Final Report

An Investigation of Health Hazards on a New Construction Project

Scott Schneider, CIH, and Pam Susie, MSPH

Occupational Health Foundation

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This study was conducted under a cooperative agreement between the Center to Protect Workers' Rights (CPWR) and the National Institute for Occupational Safety and Health (NIOSH). CPWR — the research and development arm of the Building and Construction Trades Department of the AFL-CIO — is uniquely situated to serve workers, contractors, and the scientific community. A major CPWR activity is to improve safety and health in the construction industry in the United States. This report is part of that effort.

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Contents

According to the Bureau of Labor Statistics (BLS), approximately 700 construction workers were killed on the job in 1990. As alarming as this number is, the BLS concedes that it may underestimate the number of deaths. With 25 percent of all occupational fatalities, construction stands out as the industry division with the highest number of deaths. Clearly, construction is a dangerous industry and construction workers know it. The immediate reality of deaths on the job may overshadow the fact that construction workers also face serious long-term health hazards on the job.

The National Institute for Occupational Safety and Health (NIOSH) has documented at least 77 toxic agents on construction sites. The agency has also found elevated death rates as a result of cancer and other diseases among construction workers. To date, however, little exposure monitoring has been done and reports in the literature about exposure levels on these jobs are rare. The goal of the investigation of health hazards on the new construction project — the study underlying this report — was to document the range and magnitude of exposures associated with construction work. Such information permits evaluation of the health risks posed by exposures and provides a basis for recommending suitable control methods.

We chose to start with a new construction project because we thought it would present a "cleaner" problem than looking at a renovation or demolition site where the exposure picture would be complicated by materials already in place, such as asbestos and lead. We intended to identify all chemicals scheduled for use and document exposures throughout a construction project in order to determine the full range and magnitude of potential exposures.

In addition to chemical exposures, we set out to measure noise exposures and identify potential ergonomic hazards for further investigation and intervention. Noise is a well-known hazard of construction work but little exposure monitoring has been done. Ergonomic injuries are also widespread among construction workers but have received little attention, at least in the United States.

The focus of the study was a new office construction project in the Washington, DC area. The project was a four-story steel structure which now serves as headquarters for the International Association of Machinists and Aerospace Workers. The construction project began in April of 1991 and was completed in July of 1992. The general contractor was James G. Davis Corporation. Twenty-five subcontractors were on site at different stages of construction. No more than 150 workers were working on the site at any time.

Over the course of the project, we did the following:

- Attended bimonthly Project Planning Committee meetings composed of union safety stewards, contractor representatives, the Center to Protect Workers' Rights (CPWR), the Occupational Health Foundation (OHF),[1] and the George Washington University occupational medicine program (GWU). During these meetings upcoming work was discussed and potential exposures were identified. We discussed their activities and presented sampling results. Minutes of these meetings are recorded and provide documentation of the chronological occurrence of various activities and associated exposures.

[1]The Occupational Health Foundation, a companion organization to CPWR within the AFL-CIO, provides technical services to union affiliates.

- Conducted routine site walk-throughs. Many brief, intermittent chemical exposures occur during construction work. The transience of such exposures prevents accurate characterization. In order to document the occurrences of such exposures, we began attempting during walk-throughs to track potential exposures by generating lists of chemicals on site.
- Collected samples of exposures to noise, mineral wool, asphalt fumes, welding fumes, silica, paint mists, solvents, dusts, and epoxy resins.
- Videotaped and analyzed work processes for ergonomic hazards.
- Provided recommendations and information to contractors and workers on topics such as noise levels and hearing protection, silica exposure and NIOSH-approved respiratory protection, and welding fumes and appropriate controls.

Sampling Methods and Results

Noise

Noise was a significant exposure hazard throughout the project. Time-weighted-average noise dosimetry measurements of crafts engaged in various operations ranged from 74 dBA (decibels) to 104 dBA. The arithmetic mean of 29 exposure measurements was 90.25 dBA with a standard deviation of 1.96. The standard for noise exposure set by OSHA (the Occupational Safety and Health Administration) is a time-weighted-average of 90 dBA over an 8-hour day; however, the OSHA standard is generally recognized as not adequate. Most of the study's measurements were not full shift (8-hour) samples. Because impact noise is also a problem in construction, the exposures were potentially injurious. In the early months, earth-moving equipment was a significant source of noise. Power tools, compressors, and generators continued to create high sound levels throughout the project. Sound levels associated with 17 types of common construction equipment were measured (see appendix A for detailed results).

Ergonomic Hazards

We videotaped several processes and conducting ergonomic task analyses for ironworkers and others. (Ergonomic task analyses are in appendix B). Ergonomic hazards are common in construction work. Much of the work must be done at floor or ceiling level and involves a lot of heavy-materials handling. During the early months of this project, when workers hand tamped soil, hand-arm vibration exposures appeared to be high. Hand-arm vibration exposure also appeared to be significant among laborers using jackhammers and pneumatic chipping hammers. On a new construction project, it is not uncommon to discover errors that require newly poured concrete to be chipped out. During our investigation, an entire flight of concrete steps had to be broken up with a jackhammer, while edges of concrete slabs had to be chipped out. In addition, whole-body vibration appeared to be significant for operators of earth-moving and other heavy equipment. (See CPWR report no. E1-93.)

Chemical Hazards

Mineral wool. Fireproofing composed of a resin-coated slag or rock wool was sprayed on steel beams and columns in the fall of 1991. Multiple crafts were exposed to these fibers during initial application and when working around insulated surfaces. Workers complained about eye and skin irritation from the fibers. Samples were collected to determine worker exposure to respirable and total fibers. Exposures to respirable fibers (fibers> 3 μm[2] in length and <3.5 μm in diameter) ranged from 0.006 to 0.039 f/cc with a geometric mean exposure of 0.020 f/cc (n=9). Exposures to total fibers ranged from 0.016 to 0.062 f/cc with a geometric mean exposure of 0.034 f/cc (n=10). (Summaries of the results from the major chemical exposures sampled are in appendix C and "exposure lists" of potential exposures are in appendix D.)

Asphalt fumes. In the winter of 1991-92, roofers installed a 4-ply roof system on the building. This process involved layering insulation and felt paper with several coats of hot asphalt. Cylinders of asphalt were heated on site in a kettle maintained at approximately 500^0F. Liquid asphalt was poured from a spigot at the bottom of the kettle into 5-gallon buckets and carried to mobile mop buckets. Roofers spread hot asphalt with cotton mops.

Personal breathing zone (PBZ) exposures to total particulates and the benzene soluble fraction of asphalt fumes were collected during January and February of 1992. The kettle operator had the highest exposures, which ranged from 10.4 mg/m^3 to 28.85 mg/m^3 total particulates. Other roofing crew members were sampled while carrying asphalt, while mopping, rolling out felt paper, and cutting in insulation. Exposures during these operations were lower than those received by the kettle operator by 2 to 3 orders of magnitude.

[2] μm is a microgram, one-millionth of a gram.

In addition to collecting time-weighted-average exposures using pumps and filters, instantaneous real-time data were collected using a hand-held aerosol monitor and data logger provided to us by NIOSH. Work processes monitored using real-time techniques were also videotaped. Results were synchronized with videotapes by the Engineering Controls Technology Branch of NIOSH. These videos provide us with a visual record of instantaneous asphalt fume exposures during kettle operation and hot asphalt mopping.

Laborers and operating engineers working on asphalt paving crews were also monitored for exposure to total particulates and benzene soluble particulates. Exposures to total asphalt fume particulates ranged from <0.20 to 0.59 mg/m^3 with a geometric mean of 0.34 mg/m^3 (n=3) Exposures to the benzene soluble particulates ranged from <0.05-0.29 mg/m^3 with a geometric mean of 0.08 mg/m^3 (n=5).

Welding fumes. Two crafts welded on site during the project: ironworkers and steamfitters. Sheet metal workers welded duct work in the shop and brought out fabricated modules to the site. So, welding exposures occurred off site also (but were not measured for this study).

Ironworkers on the structural steel erection crew were engaged in three general welding activities:

- Arc welding structural steel columns and beams
- Arc welding galvanized decking to structural steel
- Resistance welding metal studs to galvanized decking.

Exposures were sampled outside the welding hood during each of these processes. Exposures to total welding fumes during flux core welding structural steel were 3.78 and 2.63 mg/m^3. An exposure to total metal fumes measured during low hydrogen stick welding of structural steel was 6.43 mg/m^3. Exposures to metal fumes measured during stick welding galvanized decking to structural steel were 1.59 and 0.807 mg/m^3. Zinc exposures associated with these samples were 0.347 and 0.0722 mg/m^3, respectively. Resistance welding metal studs to galvanized decking produced a total fume exposure of 1.97 mg/m^3, with a zinc exposure of 0.542 mg/m^3.

In November 1991, steamfitters began arc welding carbon steel pipe used to construct the chiller system. Iron and manganese were the principal components of welding fume samples collected during this type of welding. Simultaneous real-time-exposure video monitoring was conducted inside and outside the welding hood in December. Tom Cooper and Margie Edmonds, of the NIOSH Engineering Control Technology Branch, assisted us in these efforts. Steamfitters remained on the site throughout the duration of the project with the bulk of work being completed in April of 1992. Exposure monitoring continued throughout this period. Real-time videos were shown to members of the welding crew and contractors at a site meeting. The principal metal fume exposures associated with welding carbon steel were iron oxide and manganese fumes. Exposures to iron oxide fumes ranged from 0.52 to 5.29 mg/m^3 with a geometric mean of 2.33 mg/m^3 and a geometric standard deviation of 2.11 (n=9). Exposures to manganese ranged between 0.05 to 0.71 mg/m^3 with a geometric mean exposure of 0.14 mg/m^3 and a geometric standard deviation of 2.99 (n=9). Exposures to two measurements of total fume were 2.52 and 9.18 mg/m^3.

Ironworkers returned in the final months of the job to install steel, circular stairs, and hand rails. The installations involved welding painted steel. Low-level exposure to lead (<0.019 and 37 ug/m^3), in addition to iron (0.108 and 0.535 mg/m^3) and manganese (0.011 and 0.027 mg/m^3), was measured during this process.

Dusts and quartz. In April and May of 1992 a two-person crew sandblasted low exterior concrete walls of the building. This was done to pit the concrete surfaces to create an appearance similar to the granite sheathing on the exterior panels of the building. Dennis Groce and Ken Linch of the NIOSH Respiratory Disease Division visited the site during one day of sampling. OHF and NIOSH conducted air sampling inside and outside the abrasive blasting helmet. We also collected one personal sample from a plasterer working approximately 20 to 30 feet from the blasting operation. There were a number of other dust generating activities that were sampled during the project including drywall sanding, cutting concrete paving blocks, jackhammering and chipping concrete, and dry sweeping. Personal exposures during these activities were collected and analyzed for total and respirable dust concentrations (table 1). Samples were further analyzed for quartz content.

Table 1. Dust and Quartz Exposures on IAM Site

Process	*Type of exposure*	*Results* in mg/m^3 (n=no. of samples)
Cutting/laying/ chipping concrete	Respirable concrete dust	0.86 - 1.07 (n=2)
Cutting/laying/ tamping concrete	Total concrete dust	1.98 - 4.89 (n=5)
Dry sweeping	Total dust	9.35 - 15.00 (n=1)
Dry sweeping	Respirable dust	0.89 (n=1)
Sanding drywall	Respirable gypsum dust	1.77 - 4.20 (n=3)
Sanding drywall	Total gypsum dust	25.30 - 59.74 (n=2)
Sandblasting	Respirable quartz outside helmet	<0.22 - 4.69 (n=4)
Sandblasting	Respirable quartz inside helmet	<0.05 - 0.06 (n=4)
Plastering near sandblasting	Respirable quartz	0.21 (n=1)
Cutting/chipping concrete	Respirable quartz	0.07 - 0.34 (n=2)
Grinding terrazzo	Respirable quartz	0.08 (n=1)
Cutting/laying/ tamping concrete	Total quartz	0.16 - 0.62 (n=3)
Sanding drywall	Total quartz	0.23 (n=1)
Grinding terrazzo	Total quartz	0.07 (n=1)

Epoxy resin. A large quantity (several 55 gallon drums) of epoxy resins was used for terrazzo floors. Smaller amounts were also used in paint systems. Monitoring the terrazzo process is a complex task because multiple two-part systems were used and the work occurs in successive stages, with chemical exposures varying with each respective stage. The steps were

(1) application of a two-part epoxy resin primer, (2) spreading of the terrazzo mixture (marble chips/dust/epoxy resins), and (3) grinding and buffing. A minimum of four hours drying time is required between steps 1 and 2 and about 24 hours is allowed to lapse between steps 2 and 3. Consequently, sampling was called off some days because the terrazzo crew was between applications. The MSDSs for the epoxy resins did not identify the hazardous ingredient by chemical name. The manufacturer's initial resistance to releasing this information hampered our ability to accurately sample exposures. A small number of samples were collected and analyzed for solvents, epichlorohydrin, and respirable dust. And a bulk sample of terrazzo dust captured by the vacuum trap of the buffing machine was analyzed. The bulk analysis indicated that the dust was — by percent weight — 59.2 percent calcium rich, 1.5 percent quartz (1.0 percent < 10 μm aerodynamic diameter (AD) and 0.27 percent was <5 μm AD), 35.1 percent dolomite, 1.1 percent calcium-silicates, 0.5 percent feldspar, 0.7 percent muscovite, and 1.9 percent miscellaneous. Personal sampling results indicated relatively low inhalation exposure to epichlorohydrin and organic solvents. But because of the reasons described above, these results do not provide a meaningful characterization of exposures associated with terrazzo work.

Communication of Results

At the completion of the project, results were presented to a workshop at the AFL-CIO National Safety and Health Conference in September 1992 in Washington, D.C.; a CPWR-GWU sponsored Conference on Construction Safety and Health at the Machinist's Building on October 15, 1992; and the American Public Health Association Conference in Washington, DC in November 1992. Additional presentations are planned for the American Industrial Hygiene Conference in New Orleans in May 1993.

