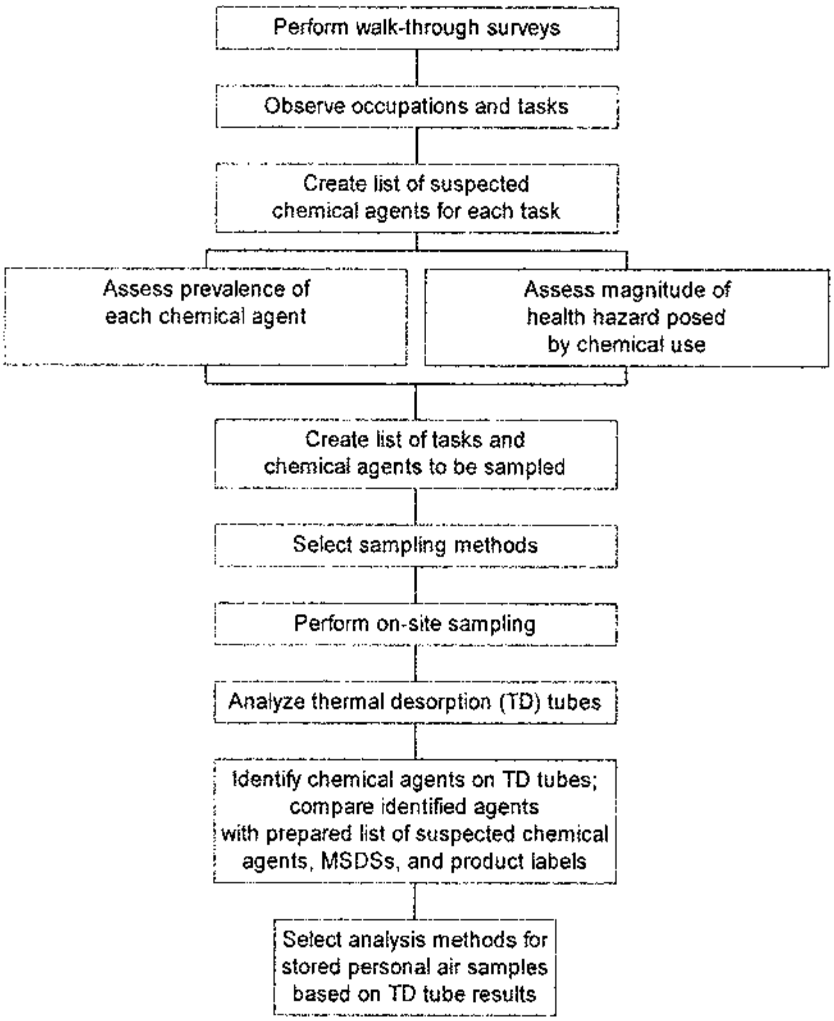

FIGURE 1
Methodology for sampling chemical agents.

7. Finger manipulation—using the fingers primarily to perform tasks;
8. Whole body vibration—whole body is exposed to vibration;
9. Segmental vibration—parts of the body (i.e., hands and arms) are exposed to vibration.

These categories were selected because they provide a simple, yet comprehensive profile of ergonomic and vibration hazards for subsequent evaluation by an ergonomist. Since vibration measurements were not taken, a questionnaire was administered to residential construction workers exposed to vibrating tools and equipment to determine the scope of reported health effects. Information from the questionnaire was used to help discern if reported health effects may have been from exposure to vibration or other physical factors.

Based on the 20 worksites visited, a listing of the identified chemical and physical hazards by task is presented in Table II.

Discussion and Conclusions

Conducting chemical and physical hazard evaluations on any construction site is uniquely different from other workplace evaluations. The diversity in tools, tasks, materials, workplaces, and the mobility of the workers makes hazard evaluations challenging in this work environment. This hazard surveillance research effort was initiated to develop a methodology for the identification and quantification of chemical and physical hazards in the residential construction industry. This research allowed for the creation of a dynamic methodology, which permits evaluation of a wide range of workplace and environmental contaminants. Classification of contaminants into four categories allowed for a more rapid evaluation of chemical and physical hazards on residential construction sites. Selection of the categories was based on observations made during the NIOSH pilot studies. The use of the categories may not be appropriate for all residential construction sites. Specific chemical and physical hazards were selected by site, based on the frequency and magnitude of the hazard posed by each contaminant present.

Evaluation methods used on specific sites should reflect the chemical and physical hazards identified. The T-BEAM was utilized for the NIOSH pilot studies because most tasks were short-duration and workers were often unavailable for sampling (i.e., at another job site) once the task was completed. Site evaluations to identify and evaluate hazards should be performed by a health and safety professional, such as an industrial hygienist, who is familiar with construction activities. It has been observed that many occupational hazards exist for the residential construction workforce including crystalline silica, mixed solvents, noise, and ergonomic and vibration risk factors, and that, if uncontrolled, can make construction work excessively hazardous. Presently, information gaps exist in the identification and quantification of exposures among construction workers, which underscores the need to continue performing chemical and physical hazard evaluations of residential construction work sites.