Results and worker fact sheets generated on the major hazards were distributed to every local union and subcontractor involved in the project. Copies were also sent to all the relevant international union safety and health representatives, the National Building and Construction Trades Department, and the local Building and Construction Trades Council. (Copies of the fact sheets are in appendix E.)

A review article on Ergonomics and Construction has been submitted for publication to the American Industrial Hygiene Association Journal. Additional scientific review articles are planned on noise and chemical hazards.

In addition, copies of the videotape showing real-time asphalt fume exposures were given to the United Union of Roofers, Waterproofers and Allied Workers' Health & Safety Office for use as a training resource. Copies of the real-time video showing welding fume exposures have been sent to the Sheet Metal Workers National Training Fund, the Welding Institute of Canada, Plumbers Local #519, and the Washington D.C. United Association Apprenticeship Training Facility.

Discussion

The principal hazards observed were ergonomic hazards, noise, mineral wool, asphalt fumes, welding fumes, solvents, epoxy resins, and dusts — including silica, concrete, and gypsum dust. The highest exposures were asphalt fumes among roofers with extremely high exposure to kettle operators; total and respirable quartz exposure to laborers, terrazzo workers, and plasterers and cement masons; and total gypsum dust exposures among drywall finishers.

Ergonomic hazards were prevalent throughout the project. Several observed work processes involved twisting, awkward postures, heavy lifting and exposure to vibration. Terrazzo workers, tile setters and carpet layers spent long periods of time working on their knees and are likely to be at elevated risk for knee injury.

High *noise* exposure was common to all trades. In the early months of the project, there were efforts made to encourage workers to use hearing protection. Cross-shift hearing examinations of workers conducted by George Washington University in conjunction with exposure measurements of tested workers demonstrated a positive correlation between cross-shift hearing threshold shifts and time-weighted sound-level exposure measurements. (Cross-shift examinations compare results at the beginning and end of a shift.) Results of monitoring were presented to workers at a tool box safety talk (these talks are held on site before work begins). The general contractor also made hearing protection available to his employees. Despite these efforts, however, attempts to get workers to wear hearing protection were largely unsuccessful. Lack of product durability, convenience, and comfort limit the use of hearing protection among construction workers. There are also concerns that hearing protection will impede communication among workers. This could make working more difficult and possibly hinder ability to hear warning sounds.

Observations from this project indicate that source control of noise through equipment engineering would be much more effective than personal protective equipment in preventing hearing loss among construction workers. Until OSHA and the unions make construction noise a priority, it is unlikely that contractors will spend the extra money to purchase quieter equipment or retrofit old equipment. The burden then falls on the use of hearing protection and the hearing protection program. Unfortunately, OSHA'S Hearing Conservation Amendment (1910.95 c) does not apply to construction. There is a great need for better hearing conservation programs on construction sites to prevent hearing loss among workers. The extension of OSHA's Hearing Conservation Amendment to construction would help greatly to increase contractor and worker awareness of the problem and increase prevention efforts.

Exposures to respirable (3.5 μm diameter =< fibers >= 10 μm length) *slag or rock wool* were relatively low. A relatively high percentage of the collected fibers were within the respirable size range. Fibers may be retained on the electrically conductive cowls used to sample. The literature reports deposition of as much as 58 percent of fibers on the interior of the cowl due to these effects. Although most sampling involved the insulating crew, the single highest measured exposure was received by an electrician pulling cable above the ceiling level. This work occurred approximately 3 months after the insulation application had been completed and insulation was dry and brittle. In addition, this task required that work be carried out in very close proximity to the sprayed surface. Skin exposure to mineral wool was one of the biggest complaints among workers. These exposures should be quantified on future jobs using collection media on the skin or clothing.

The exposures to mineral wool are an example of the significance of *bystander exposure* among construction workers. Similarly, the highest exposure to *respirable quartz* generated from sandblasting was received by a plasterer working near a sandblasting operation. While the sandblasting crew was equipped with Type CE Bullard Blasting helmets, the plasterer worked totally unprotected.

Real-time video monitoring of *welding fume* exposures taken inside the welding hood versus sampling on the collar illustrated some interesting distinctions. Average exposures on the collar were approximately twice exposures in the hood. However, the carbon steel pipe that was being welded, at times, functioned as a chimney, concentrating fumes in an upward plume. Exposures in the hood spiked when the welder leaned into the plume. In addition, the welder spent a considerable amount of time with the hood up when cleaning welds. On these occasions, collar samples may be more representative of exposure than those taken in the hood. Time analysis of these videos using collar exposures when the hood was up and hood exposures when the hood was down would yield a more accurate measurement of actual exposures. A sample holder is now available that attaches to the head band of the welding hood and permits sampling in the breathing zone of the worker at all times whether the welding hood is up or down. Exposure to welding gases also needs to be studied.

Asphalt fume exposures to the kettle operator were extremely high. We are planning to analyze real-time videos to isolate periods of high exposure and use these observations to recommend process controls. Clearly, redesign of the kettle must be considered due to the high exposures of the kettle operator and the amount of time the operator must spend near the kettle. Simple work practice controls, such as minimizing time spent near the kettle and leaving the kettle lid closed whenever possible, are also likely to reduce exposures.

Dusts are a major form of chemical exposure in construction. Dry sweeping, dry-wall sanding, mortar mixing, sandblasting, cutting bricks, blocks and wood, blowing insulation, tamping concrete paving stones and buffing terrazzo floors were all dust creating activities observed on this job. Because of the quartz content of building materials, many of these dust generating activities also created exposure to total and respirable *quartz dust.* There seemed to be little worker awareness of the hazards of these materials. For instance, one of the sandblasters was not aware that silica was a respiratory hazard and was not initially wearing an abrasive blasting helmet. After exposure results were sent to the union locals and subcontractors with fact sheets about the hazards, the subcontractor who was doing the sandblasting inquired about what he could do to reduce exposures; the subcontractor is now seriously considering using alternative abrasives.

Assessment of exposures associated with *terrazzo work* warrants greater focused attention. Such an assessment should include representative sampling during each sampling stage. Wipe sampling should also be conducted to determine skin exposure because of the sensitization properties of epoxy resins.

Conclusions and Procedural Recommendations

Our investigation indicates that there are a number of chemical exposures on construction sites for which few, if any, controls are used. Noise and ergonomic hazards are prevalent and universal to all trades. Exposure to hazardous particulates such as asphalt fumes, welding fumes, and quartz bearing dust are also widespread. There appears to be a general lack of awareness on construction sites of these hazards. This is especially true because many chemical hazards are "hidden" in dusts, such as concrete and sand, which are not perceived by many workers and contractors to be hazardous. There is a strong need for engineering and implementation of controls for identified hazards. There is also a need for greater hazard communication to workers, contractors, and union representatives about construction health hazards.

Our experience on this site underscores the difficulty in tracking the use of chemicals on a worksite. Although multiple crafts work side by side, there is little coordination among the subcontractors for whom they work regarding chemical use and exposures. A better system for coordinating and controlling chemical use and exposures on the site is needed. A checkpoint system that requires contractors to register the chemicals being used, how others may be affected, and how exposures may be controlled is desirable. Greater consideration of chemical use and potential exposures during the planning stages of a project is also needed. Bystander exposures, for instance, could be reduced by having areas where access is restricted to only those using the chemicals who are properly protected.

In addition, more focus is needed on identification of chemical exposures associated with specific tasks. Because exposures tend to be episodic and transient in construction, knowledge of exposure ranges are needed to anticipate what exposures might be and plan minimum protective measures (controls or protective equipment) accordingly. An exposure assessment and control strategy needs to be the focus of a major research effort in the next few years.

The widespread hearing loss among construction workers warrants an aggressive effort to attack the problem. A greater effort to improve hearing conservation programs in construction is needed. The OSHA Hearing Conservation Amendment (1910.95 c) requires noise surveys, annual hearing tests, and worker training in addition to provision of hearing protection for exposures above 85 dB, well below the OSHA limit of 90
ydB. Currently though it does not apply to the construction industry. In order to properly protect construction workers from hearing loss, a movement and/or petition to extend the hearing conservation requirements to construction is necessary. Increased training of contractors and workers will cultivate greater awareness of the problem. Contractor awareness of the seriousness of this hazard will promote greater consideration of noise when purchasing new equipment. Workers will also be more willing to participate in a hearing protection program.

Control of ergonomic hazards in construction will require better identification of hazardous tasks; quantification of the hazards to aid in prioritization of the problems; and work with workers, contractors, and tool manufacturers to devise solutions and proper implementation. Many solutions have already been devised— for example, new tool designs from Sweden. Where solutions have been devised, the task is to devise ways to get them onto worksites and into use. Introduction of new technology can be difficult and has to be done with the active involvement of the affected trades. Other ergonomic solutions will come from the workers themselves, who are most familiar with the work and who know what could or should be changed to make the jobs less injurious. Worker training on the recognition of hazards and discussions on how to change work procedures are essential to this process.

Hazard communication is a major problem in construction as evidenced by the large number of contractors cited by OSHA for violations. (It is the most common citation in the construction industry currently.) Tool box talks may not be an effective means of teaching the nature of chemical hazards on the job and how to control them. Many joint labor-management hazard communication training programs have found that at least four hours of quality training are needed for workers to comprehend the general concepts associated with MSDSs. In addition, regular site-specific training is necessary to supplement general principles.

Job site safety and health committees would greatly facilitate efforts to reduce hazards. To insure greater participation among all subcontractors on a site, meetings would probably need to be integrated into regular project planning meetings. Involvement of workers and line management is an essential component of an effective safety and health committee. On a construction site, this would require participation of the general site superintendent, foreman, and stewards or worker representatives from each craft.

Recommendations for Future Research

To our knowledge, few projects have been looked at from start to finish. Because the type of construction work and its setting affect the hazards to workers, other projects — in addition to the new construction site investigated for this study — should be followed from start to finish. A second new construction site investigation is planned, beginning in 1993.

Renovation of commercial and industrial facilities needs to be studied. New construction has moved toward use of safer materials — for instance, asbestos and lead are no longer used. Yet these materials exist in millions of older structures and are known to cause health problems for renovation and demolition workers. Industrial facilities have the potential to expose workers to thousands of industrial chemicals and thus merit a substantial research effort to look at potential exposures.

In addition, many settings for construction work pose site-specific hazards. For example, construction workers involved in renovation of hospitals and laboratories are at risk of exposure to chemical and biological agents.

Ergonomic hazards in construction need to be further identified and quantified to allow for prioritization. Interventions need to be assessed for their efficacy. Studies are also needed to develop effective strategies to implement successful interventions in the workplace.

Last, control technology is wholly lacking in construction. Studies are needed to develop, implement, and test the effectiveness of portable control technology. Information on the performance of control technologies will permit contractors to select appropriate equipment and figure the expense into the cost of a project. Owners and architects can specify the use of such equipment. This approach is far more manageable and effective in the construction environment where completion of the job many precede characterization of exposures and subsequent recommendations for controls.

Appendix A. Noise Presentation to IAM Conference

Construction Noise Talk for IAM Conference - 10/15/92

Presented by:
Scott Schneider, CIH
Senior Industrial Hygienist
Occupational Health Foundation

Noise is an accepted part of construction work. And hearing loss has become an accepted consequence among construction workers. It has not gotten the kind of attention it deserves because people don't die from hearing loss. But it is a serious problem that we need to fix.

Historical Studies

This is not a new problem. Back in 1882 an American researcher named Holt did the first reported study on deafness among Boilermakers. He studied 40 men in Portland, Maine and, using the sound of his watch as a measure, found that only 10 of them could hear it at a distance of 1/2 to 3 feet, and those who could hear it were the men who had been working for the least number of years. Dr. Thomas Barr repeated and extended this work in 1886 in Glasgow, Scotland. He looked at 100 Boilermakers and found only 11 could hear his watch at about 1/2 to 3 feet away. He estimated that Boilermakers as a group only had about 9 percent of normal hearing. He also visited shipyards to investigate the noise exposures to Boilermakers and recorded some of the sounds on his phonograph cylinder comparing the levels with the human voice, probably one of the first instances of noise monitoring on the job.

Recent surveys on Hearing Loss

Dr. Welch did another survey on Boilermaker's hearing loss last year, although she didn't use her watch, and found similar results. I assisted with a hearing screening at the Carpenter's Union convention in 1986 which found that 83 percent had a hearing loss of over 25 decibels in at least one ear. I have no doubt that the problem is the same in many of the trades. So maybe things haven't changed much in the past 110 years.

Standards and Safety

Hearing loss is, of course, directly related to noise exposure. OSHA allows up to 8 hours of exposure to 90 decibels of noise a day. Louder noise exposures are allowed, but for shorter periods of time. But even these levels of exposure are harmful. Studies have shown that about 20 percent of workers exposed to 90 decibels for 8 hours a day will lose some or all of their hearing. Most health professionals, and the American Conference of Governmental Industrial Hygienists (ACGIH), recommend that exposures should be reduced to 85 decibels. While this may not seem like a big drop, decibels are measured on a logarithmic scale, like earthquakes, so small increases make a big difference. A three decibel increase means a doubling of the amount of sound.

Sources of Noise in Construction

We know what causes noise on construction sites, mostly construction equipment and tools. [Slides of construction equipment which produces noise] But little work has been done to measure exposures of construction workers to noise. As far as I know prior to this project, there have only been two studies of noise exposures to construction workers. One, a Swedish study in the 1973, and the other a Canadian study in 1980, which was presented as a Master's Thesis project. The Swedish study looked at about 30 different pieces of equipment and the range of sound levels coming from them. Earth moving equipment such as excavators and scrapers produced very high levels over 100 dB. Pneumatic hammers and drills also produce extremely high sound levels. Truck noise was high, above 90 dB, but quieter trucks introduced in Sweden at the time produced levels around 70 dB in the cab. Portable construction equipment, like circular saws and bolt guns produced extremely high levels of noise, but for short periods of time. Many of them also produce very high frequency noise which can be particularly damaging.

The Canadian study found levels over 100 dB associated with Skillsaws, wood planers, router saws, punch machines, air hammers, grinders, pneumatic chipping hammers, power wrenches, and impact air guns. They also measured time weighted average exposure of several trades and found, for example, that 26 percent of Carpenters had daily exposures over 87 dB and 30 percent had at least one day over 90 dB during the week they were monitored. Comparable figures were found for pipefitters, with slightly lower exposures for Laborers. Electricians were found to have the lowest exposures, but 29 percent were still over 83 dB and 6 percent over 87 dB.

On the Machinist's site we monitored several noise sources. The exposure levels we measured are shown in the following chart. This table shows continuous noise exposures or average exposures measured over several hours. Exposure levels vary along a range for most equipment which borders on or exceeds the OSHA Permissible exposure level of 90 dB over an 8 hour day or the 85 dB level where OSHA, in general industry, requires a hearing conservation program. This next table shows sound levels from other pieces of noisy equipment, some of which are high short term exposures, like stud welding. Some of the highest levels were measured when work is done inside or in confined areas where there can be reverberation. You can see from these other figures that noise levels vary as a function of both time and distance. For example cranes are very noisy while they are operating but relatively quiet when they are idling. So the crane operators exposure is a direct function of how much of the time they are using the crane for lifting. Likewise, exposure to noise from the Grade-all, an earth moving truck, is very high close to the machine, yet within acceptable range far away from it, e.g. about 75 feet away. Noise exposures of the trades, as shown in this graph, is a direct function of the amount of time they use or work near noisy equipment and the noise level produced by that equipment. While individuals may not have exposures over the OSHA limits every day or when averaged over an 8 hour day, they will often have individual days over the limits or may exceed the shorter term limits, e.g. no more than one hour's exposure per day over 105 dB. Also since the OSHA limits are not considered safe, workers are probably still over exposed to noise, even though their exposures may be below the OSHA limits.

I should also mention that we had another noise concern we looked at on this site: airforce flyovers. This building is located next to Andrews Air Force Base and in the flight path of some of the takeoffs. While the noise exposures from flyovers was high, about 102 dB, the duration of exposure was so short, only about half a minute or less, that it did not appreciable affect overall exposures for the workers.

Solutions:

Engineering Controls

How can this information help us to protect construction workers from hearing loss? There are basically two ways to prevent hearing loss. First is by engineering controls and the second is by the use of hearing protection. The information that we have can be used to identify particularly noisy equipment that can either be retrofitted to be quieter or when new equipment is purchased, quieter models can be specified. For most construction equipment, manufacturers produce quieter models which they often market abroad, because of the stricter noise regulations in Western Europe. For some equipment EPA over the last 20 years has required quieter models and the difference has been obvious. Thus far they have regulated noise from portable air compressors and medium and heavy on-the-road trucks. Other regulations of noisy equipment have been put on hold ever since Reagan shut down the EPA Noise Control Office about 10 years ago. I believe that, in the long run, quieter equipment will have many benefits. For example, quieter jackhammers, which are available, are also vibration-dampened so they are less likely to present a vibration risk to workers. Also, when building in cities, there may also be community noise regulations, which may require the use of quieter equipment, especially if there is work going on in the evenings or at night. Noise has also been associated with many other health effects, such as difficulty sleeping and stress, which may impact on worker health and productivity. Retrofitting presents relatively straight forward engineering problems, such as enclosing an engine in sound absorbing materials. The trick is to provide incentives to contractors to retrofit their old noisy equipment.

Hearing Protection

The alternative is to provide a hearing protection program for workers. Ten years ago OSHA passed a new regulation requiring such a program for industrial workers exposed to levels of noise above 85 dB. This is also the recommended exposure level from the ACGIH and several European countries. For some reason, OSHA did not think to apply that program requirement in the construction industry. Basically the rule requires employers to survey their plants for noise levels above this limit and provide free hearing tests and hearing protection for all workers who are overexposed. Workers must also be properly trained about the hazards of noise and the program to reduce exposures.

On this construction site, workers had hearing protection available, but it is not often the case. Even when it is available, it is often not used. There are many reasons why it is not used: First, it is difficult and uncomfortable to use. The ear plugs commonly provided (the soft foam plugs that you squeeze into shape) can get dirty if they are removed and replaced several times a day and may increase the risk of ear infections. A more practical alternative are the ear plugs on a plastic band that can be hung around the neck when not in use and where the tension from the band helps keep them in place. They may not get as dirty and probably fit better. Another option is earmuff hearing protectors, which are used widely in other countries. They can be fitted onto a hardhat and used when needed and moved up when they are not. This is particularly important in construction where much of the noise is intermittent and relieves the worker of the burden of having to wear hearing protection all day.

Training

Secondly, workers are not given much training on the need for hearing protection and its proper use. Most hearing protection is not used properly and provides less than optimal protection. Without training on the need for protection, many workers will not want to bother because they don't fully appreciate the risks. This is true of many risks like hearing loss where the loss occurs gradually over time and may not be recognized until it is too late. Another factor is that hearing protection is generally laxly enforced on construction sites. Unlike other safety rules, like wearing hardhats, wearing hearing protection is not as much a priority.

In addition, many workers have raised concerns about hearing protection interfering with their ability to hear warning sounds on the job that are necessary to protect them, e.g. vehicle back-up alarms. Workers also have to communicate frequently over high noise levels and large distances to get their work done. A very noisy worksite makes such communication very difficult. Hearing protection can add to that difficulty. For workers with significant hearing loss, which includes many construction workers, the problem is compounded. For this reason, the emphasis has to be on the intermittent use of hearing protection only when it is needed.

Another approach is to use the minimum amount of protection necessary. For example, if a workers is exposed to 92 dB from the equipment they use, it is not necessary to have an earplug with a noise reduction rating of 21 dB. However in selecting the proper protection, be aware that the plugs often provide less protection than their ratings, for several reasons, but especially because of improper use. In general workers will resist the use of hearing protection unless they feel the contractor is meeting them half way, by trying to reduce exposures as much as possible using engineering controls thereby making protective equipment unnecessary.

Recommendations for an Action Program

So where does that leave us now? I believe that contractors should have a hearing conservation program for their workers, despite the lack of an OSHA requirement at the present time. This program would:

1) Identify common noise sources and measure their exposure levels.

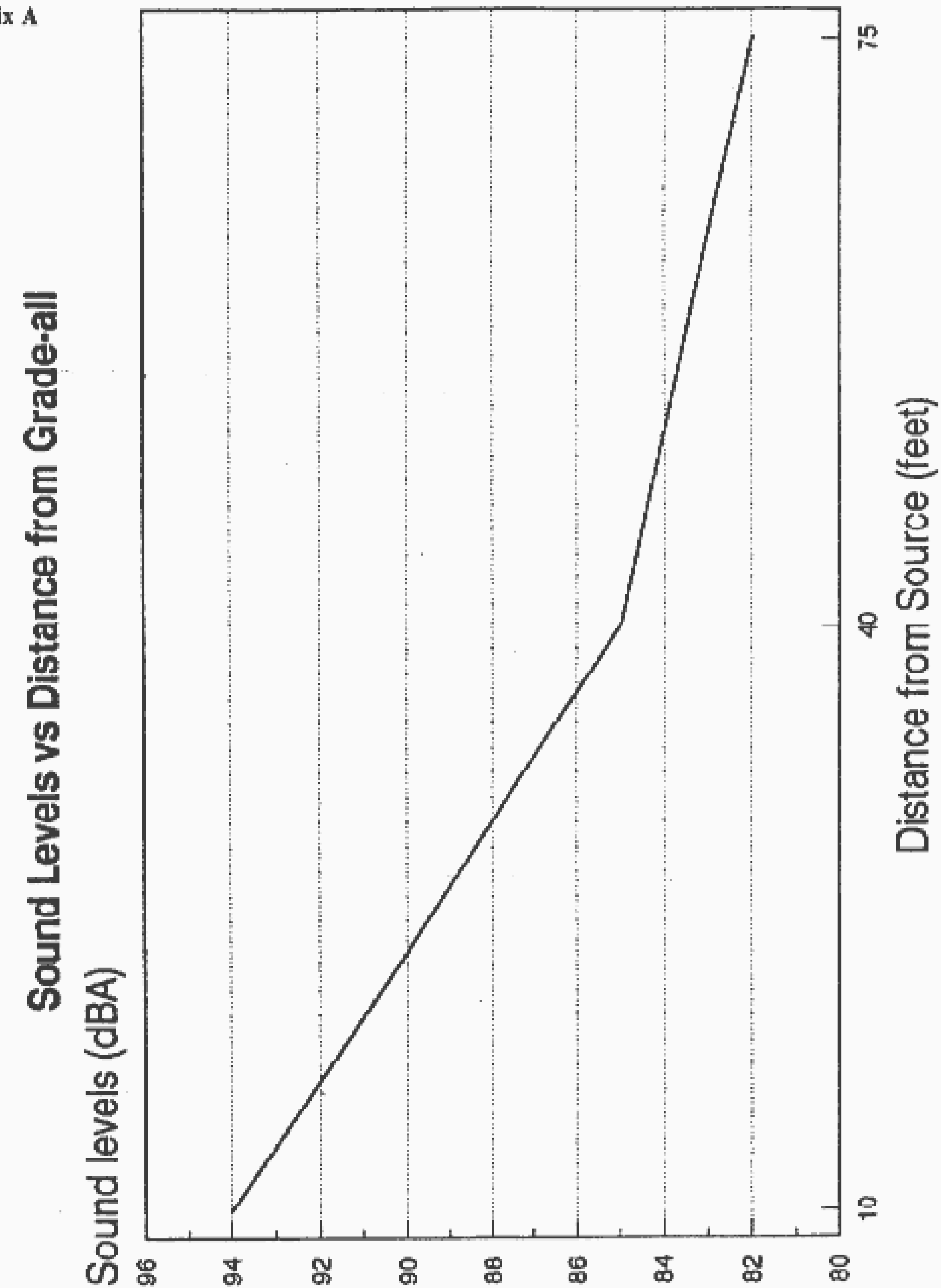
2) Reduce worker exposures by either time or distance from the source.

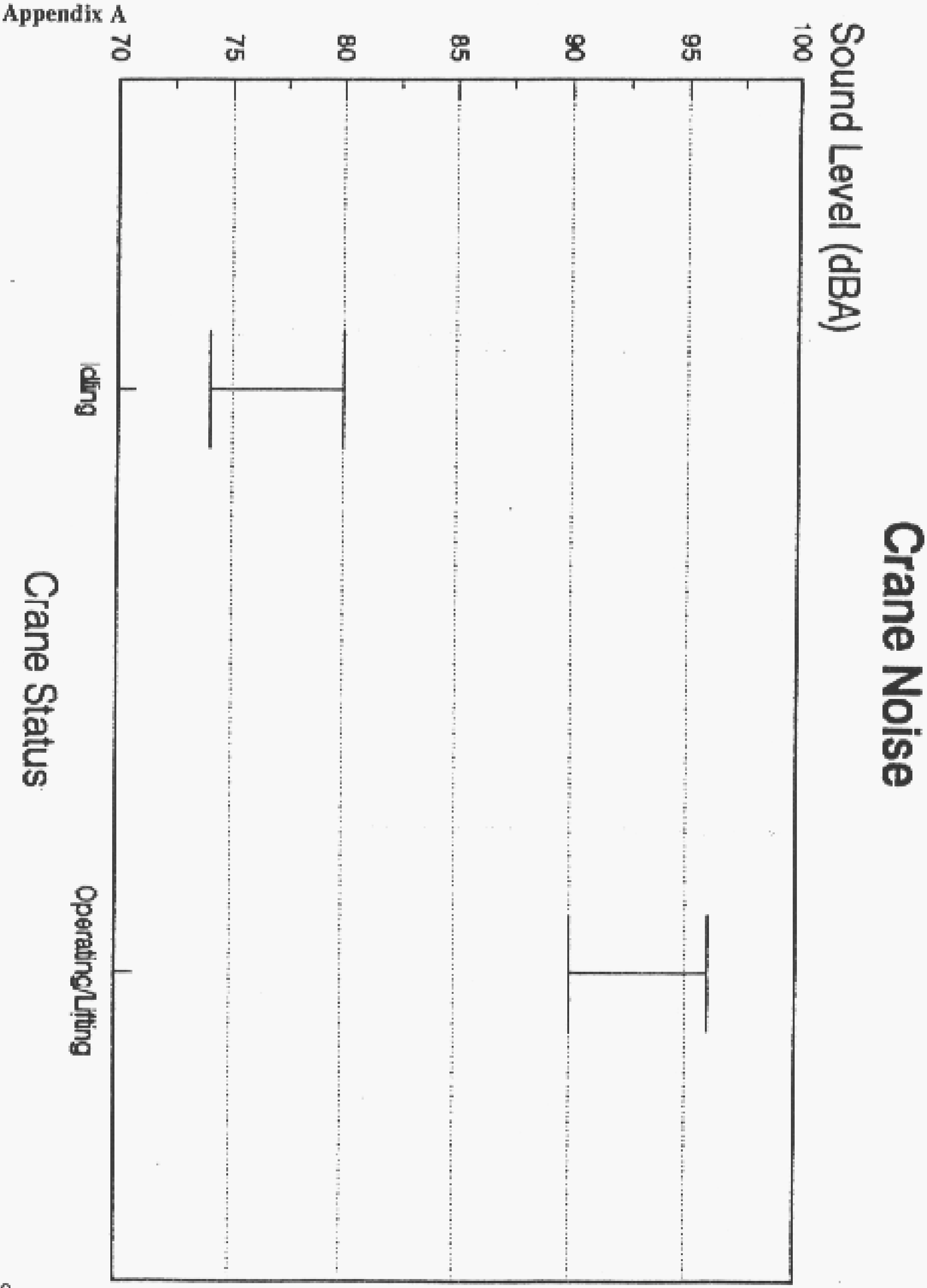
3) Anyone working in close proximity of or using a piece of noisy equipment should be given annual hearing exams and hearing protection and trained on its proper use and its use should be enforced just like hardhats but use should be keyed to noise exposure and only required when using the equipment or in the area.