Currently, NIOSH is analyzing residential construction hazard evaluation data from the pilot studies conducted in Ohio and Colorado. Once analyses are complete, findings from the T-BEAM data collected will be disseminated. For further information on topics of interest in construction, NIOSH reports and other publications may be obtained by accessing the NIOSH web site at http://www.cdc.gov/niosh/pubs.html or calling 1-800-35-NIOSH.

TABLE II
Identified chemical and physical hazards by task

Construction phase	Occupation	Tasks	Identified chemical and physical hazards with analytical methods[A]
Carpentry	Finish carpenter	Apply glue, make and install cabinets	Acetone (1300); Hexane (1500); Toluene (1500)
		Install windows, doors, trim wood, make and install cabinets, sand, nail, and saw wood	Inhalable crystalline silica (7500); Inhalable PNOC (0500)
		Apply glue, make and install cabinets, install windows, doors, trim wood, sand, nail, and saw wood	Noise (Dosimeter); Vibration (Questionnaire)
	Framing carpenter	Apply plywood subfloor glue	Toluene (1500); Benzene (1500); Stoddard solvent (1550)
		Frame floors, walls, install roof trusses, OSB sheeting stairs	Inhalable crystalline silica (7500); Inhalable PNOC (0500)
		Frame floors, walls, install roof trusses, OSB sheeting, stairs, apply plywood subfloor glue	Noise (Dosimeter); Vibration (Questionnaire)
		Frame deck	Inhalable PNOC (0500)
Drywall	Drywall finisher	Sand interior drywall	Inhalable crystalline silica (7500); Inhalable PNOC (0500); Respirable PNOC (0600)
Excavation	Heavy equipment operator	Excavate lot, dig trenches, backfill trenches and foundations, grade dirt, clean up debris	Diesel exhaust (5040); Noise (Dosimeter); Vibration (Questionnaire)
Exterior finishing	Asphalt paver	Perform driveway paving tasks	Asphalt fume (5042); Benzene (1500); Inhalable PNOC (0500); Stoddard solvent (1550); Toluene (1500); Xylene (1501); Noise (Dosimeter); Vibration (Questionnaire)
	Mason	Caulk around windows adjoining stone or brick fascia	Trimethylbenzene (1501); Xylene (1501)
		Cut and lay cinder block, brick, and stonework install stone or brick fascia on outside walls, mix mortar	Inhalable crystalline silica (7500); Inhalable PNOC (0500); Noise (Dosimeter)
		Mix mortar	Chromium (7300); Respirable crystalline silica (7500); Respirable PNOC (0600)
Finish mechanics	Ceramic tile installer	Install ceramic bath, kitchen floor, and wall tile using mastic	Benzene (1500); Stoddard solvent (1550); Toluene (1500); Xylene (1501)
		Cut and install ceramic bath, kitchen floor, and wall tile	Inhalable PNOC (0500)
		Cut ceramic bath, kitchen floor, and wall tile	Respirable crystalline silica (7500)
Flooring/carpeting	Floor preparation technician	Clean up activities	Inhalable crystalline silica (7500); Inhalable PNOC (0500)
	Flooring installer	Apply polyurethane sealer	Stoddard solvent (1550)
		Install ceramic tile on floor using mastic	Ethylene glycol (5523)
		Install vinyl using vinyl glue	Methylene bisphenyl isocyanate (ID-47)
		Install wood floors	Respirable PNOC (0600)

Construction phase	Occupation	Tasks	Identified chemical and physical hazards with analytical methods[A]
Foundation pouring	Concrete worker	Apply concrete curing agent	Benzene (1500); Stoddard solvent (1550); Toluene (1500); Xylene (1501); Trimethylbenzene (1501)
		Build forms, pour/trowel concrete	Inhalable crystalline silica (7500); Inhalable PNOC (0500)
	Waterproofing worker	Apply liquid waterproofing material	Benzene (1500); Stoddard solvent (1550); Toluene (1500)
Painting	Painter	Apply paint, stain, and lacquer to interior and exterior of home	Benzene (1500); Butyl cellosolve (1403); Ethanol (1400); Ethylene glycol (5523); Isobutanol (1401); Isobutyl acetate (1450); Isobutyl isobutyrate (1450); Isopropanol (1400); Methyl ethyl ketone (2500); Propylene glycol (5523); Stoddard solvent (1550); tert-Butyl alcohol (1400); Toluene (1500); Xylene (1501)
Rough mechanics	Plumber	Install PVC water pipes using pipe cleaner and pipe cement	Acetone (1301); Cyclohexanone (1300); Methyl ethyl ketone (2500); Tetrahydrofuran (1609); Toluene (1500)
		Solder copper water pipes	Ammonium chloride (ID-188); Antimony (ID-121); Cooper (ID-121); Silver (ID-121); Tin (ID-121); Zinc Chloride fume (ID-121)
		Install water, sewer and gas pipes in home, attach house lines to public utilities	Noise (Dosimeter)
	Pre-drywall worker	Apply insulating spray foam	Methylene bisphenyl isocyanate (ID-47)
		Install blown-in and rolled batts of insulation materials	Fibrous glass wool (0500)
		Install insulating materials in living area of home	Noise (Dosimeter)

[A]OSHA analytical methods are prefixed 'ID.' All others are NIOSH analytical methods.

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