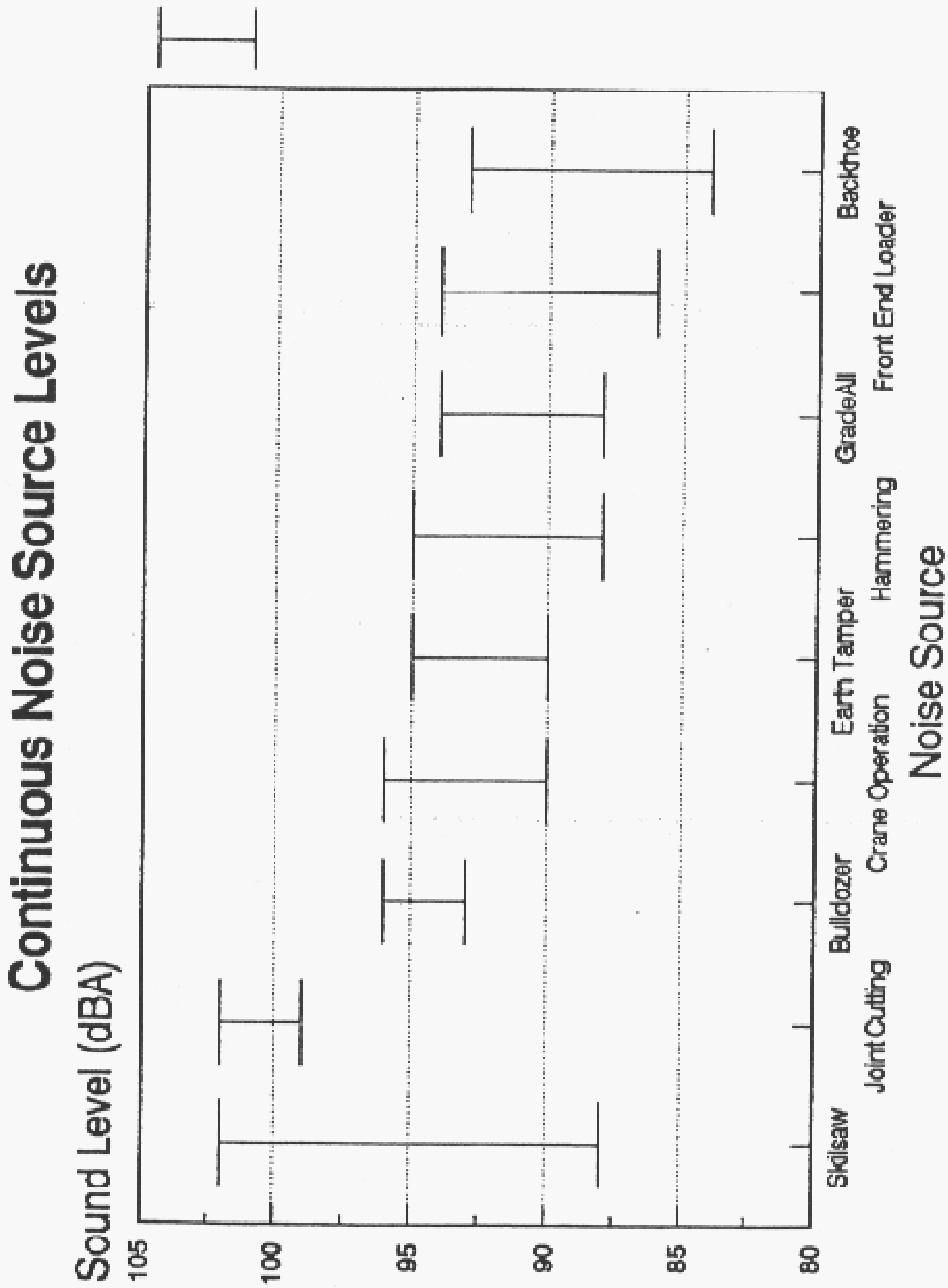
4) Contractors should have a "Buy Quiet" program to require quieter equipment whenever it is purchased and consider retrofitting particularly noisy equipment.

5) Unions should push OSHA to apply the hearing conservation requirement in construction to provide a level playing field for all contractors and protection for all construction workers.

Unless we begin this process and work hard to attack this problem, construction workers will continue to lose their hearing at phenomenal rates and we will be in the same position 110 years from now as we have been for the past 110 years.

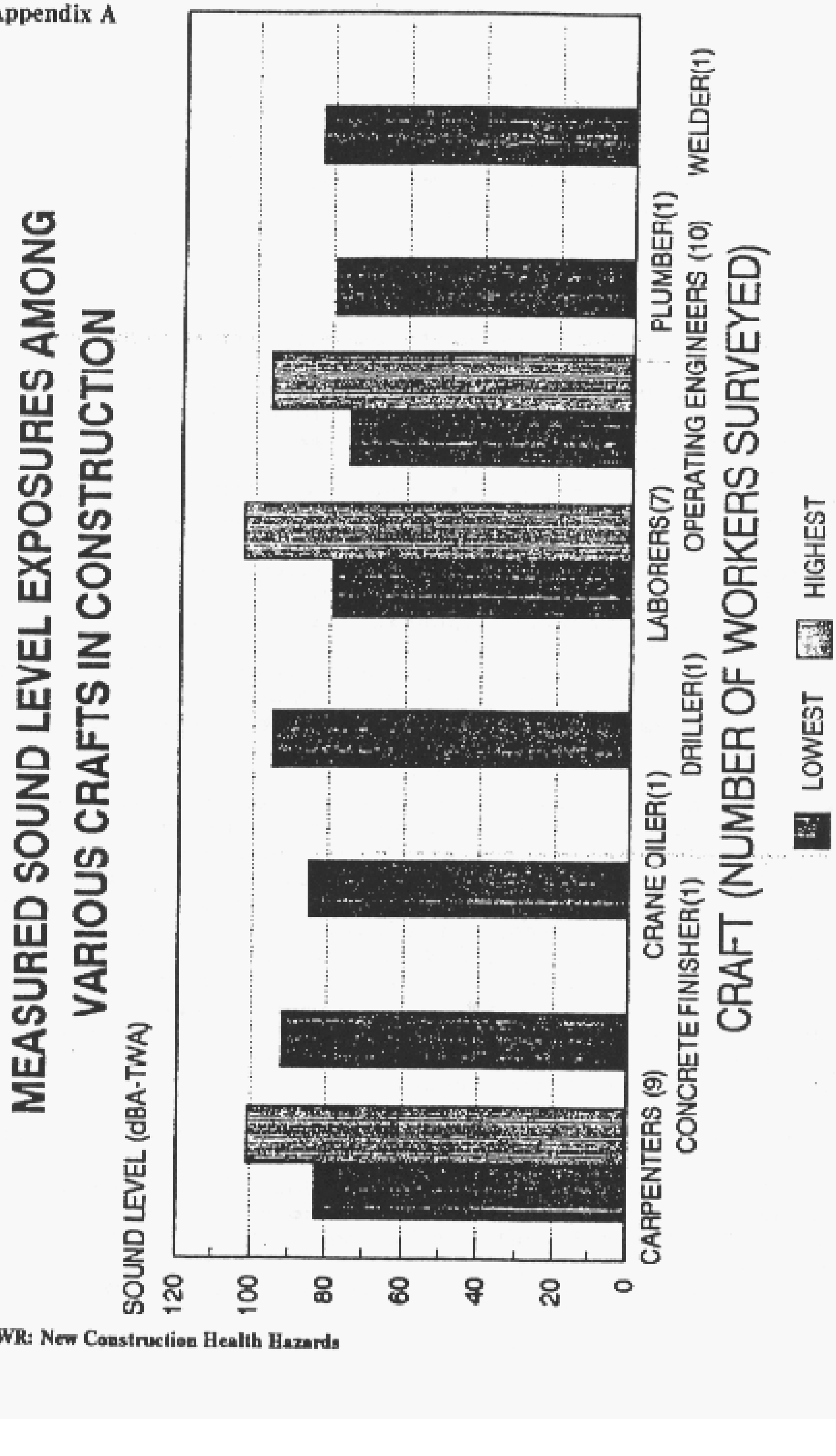

Sound Levels vs Distance from Grade-all
Sound levels (dBA)
96
94
92
90
88
86
84
82
80
10
40
75
Distance from Source (feet)


Crane Noise
Sound Level (dBA)
100
95
90
85
80
75
70
Idling
Operating/Lifting
Crane Status


Continuous Noise Source Levels
Sound Level (dBA)
105
100
95
90
85
80
Skilsaw
Joint Cutting
Bulldozer
Crane Operation
Earth Tamper
Hammering
GradeAll
Front End Loader
Backhoe
Noise Source

MEASURED SOUND LEVELS OF CONSTRUCTION NOISE SOURCES/TASKS

	SOUND LEVEL (dBA)
MOTOR WHEEL BARROW	85.7
CONCRETE VIBRATOR	90-94
HAMMER DRILL/HAMMER	90.4
ELEVATOR SHAFT DRILL	95
STUD WELDERS	101
JACK HAMMER-IN HOLE	102-104
CHIPPING HAMMER-IN	103-113
JACK HHAMMER-STEPS	108-111



Sound levels represent a time-weighted average across the time period measured. Most values come from brief, random measurements.

ERGONOMIC JOB TASK ANALYSIS

DATE: July 29, 1991

POSITION: "Iron Worker"

COMPANY: James C. Davis Construction Site

ANALYSTS: Dennis L. Hart, PhD
Janice Link, OTR
Assessment Centers Technology
103 West Broad Street
Suite 300
Falls Church, VA 22046

GENERAL DESCRIPTION: Over the month of July and August, 1991 we had the opportunity to visit the construction site for the IAM Building off of Route 4, east of Route 95 where the James C. Davis Construction Company is constructing the IAM Building. On July 15 and 16th, we had the opportunity to observe the iron workers performing many of the tasks necessary for the construction of that building. On occasion, Mr. Scott Schneider, CIH of Occupational Health Foundation accompanied us. We had the opportunity to interview several of the individuals on the "raising crew" and the "decking crew" and video tape some of the operations.

In general, Iron Workers are responsible for the erection of the steel structures for the initial construction of buildings. The Iron Workers for this site were divided into four different job categories with a working crew for each of those categories. Those crews were as follows: the raising crew, the bolters, the decking crew and the welders.

In general, the raising crew was responsible for erecting the main steel supports which were bolted firmly in place by the bolters, on which the decking crew placed the steel structure over which cement will be poured for the floors of the building. The welders were responsible for welding various joints for more stability of the structure. As can be expected, since these workers are working on a structure that is not complete and is suspended above the ground, most tasks have a certain amount of safety and ergonomic issues. For this analysis, it was difficult to obtain specific forces through the analyses, secondary to difficulty in actually working with the Iron Workers doing their various types of jobs because of safety concerns for the ergonomists.

The jobs were described as full-time work, with the recognized limitation that the employees would be hired to complete a task. Therefore, at the end of that task, their job would be dissolved. Further, since this is a position exposed to the outside elements and to the difficulties in delivery of various stock, i.e. steel deliveries, there would be days when the workers would be available for work, but they would not be working secondary to the difficulties with the weather or delivery of materials. On the other hand, if the stock was available and there was a deadline to meet, they may work at an accelerated pace and overtime to meet the deadline. The work schedule observed was one having a 15 minute break in the morning, a 15 minute break in the afternoon, with 30 minutes for lunch.

SPECIFIC TASKS EXAMINED:

1. Raising Crew.
2. Bolters.
3. Decking Crew.
4. Welders.

TASK NUMBER ONE: Raising Crew.

ENVIRONMENT: Outside and exposed to the weather.

WORK POSTURES: The raising crew was a five man crew. There were two groundsman, two connectors, and one foreman. The tasks were distinctly different between the three various personnel.

The Groundsman were responsible for walking around the iron (on the ground) that had been delivered, marking the iron for proper assembly, piece by piece, in the erection of the steel structure as well as marking the middle of the piece of iron to balance the piece of iron the single wire cable connector for the crane. The Groundsman walked on uneven ground, over stones, loose gravel, loose dirt, iron, steel cables, and other construction items. They would bend to ground level to lift large pieces of wood as well as other items and climb over the stacked iron. If a piece of material needed to be moved, they would either move the material manually, i.e. piece of wood or wire cable, or have the crane move the material, i.e. piece of iron.

The Connectors climbed the various pieces of iron as they were being erected to make the initial connections with bolts to loosely assemble the pieces of iron. These individuals wore a work belt in which they had several tools including the spud wrench which was used to insert into the connecting holes between two pieces of iron for a temporary hold while they placed a nut and bolt in another pair of holes to secure the two pieces of iron. They also had a connecting bar which is a small crow bar used to move various pieces of iron to gain proper alignment between the pieces of steel.

These individuals would walk on uneven ground, over various pieces of construction material to the area to be constructed. They would reach up over head to maneuver the iron that was supported by the crane to the location where the iron is to be bolted. Once the iron is in place, the connectors would place a temporary bolt for initial stability requiring body movements of reaching to ground level when standing for the first initial vertical piece of iron. More often, they would be climbing either the vertical piece of iron or walking across a horizontal piece of iron that was supported by the crane and erect a secure piece of iron. When working with horizontal beams in contact with vertical beams, the connectors would bend below foot level while sitting on the beam to insert the bolts. Periodically the connectors would need to work in awkward positions to reach under various beams to secure bolts or force the various beams apart to make the proper connections. Obstructed view construction was not uncommon. They would shinny up the vertical steel, and once in place at the top of a vertical steel, would reach the steel which was over head and supported by the crane to push, pull or lift the steel to position in place to receive the bolts.

The Foreman was responsible for coordinating the work of the groundsman and the connectors. Therefore, this individual would need to walk on uneven ground, as well as spend some time on the steel structures, climbing ladders, walking on beams, reaching below foot level to inspect various connections, etc. Time was spent walking around the construction site with the proper blueprints for appropriate analysis and supervision of the erection process.

BODY MOVEMENTS: The typical body movements were slightly different between the three different Iron Workers on the raising crew. However, it should be emphasized that at any one particular time, each of these individuals would be required to perform almost the exact same type of body movements.

The Groundsman would need the ability to squat or bend to ground level, reach around the steel to mark the steel, walk on uneven ground, climb over various pieces of steel and produce forces in awkward positions to move steel, pieces of wood and other pieces of construction material on the ground.

The Connectors would need to be able to reach to ground level as well as below ground level in a standing position, sitting position or squatting position. They would need to be able to shinny up a vertical piece of steel, climb over objects on the ground or on the steel, walk and balance on a horizontal piece of steel, as well as reach in awkward postures various objects in the construction area. Good manipulation of medium sized objects with both hands in good visual site and in obstructive views as well.

The Foreman would need to perform similar movements as the other crew members, but not as often. Finer manipulation of paper work was needed.

The body movements observed would be considered the ends of the "normal" ranges of motion for the average adult. The movements are: cervical spine forward bending to 60 degrees, extension to 60 degrees, rotation to 80 degrees bilaterally, shoulder flexion to 170 degrees, shoulder internal rotation 70 degrees, external rotation 90 degrees, elbow flexion 0 to 150 degrees, full pronation/supination of 80 degrees each, wrist extension 60 degrees, flexion 60 degrees, radial deviation 20 degrees, ulnar deviation 30 degrees, with complete full hand grasp. Forward bending of trunk would be to 120 degrees from the vertical, with ability to side bend 25 degrees bilaterally, with rotation 30 degrees bilaterally. Hip flexion to 120 degrees, abduction 40 degrees, knee flexion 150 degrees, ankle dorsiflexion 20 degrees and plantar flexion 40 degrees with 30 degrees of inversion and eversion of 20 degrees. Various singular movements may be less, but the total range of motion would need to be possessed through joint substitution to accomplish the task.

FORCES: It was not possible to make measurements of the various forces required to perform the job of the members of the raising crew. However, it appeared as if the typical pushing/pulling and lifting forces required were within the low category (less than 20 lbs) for most of the jobs that were performed. However, it should be emphasized that the pushing/pulling and lifting forces could exceed the forces capable of a normal male adult at any time. Specifically, when moving the steel supported by the crane, there was minimal force to move a balanced piece of steel. Once the beams of steel were in place, a certain amount of limited force was required to place the beam in position. However, if there were any problems in positioning those beams, the forces could exceed normal requirements for an average male adult. The use of the connecting bars and spud wrenches to maneuver the steel and nuts and bolts was typically smooth and required limited forces. However, one spud wrench became stuck between two pieces of steel requiring the use of a sledge hammer (while sitting on a horizontal beam of steel) and multiple awkward pushes/pulls and lifts. They would periodically need to lift small pieces of steel (estimated to be 50 lbs) without the aid of a crane to position them. The lifting forces were not able to be measured. It should be expected that the raiser occasionally would need to exert maximal lifting forces on the job.

REPETITION/TASK CYCLING: It was not possible to break the typical jobs of the raiser into consistently cycled tasks. The tasks that were observed were generically similar, but the tasks performed were dictated by the supplies on hand, the foreman, the groundsman and the ability of the various raisers. Therefore, there were few specific tasks that were cycled on a consistent basis for the possibility of ergonomic analysis. From this analysis though, it should be emphasized that there was enough time between various tasks for the individual raisers to change body posture, use other musculature and therefore, the task should not be considered repetitive in the light of ergonomic analyses.

EQUIPMENT: Steel, waist tool belt, spud wrenches, connecting bars, bolts and nuts, a wire rope.

TASK NUMBER TWO: Bolters.

ENVIRONMENT: The same.

WORK POSTURES: The bolter would walk on uneven ground, climb ladders, walk across the erected steel structures, sit on a horizontal beam, tie himself to the beam with a safety strap and reach under the top of the beam to place the bolts in the remaining holes for the steel structure. These bolts would be placed in firmly with his spud wrench, and another bolter or the same bolter would use a pneumatic or hydraulic wrench to tighten the bolts firmly. Therefore, this individual spent the majority of his work day reaching below waist level in a sitting position performing his bolting tasks.

BODY POSTURES: This individual would need to be able to climb ladders, walk on level and uneven ground and steel structures, sit and reach ~~forward typically down.~~ ~~Therefore,~~ the following movements were required: cervical forward bending of 60 degrees, rotation 20 degrees bilaterally, shoulder flexion of 120 degrees, shoulder abduction of 45 degrees, internal rotation of 70 degrees, elbow flexion of 0 to 140 degrees, supination/pronation of 80 degrees each way, and good movement of hands and wrists to manipulate bolts and wrenches in good view and obstructed view.

FORCES: Typical forces were not recorded, but would be related to the ability to secure the nut with his spud or pneumatic/hydraulic wrench.

REPETITION/TASK CYCLING: The bolter would typically spend approximately two minutes or less working with an individual bolt. After this time, they would sit upright, reach another bolt in their waist belt and reach forward to insert another bolt into the steel. The amount of time spent sitting in one posture securing the joints between two steel structures was variable. However, the position of sitting and bending forward is a static task.

EQUIPMENT: Nuts, bolts, waist tool belt, spud wrenches and pneumatic/hydraulic wrenches.

TASK NUMBER THREE: Decking crew.

ENVIRONMENT: The same.

WORK POSTURES: The decking crew is responsible for placing the corrugated steel over the firmly bolted iron structures. The crew would move one piece of corrugated steel and lie it on the steel structures, move the next piece of corrugated steel to interlock with the first piece until the entire area was covered. They would then cut and fit the corrugated steel pieces, so they would fit around various structures in the building. Once the corrugated steel pieces were fitted on the steel structures, the decking crew would burn a hole in the various structures and weld the corrugated steel structures to the iron beams. Therefore, the decking crew would be required to pull or drag the steel to its place while walking across horizontal beams, and place the corrugated structures in proper location.

BODY MOVEMENTS: The decking crew members would need to be able to climb the ladders to the location where decking was required, then move the corrugated steel into place, and spend time bending to floor level performing the burning and welding, so the corrugated steel structures would fit. This would require range of motion of cervical forward bending of 60 degrees, rotation 20 degrees bilaterally, shoulder flexion 0 to 120 degreee, elbow flexion 0 to 120 degrees, wrist supination/pronation 80 degrees, wrist extension 60 degrees, flexion 30 degrees, radial deviation 20 degrees, ulnar deviation 30 degrees, and good hand grasp and ability to manipulate medium sized objects. Trunk flexion of 120 degrees from the vertical, hip flexion 120 degrees, knee flexion 150 degrees and plantar flexion 40 flexion, dorsiflexion 20 degrees, inversion 30 degrees, eversion 20 degrees were also required.

FORCES: The weight of the corrugated steel structures was not measured, but estimated to approach 100 to 150 lbs of lift/pull. The corrugated steel comes in various lengths and is cut to various lengths, therefore, the weights would be variable. Once in position, there would be forces in awkward positions needed to position the steel into place, which was not measured. The steel would get stuck in one position requiring high forces to move the steel as well. More than one worker was available typically to assist in the movement.

REPETITION/TASK CYCLING: The decking crew would spend a certain amount of time moving the corrugated steel into position, burning the pieces to make them fit and then welding. The laying down of the steel required repetitive movements of walking to the bundles of steel, dragging or lifting the corrugated steel to the proper location, and placing them in location and then returning to the bundle to lift another piece of the steel. Once in place, the burning of the various pieces to make them fit would be exceedingly variable depending upon the types of structures about which the steel was being placed. When the decking crew performed the welding, they would typically stand in a static posture of straight knees and trunk forward bent to 120 degrees to perform their welding at floor level or slightly below floor level. Therefore, there was variable task cycling for lying down of the steel, and burning the various portions of the steel to make the steel structures fit, but the welding was performed in static postures. The quantity of time in any of these postures was dependent upon multiple factors and was variable.

EQUIPMENT: Corrugated steel, welding equipment and acetylene torch equipment.

TASK NUMBER FOUR: Welding.

ENVIRONMENT: The same.

WORK POSTURES: The welder, responsible for welding the various large steel structures, would walk on uneven ground, climb ladders, walk on the steel beams, move (carry, drag, lift) their welding equipment, i.e. the long hoses and cords for their welding equipment to the location, and weld. They would periodically use a small platform on which they would be suspended below the level of the joint needing to be welded. If they used the small platform, the welding would be performed between mid thigh and shoulder levels. However, the welders were seen standing on beams without this platform, reaching with awkward postures to reach the opposite side of the beam while standing on the platform or standing on the individual beam. Therefore, the work postures were exceedingly variable. However, once in the position for the weld, they would hold a static posture to perform the actual weld until the weld was complete which would be variable in time.

BODY MOVEMENTS: Therefore, the body movements were typical of the groundsman but required more frequent awkward postures such as the connectors. Climbing over and around the various pieces of steel required multiple large joint ranges of motion.

FORCES: Forces were not able to be measured, and were seen as variable from limited forces such as holding the weight of the welding equipment to needing to pull various steel structures, as well as assisting the crane in the placement of their welding supplies which may be on a pallet onto the steel structures. We did not observe any forceful movements being performed by any of the welders, but did observe the welder standing on a steel beam moving a wire cable that required balance and some force.

REPETITIONS/TASK CYCLING: It was typical to see the welder hold a static posture to perform their welds for significant periods of time, i.e., greater than two minutes and up to ten. The common postures were standing forward bending up to 30 degrees from the vertical, or sitting leaning forward up to 30 degrees. The static forces were typically in normal standing postures (while on the small platform) but could also be in awkward positions (on the platform or not). These variable postures were repeated for the entire shift, and interspersed with movement when the need to move a structure on which the welder was working was required, material needed to be replenished, etc. The amount of time required to move their stock could be substantial, i.e, 30 minutes or more, or be relatively quick, i.e, less than two minutes.

EQUIPMENT: Welding equipment, various platforms, and pallets.

CRITICAL JOB DEMANDS

DATE: July 29, 1991

POSITION: "Iron Worker"

COMPANY: James C. Davis Construction Site

ANALYSTS: Dennis L. Hart, PhD
Janice Link, OTR
Assessment Centers Technology
103 West Broad Street
Suite 300
Falls Church, VA 22046

BODY POSTURES: Standing, walking (level and uneven ground), climbing, reaching, bending, stooping, sitting, ~~carrying,~~ ~~lifting,~~ ~~pushing,~~ pulling, and fingering/feeling

RECOMMENDED BODY MOVEMENTS (CRITERIA):

Cervical Spine:	0-60 degrees of flexion,
	0-60 degrees of extension,
	0-80 degrees of rotation bilaterally,
Shoulder:	0-170 degrees of flexion,
	0-70 degrees of internal rotation,
	0-90 degrees of external rotation
Elbow:	0-150 degrees of flexion
	0-80 degrees of pronation and supination
Wrist:	0-60 degrees of flexion
	0-60 degrees of extension,
	0-20 degrees of radial deviation,
	0-30 degrees of ulnar deviation
Hand:	Full grasp
Trunk:	0-120 degrees of forward bending from the vertical,
	0-25 degrees of side bending,
	0-30 degrees of rotation
Hip:	0-120 degrees,
	0-40 degrees of abduction
Knee:	0-150 degrees
Ankle:	0-20 degrees dorsiflexion,
	0-40 degrees plantar flexion,
	0-30 degrees inversion
	0-20 eversion

Substitutions may be used as well, so the tasks need to be functionally tested to determine if the substitutions are safe if a specific range of motion criterion is not met.

ESSENTIAL FUNCTIONS:

1. RAISING CREW:

Walking, standing, sitting and climbing with excellent balance
Standing for entire shift (and possibly overtime)
Walking on level and uneven ground, horizontal girders and over loose objects
Climbing ladders and vertical girders
Reaching overhead and below foot level
Sitting on horizontal girders
Lifting and carrying small to large construction items
Pushing/pulling steel structures and tools
Manipulation of medium sized objects and hand tools with obstructed views

2. BOLTERS:

Walking, standing, sitting and climbing with excellent balance
Sitting on steel girders for majority of shift (and possibly overtime)
Walking on level and uneven ground, horizontal girders and over loose objects
Climbing ladders
Reaching overhead and below foot level
Lifting and carrying small to large construction items
Pushing/pulling steel structures and tools
Manipulation of medium sized objects and hand tools on a repetitive basis with obstructed views
Use of pneumatic tools

3. DECKING CREW:

Walking, standing, sitting and climbing with excellent balance
Standing for entire shift (and possibly overtime) typically in forward bent postures reaching to ground level
Walking on level and uneven ground, horizontal girders and over loose objects
Climbing ladders
Reaching overhead and below foot level
Lifting and carrying small to large construction items
Pushing/pulling steel structures and tools
Use of welding equipment and acetylene torches

4. WELDERS:

Walking, standing, sitting and climbing with excellent balance
Standing for entire shift (and possibly overtime) typically in forward bent or awkward static postures for extended times
Walking on level and uneven ground, horizontal girders and over loose objects
Climbing ladders and over girders
Reaching overhead and below foot level

Lifting and carrying small to large construction items
Pushing/pulling steel structures and tools
Use of welding equipment and acetylene torches

FORCES: Variable from limited to maximum for typical adult male in lifting, carrying, pushing/pulling.

EQUIPMENT: Ladders, hand wrenches, hammers (small and sledge), welding tools, large nuts/bolts, tool belts, wire cable, pallets, pneumatic/hydraulic wrenches, and variable construction items

PROBLEMS AND CONCERNS:

SAFETY CONCERNS:

Falling/Slips & Falls: The obvious safety concern is the balance required by the workers when walking, climbing and working on the steel beams, either by the Groundsmen low to the ground or the Connectors, Bolters, Decking Crew or Welders. Frequently, the workers would not only be walking on the beams, but they would be pushing/pulling objects with varying degrees of "stiffness" or "elasticity" in various directions while on the beams. With any loose gravel/dirt on their boots or the steel, wind gusts, spring in the cable they may be manipulating, etc. slips would be expected to be not uncommon. We observed only one Bolter lose his balance but not fall. When walking on the corrugated steel which may or may not be secured (welded), the risk of falling was present. One welder was observed attempting to manipulate steel cable while standing on a beam three stories high with no safety net under him. The steel cable has a some "elasticity" and could twist and spring in a direction that could make the welder lose their balance and fall off the beam. Recommendation: Use safety nets below the work areas and use safety belts where ever possible. Explore the possibility of using nonslip clothing for Connectors climbing beams (high friction pads on pants around the medial sides of their pants).

Being Struck By Stock: Steel is delivered by a crane to the proper location for erection. Some times more than one piece of steel is suspended by a single wire cable from the crane, so time can be used effectively during the building. When the pieces of steel are suspended by cable, either one or more at a time, the potential for the steel to swing around and inadvertently strike a worker exists. The probability of inadvertent strikes increases when there are more than one piece of steel on the cable. Recommendation: Continuously use standard communication techniques between the Connectors and the crane operator. Use electronic communication when ever possible. Instruct the workers about the safety issue of working under moving steel overhead. It should be pointed out that there appeared to be excellent communication between the Connectors and crane operators on the site.

Crush Injuries: There is a potential for hand, foot, etc. crushes when the Connectors move the steel beams into position for securing. If there is a slip of the material or clothing being caught, the probability of a crush injury increases. Crush injuries exist for Bolters using wrenches, Welders moving stock, Groundsmen moving stock, Deckers moving steel, etc. Recommendation: Use protective clothing including proper boots and gloves and eliminate loose clothing that might get caught on pieces of steel. Educate workers about the danger of improper clothing.

Walking on Uneven Ground: The potential for ankle and foot injuries is increased when walking on uneven ground, particularly when the surface is covered with loose gravel, construction equipment and supplies, etc. Walking on the corrugated steel is an uneven surface over which the workers pull/push or carry equipment, steel, etc. commonly in awkward postures. Recommendation: Wear proper boots. Educate workers in the dangers of walking on uneven ground.

Use of Acetylene Torches: Typical safety issues for working around flammable gases need standard safety procedures. Recommendation: Follow OSHA standards.

Use of One Wire Cable to Support Steel Beams with the Crane: One wire cable was used to balance the steel beams when moving the beams. Recommendation: Use a split, two cable system to attach the beam to the crane.

ERGONOMIC CONCERNS:

Awkward Postures: All workers observed used awkward postures from time to time, depending on the job performed. These awkward postures increase the probability of injury. Primary concerns were for the lumbar spine and upper extremity. Recommendation: Workers should be instructed in the hazards of using awkward postures and the need to be flexible (joint range of motion) and physically strong (muscular strength), so the use of these postures, many of which are inevitable and cannot be ergonomically designed out of the job, is easier for the workers to perform. Problems may arise following an injury when the worker under rehabilitation will need to be able to produce these postures, i.e. joint range of motions, and perform work in those postures. Rehabilitation professionals should use these critical job demands to plan their rehabilitation efforts and return to work decisions. Educational programs should be used to inform workers of the more favorable postures in which to work. Management/supervisors should be encouraged to have employee compliance with the postures, i.e. squatting instead of flexing the trunk while the knees are straight.

Forces in Awkward Postures: While in the awkward postures, the workers must on occasion produce large forces. A good example was leaning forward while sitting on a beam and then lifting an end of a beam requiring high lifting forces. These forces and posture combinations have been related to increased injuries. Recommendation: Workers need to be instructed in the difficulties of producing high forces in awkward postures as well as the need to remain in excellent physical condition. If there is a possibility of reducing the awkwardness of these postures, the worker should attempt to reduce the forces and awkwardness of the postures. Management should be aware of the savings of taking extra time to perform work in safe postures and encourage compliance.

Static Postures: Static postures are particularly troublesome for the musculoskeletal system and have been related to increased injuries. The Bolter sitting and leaning over the beam repetitively daily increases the risk of low back injuries. The Welder using standing or awkward postures have increased risk of injuries to the upper extremities and trunk. Decking crew members spot welding or burning holes in the corrugated steel have increased risk of lower back trauma. Recommendation: Workers should be instructed in the use of alternative postures in which to perform their work. They should be instructed in the need for changing posture on a regular basis. Crew leaders should schedule work around the need to change postures. Supervisors should be encouraged to have their workers comply with the instructions. Design a long handled tool for the spot welding that would reduce (in some cases eliminate) the need to bend at the waist to perform the welding of the deck. Examine the possibility of redesigning the welder's platform to reduce the typical forward bent posture (height adjustment) and to increase the size of the platform to allow better body mechanics while welding. Examine the possibility of designing a platform for the bolter that would reduce the trunk forward bending while bolting.

Repetitive Movements in Bolting: The Bolter used their hands repetitively to perform limited tasks with their upper extremities. These activities required nonpower wrenches and power pneumatic tools. Recommendation: Use good work/rest cycling while bolting. Explore the possibility of using more ergonomically sound tools to perform the bolting. Encourage supervisors to improve compliance with work/rest cycling.

Use of Pneumatic Hand Tools: The Bolter using pneumatic power tools has increased risk of upper extremity cumulative trauma to the wrists, elbows and shoulders. Recommendation: Use acceleration absorbing gloves when ever possible. Instruct the workers in the proper use of tools, work/rest cycling. Examine the handle grip size and angle of the tools to improve the wrist position is necessary. Encourage supervisors to improve compliance with the instructions.

Lifting: The only regular lifting we observed was the need of the Bolter to lift and carry a bucket of bolts. We did not weigh the bucket. However, if a Bolter had a back problem with a restriction in lifting, the Recommendation could be made to use smaller buckets of bolts for the Bolter to use when walking from the steel and the bolt bucket.

EDUCATIONAL CONCERNS:

Educational Seminars:

Low Back School Programs

Upper Extremity Cumulative Trauma Programs

Safety Issues:

- Slips & Falls
- Use of Torches
- Physical Conditioning
- Safety Supervisors Enforcing Safety Regulations

OBSERVATIONS ON ERGONOMIC HAZARDS AT THE IAM WORKSITE 7/15/91
by Scott Schneider, CIH Occupational Health Foundation

On Monday July 15,1991, I accompanied Dennis Hart and Janice Link, ergonomists from Assessment Centers Technology, to the IAM jobsite to look at ergonomic hazards on the site. Their primary focus is the Ironworkers, but I also observed the Concrete workers and Masons.

Ironworkers

The ironworkers were divided into four crews for steel erection : Raisers, Bolters, Decking and Welding. Raisers had an ergonomically difficult task. They had to balance themselves on the steel or shimmy up to the end of a beam to bolt it to the next piece. To do so they had to reach out to grab the beam, without getting off balance. Then they must position the other beam if it is not properly aligned. The beam is secured, often initially with the end of their wrench, and the a bolt is inserted. This requires reaching below foot level and applying torque to the wrench in that awkward angle. They must reach up and unhook the beam from the crane. They sometimes must carry short pieces of iron, which according to them, weigh about 150 pounds. Bolters have a similar ergonomic problem. Their job requires them to bolt under foot level, but since they are inserting and tightening several bolts, they sit in one place to do it and are closer to the work level. They initially insert the bolts and later tighten them with a power wrench. So their job should be somewhat easier than the raisers.

Decking requires the bundles of decking to be hoisted into place and the wire around them to be cut. The bundles are unhooked from the crane and individual pieces are placed over the beams one at a time, overlapping each other. Pieces are carried by two people, because of their length and weight (approximately 150 lbs.?). Decking crews must do a lot of bending, lifting and carrying. Welding is done of joints in the beams and to weld the decking to the beams. Welding of the beams is done on a platform hanging from the beam, so it is done about shoulder height. Welding of the decking, however is done at floor level, which is harder to do ergonomically.

Concrete Work

A concrete floor was poured on the ground floor this day. It involved about 8 separate tasks: 1) Filling the area with gravel, 2) Putting wire mesh on the gravel, 3) Pouring the concrete, 4) Spreading out the concrete with a "come along", 5) Smoothing the surface and filling in the area with a "straight edge", 6) Smoothing the surface with a long handled rake, 7) Trowelling the edges and hard to reach areas by hand, 8) Use of a trowelling machine to finish the surface after it has partially dried.

Filling in the area with gravel requires a lot of manual effort to spread the gravel evenly using shovels and rakes. Some effort is also required to release the gravel from the concrete buckets used to transport it to the work area. (Sometimes full body weight is used to release the lever). The wire mesh is transported by hand from a pile near the work, usually 2 at a time (weight unknown). The workers often carry them overhead. They are placed in the gravel and tied together by hand using wire ties. This requires considerable bending and squatting and is likely very stressful to the back.

Concrete is pumped into the area via a crane. One worker positions and moves the hose while others spread the concrete around. The worker positioning the hose is subject to a lot of splashes of concrete. Workers also must pull up the wire mesh with a hooked bar to get the concrete under the mesh. This requires a lot of back effort as well. The concrete is spread with a "come along", a flat head rake. This is very labor intensive and requires a lot of back effort. A "straight edge", a 2X4 with handles was used to fill in areas and smooth the surface. Workers pulled it in a zig zag fashion at ankle height. It seemed to require a lot of force, due to the viscosity of the concrete.

The workers trowelling the edges did so in a bent-at-the-waist posture, requiring them to bend full over to ground level, a very difficult position ergonomically to work in. Trowelling was also done in hard to reach areas, like around pipes, by hand on hands and knees, another difficult posture to work in for long periods of time. Smoothing the surface with a long-handled rake required a lot of reaching and some force. The powered trowelling machine was like a buffer and required force to guide it by leaning on one side or the other. The handles seemed to be at a good height, about waist height for working. The workers though had to drag the machine from one area to where it was to be used, requiring a lot of force for pulling it there.

Masons

On the day of our site visit, the masons were filling a cinder block wall with grout to stabilize it and add strength to it. It was being filled by hand by three workers carrying grout from a mixing box to the side of the site in buckets over to a 4 four scaffold platform by the wall. One worker was mixing grout in the mixing bucket and filling buckets with shovelfuls of grout. Another was carrying buckets over to the scaffold. The third was pouring the buckets into the wall. The buckets weighted between 45-75 pounds, depending on how full they were. The distance carried varied from 15-30 ft, as the work progressed. The worker mixing grout in the box was mixing at a good height (knee height). The buckets had handles, but they were not comfortable. Buckets were lifted up to the scaffold using a two-handed lift. The height of lift included 49" for the scaffold plus 20" for the handle height, totalling 69" which came to the top of this worker's head, a fairly stressful height, considering the weight being lifted. Pouring the grout into the wall was stressful in that it was poured at below knee height, but buckets were tipped so the weight factor was lower. Water also had to be carried to the mixing box by hand for diluting the grout from a trailer.

Solutions and suggestions

Steel erection is a very difficult operation to modify ergonomically. Much of the heavy work is already done by cranes. The difficult part is having to do work in unusual postures or while maintaining balance. Ironworkers welding the steel joints have, in part, solved this problem by using hanging platforms to work at the proper height. This is not possible for raisers, unless they could work out of a bucket and crane. The decking crew could be helped if decking could be moved more by crane as well (perhaps in a christmas tree arrangement like the steel is for short sections).

Concrete finishers have been studied in Sweden and several solutions have been developed to reduce the ergonomic stresses they face. Workers tying wire rods together there have a device called a "tieing automat" which allows them to tie rods together while standing. They recommend keeping each size of rebar separately stacked to avoid lifting and pulling them to separate them. Rollers are being developed to move the rebar from place to place. Using ready cut and bent rebar reduces the amount of manual work. Using welded fabric nets rather than rebar saves manual work. Placing them by crane could also save work. Workers tending the hose pumping the concrete should be rotated to relieve them. Vibrating lathes are used in Sweden for leveling the concrete. Super plasticizers added to the concrete also make the work easier. All concrete used in Sweden now requires the addition of iron sulfate to eliminate the problem of concrete dermatitis.

Masons on this particular job could have had an improved work task if the grout could have been moved to the wall by dolly or cart rather than by hand, or if the scaffold height was about 1 foot lower. That would allow the person transporting the bucket to raise it to about shoulder height, rather than head height.

Appendix C. Chemical Exposure Results

IAM NEW CONSTRUCTION SITE (1991-1992)

DATE	SAMPLE NO.	EXPOSURE	UNION	PROCESS	SAMPLE TIME	RESULT	UNITS
8/22/91	510	ASPHALT(BSFTM)	LIUNA #516	SCREEN-MAN/PAVING	201	0.29	MG/M3
8/22/91	511	ASPHALT(BSFTM)	LIUNA #516	SCREEN-MAN/PAVING		0.12	MG/M3
5/19/92	790	ASPHALT(BSFTM)	LIUNA #516	SCREEN-MAN/PAVING	211	<0.04	MG/M3
5/19/92	792	ASPHALT(BSFTM)	LIUNA #516	SCREEN-MAN/PAVING	210	<0.05	MG/M3
5/19/92	794	ASPHALT(BSFTM)	LIUNA #516	SPREADING ASPHALT/PAVING	185	<0.05	MG/M3
1/13/91	660	ASPHALT(BSFTM)	ROOFERS #90	CARRYING BUCKETS OF HOT ASPHALT	271	0.51	MG/M3
1/13/92	661	ASPHALT(BSFTM)	ROOFERS #90	CARRYING BUCKETS OF HOT ASPHALT	258	1.89	MG/M3
1/13/92	662	ASPHALT(BSFTM)	ROOFERS #90	MOPPING HOT ASPHALT	283	0.17	MG/M3
1/24/92	673	ASPHALT(BSFTM)	ROOFERS #90	KETTLE OPERATION	42	21.8	MG/M3
1/24/92	674	ASPHALT(BSFTM)	ROOFERS #90	MOPPING HOT ASPHALT	102	0.26	MG/M3
1/28/92	680	ASPHALT(BSFTM)	ROOFERS #90	MOPPING HOT ASPHALT	20	0.35	MG/M3
1/28/92	684	ASPHALT(BSFTM)	ROOFERS #90	CUTTING INSULATION BOARD	85	0.92	MG/M3
1/28/92	685	ASPHALT(BSFTM)	ROOFERS #90	CUTTING INSULATION BOARD	80	0.33	MG/M3
2/5/92	693	ASPHALT(BSFTM)	ROOFERS #90	MOPPING HOT ASPHALT	122	0.08	MG/M3
8/22/91	510	ASPHALT(TOTAL)	LIUNA #516	SCREEN-MAN/PAVING		0.20	MG/M3
8/22/91	511	ASPHALT(TOTAL)	LIUNA #516	SCREEN-MAN/PAVING	186	0.59	MG/M3
5/19/92	791	ASPHALT(TOTAL)	LIUNA #516	SCREEN-MAN/PAVING	210	0.33	MG/M3
5/19/92	793	ASPHALT(TOTAL)	LIUNA #516	DUMP-MAN/PAVING	207	0.16	MG/M3
1/22/92	671	ASPHALT(TOTAL)	ROOFERS #90	KETTLE OPERATION	11	14.7	MG/M3
1/24/92	673	ASPHALT(TOTAL)	ROOFERS #90	KETTLE OPERATION	42	28.85	MG/M3
1/24/92	674	ASPHALT(TOTAL)	ROOFERS #90	MOPPING HOT ASPHALT	102	0.82	MG/M3
1/28/92	684	ASPHALT(TOTAL)	ROOFERS #90	CUTTING INSULATION BOARD	85	0.97	MG/M3
1/28/92	685	ASPHALT(TOTAL)	ROOFERS #90	CUTTING INSULATION BOARD	80	0.52	MG/M3
2/5/92	692	ASPHALT(TOTAL)	ROOFERS #90	MOPPING HOT ASPHALT	123	<0.03	MG/M3
2/5/92	693	ASPHALT(TOTAL)	ROOFERS #90	MOPPING HOT ASPHALT	122	0.04	MG/M3
2/12/92	701	ASPHALT(TOTAL)	ROOFERS #90	MOPPING HOT ASPHALT	293	3.66	MG/M3
2/12/92	702	ASPHALT(TOTAL)	ROOFERS #90	KETTLE OPERATION	296	10.4	MG/M3
2/26/92	710	BRAZING FUME (ZINC OXIDE)	STEAMFITTERS #602	BRAZING COPPER PIPE	70	0.010	MG/M3
2/26/92	710	BRAZING FUME(CADMIUM)	STEAMFITTERS #602	BRAZING COPPER PIPE	70	0.0054	MG/M3
2/26/92	710	BRAZING FUME(COPPER)	STEAMFITTERS #602	BRAZING COPPER PIPE	70	0.013	MG/M3
10/3/91	552	CEMENT/GYPSUM(RESPIRABLE)	PLASTERERS #571	SPRAYING INSULATION	150	0.07	MG/M3
10/21/9	562	CEMENT/GYPSUM(RESPIRABLE)	PLASTERERS #571	SPRAYING INSULATION	224	0.010	MG/M3
6/17/92	858	CONCRETE DUST(RESPIRABLE)	LIUNA #456	CUT/LAY CONCRETE PAVING BLOCK/BRICK	142	1.07	MG/M3
6/9/92	815	CONCRETE DUST(RESPIRABLE)	LIUNA #74	CHIPPING CONCRETE	89	0.86	MG/M3
5/22/92	801	CONCRETE DUST(TOTAL)	C&CM #891	CUT/LAY CONCRETE BLOCK/BRICK	230	3.10	MG/M3
6/9/92	840	CONCRETE DUST(TOTAL)	LIUNA #456	CUT/LAY CONCRETE PAVING BLOCK/BRICK	97	2.16	MG/M3
6/17/92	850	CONCRETE DUST(TOTAL)	LIUNA #456	TAMPING PAVING BLOCK	130	2.49	MG/M3
6/17/92	851	CONCRETE DUST(TOTAL)	LIUNA #456	CUT/LAY CONCRETE PAVING BLOCK/BRICK	133	4.89	MG/M3
6/17/92	859	CONCRETE DUST(TOTAL)	LIUNA #456	CUT/LAY CONCRETE PAVING BLOCK/BRICK	137	1.98	MG/M3

Date	Sample No.	Exposure	Union	Process	Sample Time	Result	Units
5/14/92	786	DUST(RESPIRABLE)	LIUNA #74	DRY-SWEEPING	295	0.89	MG/M3
5/8/92	784	DUST(TOTAL)	LIUNA #74	DRY-SWEEPING	139	9.35-15.	MG/M3
6/17/92	854	EPICHLOROHYDRIN	IBPAT #1773	AIRLESS PAINTSPRAYING	90	<0.035	PPM
6/9/92	814	EPICHLOROHYDRIN	TERRAZZO FINISHERS #31	SPREADING PRIMER	110	<0.065	PPM
6/9/92	819	EPICHLOROHYDRIN	TERRAZZO FINISHERS #31	SPREADING EPOXY/MARBLE SLURRY	64	<0.12	PPM
5/8/92	780	GYPSUM DUST(RESPIRABLE)	PLASTERERS #96	SANDING DRYWALL	230	1.88	MG/M3
5/8/92	781	GYPSUM DUST(RESPIRABLE)	PLASTERERS #96	SANDING DRYWALL	239	4.2	MG/M3
5/14/92	785	GYPSUM DUST(RESPIRABLE)	PLASTERERS #96	SANDING DRYWALL	309	1.77	MG/M3
5/8/92	782	GYPSUM DUST(TOTAL)	PLASTERERS #96	SANDING DRYWALL	156	25.30	MG/M3
6/10/92	844	GYPSUM DUST(TOTAL)	PLASTERERS #96	SANDING DRYWALL	50	59.74	MG/M3
6/17/92	854	HEPTANE	IBPAT #1773	AIRLESS PAINTSPRAYING	90	0.021	PPM
5/22/92	802	HEPTANE	TERRAZZO FINISHERS #29	TROWELING EPOXY RESINS	188	0.485	PPM
6/9/92	814	HEPTANE	TERRAZZO FINISHERS #31	SPREADING PRIMER	110	<0.023	PPM
6/9/92	819	HEPTANE	TERRAZZO FINISHERS #31	SPREADING EPOXY/MARBLE SLURRY	64	0.045	PPM
6/17/92	854	HEXANE	IBPAT #1773	AIRLESS PAINTSPRAYING	90	0.10	PPM
5/22/92	802	HEXANE	TERRAZZO FINISHERS #29	TROWELING EPOXY RESINS	188	6.05	PPM
6/9/92	814	HEXANE	TERRAZZO FINISHERS #31	SPREADING PRIMER	110	0.16	PPM
6/9/92	819	HEXANE	TERRAZZO FINISHERS #31	SPREADING EPOXY/MARBLE SLURRY	64	0.529	PPM
6/17/92	853	METHANOL	CARPENTERS#1631-C	GLUING CARPET	213	0.44	PPM
6/9/92	816	METHYLCHLOROFORM	CARPENTERS#1631-C	GLUING CARPET	55	4.56	PPM
6/17/92	852	METHYLCHLOROFORM	CARPENTERS#1631-C	GLUING CARPET	213	5.50	PPM
6/17/92	854	METHYLCHLOROFORM	IBPAT #1773	AIRLESS PAINTSPRAYING	90	0.530	PPM
5/14/92	788	MINERAL SPIRITS	LIUNA #456	LAYING PAVING BLOCK W/ASPHALT	55	3.9	MG/M3
2/12/92	703	MINERAL WOOL(RESPIRABLE)	IBEW #26	PULLING CABLE	270	0.039	F/CC
10/24/9	570	MINERAL WOOL(RESPIRABLE)	LIUNA #571	SPRAYING INSULATION	242	0.011	F/CC
10/13/9		MINERAL WOOL(RESPIRABLE)	PLASTERERS #571	SPRAYING INSULATION	150	0.022	F/CC
9/25/91	533	MINERAL WOOL(RESPIRABLE)	PLASTERERS #571	SPRAYING INSULATION	250	0.036	F/CC
9/27/91	540	MINERAL WOOL(RESPIRABLE)	PLASTERERS #571	SPRAYING INSULATION	166	0.017	F/CC
9/27/91	541	MINERAL WOOL(RESPIRABLE)	PLASTERERS #571	SPRAYING INSULATION	155	0.028	F/CC
10/21/9	563	MINERAL WOOL(RESPIRABLE)	PLASTERERS #571	SPRAYING INSULATION	225	0.019	F/CC
10/21/9	564	MINERAL WOOL(RESPIRABLE)	PLASTERERS #571	SPRAYING INSULATION	136	0.006	F/CC
9/25/91	532	MINERAL WOOL(RESPIRABLE)	PLASTERERS #96	SPRAYING INSULATION	355	.033	F/CC
10/24/9	570	MINERAL WOOL(TOTAL)	LIUNA #571	SPRAYING INSULATION	242	0.025	F/CC
9/6/91	521	MINERAL WOOL(TOTAL)	PLASTERERS #571	LOADING HOOPER	235	0.049	F/CC
9/25/91	533	MINERAL WOOL(TOTAL)	PLASTERERS #571	SPRAYING INSULATION	250	0.041	F/CC
9/27/91	540	MINERAL WOOL(TOTAL)	PLASTERERS #571	SPRAYING INSULATION	166	0.023	F/CC
9/27/91	541	MINERAL WOOL(TOTAL)	PLASTERERS #571	SPRAYING INSULATION	155	0.034	F/CC
10/13/9	550	MINERAL WOOL(TOTAL)	PLASTERERS #571	SPRAYING INSULATION	150	0.041	F/CC
10/21/9	563	MINERAL WOOL(TOTAL)	PLASTERERS #571	SPRAYING INSULATION	225	0.034	F/CC
10/21/9	564	MINERAL WOOL(TOTAL)	PLASTERERS #571	SPRAYING INSULATION	136	0.016	F/CC
9/16/91	522	MINERAL WOOL(TOTAL)	PLASTERERS #96	SPRAYING INSULATION	233	0.062	F/CC
9/25/91	532	MINERAL WOOL(TOTAL)	PLASTERERS #96	SPRAYING INSULATION	355	.039	F/CC
6/9/92	816	NAPTHA(VM&P)	CARPENTERS#1631-C	GLUING CARPET	55	18.6	MG/M3
6/17/92	852	NAPTHA(VM&P)	CARPENTERS#1631-C	GLUING CARPET	213	48.5	MG/M3
6/17/92	854	NAPTHA(VM&P)	IBPAT #1773	AIRLESS PAINTSPRAYING	90	7.7	MG/M3

Date	Sample No.	Exposure	Union	Process	Sample Time	Result	Units
5/6/92	774	ORGANIC SOLVENTS	TERRAZZO FINISHERS #29	SPREADING PRIMER	68	46.3	MG/M3
6/17/92	860	PAINT MISTS	IBPAT #1773	AIRLESS PAINTSPRAYING	90	32.72	MG/M3
5/14/92	787	PAINT MISTS	IBPAT #368	AIRLESS PAINTSPRAYING	111	37.91	MG/M3
5/6/92	771	QUARTZ(RESPIRABLE)	AREA	SANDBLASTING	94	1.883	MG/M3
5/6/92	759	QUARTZ(RESPIRABLE)	AREA SAMPLE	SANDBLASTING	87	0.223	MG/M3
4/29/92	763	QUARTZ(RESPIRABLE)	AREA SAMPLE	SANDBLASTING	38	12.165	MG/M3
4/29/92	764	QUARTZ(RESPIRABLE)	AREA SAMPLE	SANDBLASTING	115	9.154	MG/M3
6/17/92	858	QUARTZ(RESPIRABLE)	LIUNA #456	CUT/LAY PAVING BLOCK/BRICK	142	0.07	MG/M3
6/9/92	815	QUARTZ(RESPIRABLE)	LIUNA #74	CHIPPING CONCRETE	89	0.34	MG/M3
4/27/92	758	QUARTZ(RESPIRABLE)	PLASTERERS #96	PLASTERING NEAR SANDBLASTING	107	0.21	MG/M3
6/9/92	820	QUARTZ(RESPIRABLE)	TERRAZZO FINISHERS #31	GRINDING TERRAZZO	73	0.08	MG/M3
4/29/92	760	QUARTZ(RESPIRABLE-INSIDE HELMET)	C&CM #891	SANDBLASTING	35	0.06	MG/M3
4/24/92	751	QUARTZ(RESPIRABLE-INSIDE HELMET)	LIUNA #74	SANDBLASTING	80	0.06	MG/M3
4/24/92	754	QUARTZ(RESPIRABLE-INSIDE HELMET)	LIUNA #74	SANDBLASTING	9	<0.22	MG/M3
4/27/92	756	QUARTZ(RESPIRABLE-INSIDE HELMET)	LIUNA #74	SANDBLASTING	44	<0.05	MG/M3
4/24/92	755	QUARTZ(RESPIRABLE-OUTSIDE HELMET)	LIUNA #74	SANDBLASTING	9	<0.22	MG/M3
4/27/92	757	QUARTZ(RESPIRABLE-OUTSIDE HELMET)	LIUNA #74	SANDBLASTING	44	1.07	MG/M3
5/6/92	770	QUARTZ(RESPIRABLE-OUTSIDE HELMET)	LIUNA #74	SANDBLASTING	135	2.89	MG/M3
5/6/92	777	QUARTZ(RESPIRABLE-OUTSIDE HELMET)	LIUNA #74	SANDBLASTING	55	4.69	MG/M3
6/9/92	840	QUARTZ(TOTAL)	LIUNA #456	CUT/LAY CONCRETE PAVING BRICK/BLOCK	97	0.19	MG/M3
6/17/92	850	QUARTZ(TOTAL)	LIUNA #456	TAMPING PAVING BLOCK	130	0.34	MG/M3
6/17/92	851	QUARTZ(TOTAL)	LIUNA #456	CUT/LAY CONCRETE PAVING BLOCK/BRICK	133	0.62	MG/M3
6/17/92	859	QUARTZ(TOTAL)	LIUNA #456	CUT/LAY CONCRETE PAVING BRICK/BLOCK	137	0.16	MG/M3
6/10/92	844	QUARTZ(TOTAL)	PLASTERERS #96	SANDING DRYWALL	50	0.23	MG/M3
6/10/92	843	QUARTZ(TOTAL)	TERRAZZO FINISHERS #31	GRINDING TERRAZZO	63	0.07	MG/M3
4/29/92	760	SAND CONCRETE DUST(RESP.-INSIDE HELMET)	C&CM #891	SANDBLASTING	35	<0.17	MG/M3
5/6/92	759	SAND/CONCRETE DUST(RESPIRABLE)	AREA	SANDBLASTING	87	1.173	MG/M3
4/29/92	763	SAND/CONCRETE DUST(RESPIRABLE)	AREA	SANDBLASTING	38	33.070	MG/M3
5/6/92	771	SAND/CONCRETE DUST(RESPIRABLE)	AREA	SANDBLASTING	94	4.790	MG/M3
4/27/92	758	SAND/CONCRETE DUST(RESPIRABLE)	PLASTERERS #96	PLASTERING NEAR SANDBLASTING	107	0.62	MG/M3
4/24/92	751	SAND/CONCRETE DUST(RESP.-INSIDE HELMET)	LIUNA #74	SANDBLASTING	80	0.20	MG/M3
4/24/92	754	SAND/CONCRETE DUST(RESP.-INSIDE HELMET)	LIUNA #74	SANDBLASTING	9	<0.67	MG/M3
4/27/92	756	SAND/CONCRETE DUST(RESP.-INSIDE HELMET)	LIUNA #74	SANDBLASTING	44	<0.14	MG/M3
4/29/92	762	SAND/CONCRETE DUST(RESP.-OUTSIDE HELMET)	C&CM #891	SANDBLASTING	48	<0.15	MG/M3
4/24/92	755	SAND/CONCRETE DUST(RESP.-OUTSIDE HELMET)	LIUNA #74	SANDBLASTING	9	<0.67	MG/M3
4/27/92	757	SAND/CONCRETE DUST(RESP.-OUTSIDE HELMET)	LIUNA #74	SANDBLASTING	44	3.16	MG/M3
5/6/92	770	SAND/CONCRETE DUST(RESP.-OUTSIDE HELMET)	LIUNA #74	SANDBLASTING	135	8.49	MG/M3
5/6/92	777	SAND/CONCRETE DUST(RESP.-OUTSIDE HELMET)	LIUNA #74	SANDBLASTING	55	13.79	MG/M3
6/17/92	861	WELDING FUMES(LEAD)	IRONWORKERS #5	MMA WELDING PAINTED STEEL	69	19	UG/M3
10/30/9	582	WELDING FUME(ALUMINUM)	STEAMFITTERS #602	MMA WELDING CARBON STEEL	55	<0.19	MG/M3
4/6/92	720	WELDING FUME(CALCIUM)	STEAMFITTERS #602	MMA WELDING CARBON STEEL	128	0.114	MG/M3
4/10/92	730	WELDING FUME(CALCIUM)	STEAMFITTERS #602	MMA WELDING CARBON STEEL	34	0.114	MG/M3
4/6/92	720	WELDING FUME(IRON OXIDE)	STEAMFITTERS #602	MMA WELDING CARBON STEEL	128	3.94	MG/M3
4/10/92	730	WELDING FUME(IRON OXIDE)	STEAMFITTERS #602	MMA WELDING CARBON STEEL	34	1.23	MG/M3
10/30/9	582	WELDING FUME(IRON)	STEAMFITTERS #602	MMA WELDING CARBON STEEL	55	4.34	MG/M3

Date	Sample No.	Exposure	Union	Process	Sample Time	Result	Units
11/13/9	591	WELDING FUME(IRON)	STEAMFITTERS #602	MMA WELDING CARBON STEEL	59	2.73	MG/M3
11/22/9	600	WELDING FUME(IRON)	STEAMFITTERS #602	MMA WELDING CARBON STEEL	37	0.522	MG/M3
12/12/9	644	WELDING FUME(IRON)	STEAMFITTERS #602	MMA WELDING CARBON STEEL	39	5.29	MG/M3
12/13/9	651	WELDING FUME(IRON)	STEAMFITTERS #602	MMA WELDING CARBON STEEL	21	1.39	MG/M3
2/5/92	690	WELDING FUME(IRON)	STEAMFITTERS #602	MMA WELDING CARBON STEEL	107	3.26	MG/M3
2/5/92	691	WELDING FUME(IRON)	STEAMFITTERS #602	MMA WELDING CARBON STEEL	105	2.81	MG/M3
10/3/91	554	WELDING FUME(IRON)	STONE MASON #2	MMA WELDING STRUCTURAL STEEL	50	0.384	MG/M3
10/30/9	582	WELDING FUME(LEAD)	STEAMFITTERS #602	MMA WELDING CARBON STEEL	55	<37	UG/M3
11/13/9	591	WELDING FUME(LEAD)	STEAMFITTERS #602	MMA WELDING CARBON STEEL	59	<27	UG/M3
4/6/92	720	WELDING FUME(LEAD)	STEAMFITTERS #602	MMA WELDING CARBON STEEL	128	<5.8	UG/M3
4/10/92	730	WELDING FUME(LEAD)	STEAMFITTERS #602	MMA WELDING CARBON STEEL	34	<21	UG/M3
4/6/92	720	WELDING FUME(MAGNESIUM)	STEAMFITTERS #602	MMA WELDING CARBON STEEL	128	0.0346	UG/M3
4/10/92	730	WELDING FUME(MAGNESIUM)	STEAMFITTERS #602	MMA WELDING CARBON STEEL	34	0.018	MG/M3
10/30/9	582	WELDING FUME(MANGANESE)	STEAMFITTERS #602	MMA WELDING CARBON STEEL	55	0.278	MG/M3
11/13/9	591	WELDING FUME(MANGANESE)	STEAMFITTERS #602	MMA WELDING CARBON STEEL	59	0.259	MG/M3
11/22/9	600	WELDING FUME(MANGANESE)	STEAMFITTERS #602	MMA WELDING CARBON STEEL	37	0.049	MG/M3
12/12/9	643	WELDING FUME(MANGANESE)	STEAMFITTERS #602	MMA WELDING CARBON STEEL	21	0.12	MG/M3
12/13/9	651	WELDING FUME(MANGANESE)	STEAMFITTERS #602	MMA WELDING CARBON STEEL	21	0.068	MG/M3
2/5/92	690	WELDING FUME(MANGANESE)	STEAMFITTERS #602	MMA WELDING CARBON STEEL	107	0.134	MG/M3
2/5/92	691	WELDING FUME(MANGANESE)	STEAMFITTERS #602	MMA WELDING CARBON STEEL	105	0.332	MG/M3
4/6/92	720	WELDING FUME(MANGANESE)	STEAMFITTERS #602	MMA WELDING CARBON STEEL	128	0.021	MG/M3
4/10/92	730	WELDING FUME(MANGANESE)	STEAMFITTERS #602	MMA WELDING CARBON STEEL	34	0.705	MG/M3
10/3/91	554	WELDING FUME(MANGANESE)	STONE MASON #2	MMA WELDING STRUCTURAL STEEL	50	0.061	MG/M3
11/13/9	591	WELDING FUME(TITANIUM)	STEAMFITTERS #602	MMA WELDING CARBON STEEL	59	<0.67	MG/M3
4/6/92	720	WELDING FUME(TOTAL)	STEAMFITTERS #602	MMA WELDING CARBON STEEL	128	9.18	MG/M3
4/10/92	730	WELDING FUME(TOTAL)	STEAMFITTERS #602	MMA WELDING CARBON STEEL	34	2.52	MG/M3
10/30/9	582	WELDING FUME(VANADIUM)	STEAMFITTERS #602	MMA WELDING CARBON STEEL	55	0.018	MG/M3
11/13/9	591	WELDING FUME(ZINC)	STEAMFITTERS #602	MMA WELDING CARBON STEEL	59	<0.014	MG/M3
4/10/92	730	WELDING FUME(ZINC)	STEAMFITTERS #602	MMA WELDING CARBON STEEL	34	<0.011	MG/M3
6/17/92	861	WELDING FUMES(ALUMINUM)	IRONWORKERS #5	MMA WELDING PAINTED STEEL	69	<0.16	MG/M3
6/9/92	813	WELDING FUMES(IRON OXIDE)	IRONWORKERS #5	MMA WELDING PAINTED STEEL	35	0.108	MG/M3
6/17/92	861	WELDING FUMES(IRON)	IRONWORKERS #5	MMA WELDING PAINTED STEEL	69	0.535	MG/M3
6/9/92	813	WELDING FUMES(LEAD)	IRONWORKERS #5	MMA WELDING PAINTED STEEL	35	32	UG/M3
6/9/92	813	WELDING FUMES(MANGANESE)	IRONWORKERS #5	MMA WELDING PAINTED STEEL	35	<0.011	MG/M3
6/17/92	861	WELDING FUMES(MANGANESE)	IRONWORKERS #5	MMA WELDING PAINTED STEEL	69	0.027	MG/M3
6/9/92	813	WELDING FUMES(TOTAL)	IRONWORKERS #5	MMA WELDING PAINTED STEEL	35	2.92	MG/M3
6/17/92	861	WELDING FUMES(TOTAL)	IRONWORKERS #5	MMA WELDING PAINTED STEEL	69	3.28	MG/M3
6/9/92	813	WELDING FUMES(ZINC)	IRONWORKERS #5	MMA WELDING PAINTED STEEL	35	0.015	MG/M3
6/17/92	861	WELDING FUMES(ZINC)	IRONWORKERS #5	MMA WELDING PAINTED STEEL	69	0.015	MG/M3
10/30/9	580	XYLENE	ROOFERS #90	APPLYING ASPHALT MASTIC FOR WATERPRO	48	21.6	PPM
4/29/92	766	XYLENE	ROOFERS #90	APPLYING ASPHALT MASTIC FOR WATERPRO	48	2.23	PPM
4/29/92	767	XYLENE	ROOFERS #90	APPLYING ASPHALT MASTIC	78	11.5	PPM

Appendix D. Exposures Observed During Walk-Throughs of IAM Project (page 1 of 7)

Date	*Craft*	*Process*	*Exposure*
3/11/92	Carpenters	Gluing down pedestals for raised floor grating	Solvents
3/11/92	Ironworkers	Removing and sweeping dry mineral wool insulation from around steel columns	Mineral wool
3/11/92	Marble Workers	Grinding and shaving granite	Respirable quartz
3/11/92	Abrasive Blasters	Finishing pre-cast with Black Beauty	Respirable dust
3/11/92	Laborer	Chipping concrete with pneumatic chipping hammer	Vibration and concrete dust
3/11/92	Steamfitters	Welding carbon steel	Welding fumes (iron and manganese)
4/3/92	Steamfitters	Tack welding in machine room	Welding fumes
4/3/92	Sheet Metal Workers	Installing draft dampers	Mineral wool dust
4/3/92	Caulkers (Stone Mason)	Cleaning tools	Xylol
4/3/92	Drywallers	Cutting rigid insulation	Fiberglass
4/3/92	Steamfitters	Soldering copper pipe in ceiling	Soldering fumes, NOKORODE (Zinc Chloride)
4/3/92	Laborer	Dry sweeping	Concrete dust, Mineral wool, dust
4/3/92	Multiple crafts — steamfitters, electricians, etc.	Working near ceiling and disturbing fireproofing	Mineral wool (Slag or rock wool)
5/6/93	Laborer	Breaking up Concrete in dumpster with jackhammer	Vibration
5/6/93	Terrazzo Workers	Spreading primer and epoxy-based marble chips or dust	Epoxy-resins, knee strain
5/6/93	Carpenters	Using "worm-driver" skill saw	Noise

Appendix D. Exposures Observed During Walk-Throughs of IAM Project (page 2 of 7)

Date	*Craft*	*Process*	*Exposure*
5/6/92	Laborer	Sandblasting wall	Silica, noise
5/6/92	Laborer	Tamping subgrade for paving	Vibration
5/6/92	Painters	Spraying water-based paint	Paint mists
5/6/92	Steamfitters	Welding pipe in unventilated machine room	Welding fumes
5/6/92	Tilesetters	Setting tile with gravel and mortar mix 3701 (Laticrete)	Knee strain, Styrene, Butadiane
5/6/92	Laborer	Dry-sweeping	Particulates
5/6/92	Ironworkers	Welding red-iron handrail	Welding fumes
5/6/92	Drywall finisher	Sanding drywall	Gypsum dust
5/6/92	Carpenters	Cutting block to fit metal door jams	Noise, cement dust
5/6/92	Painters	Cleaning tools and spray pot with Oriole lacquer thinner	(Toluene, petroleum distillate alcohols, ketones, asters)
5/6/92	Painters	Spraying Polomyx	Mineral spirits, paint mists
5/6/92	Sheet metal workers	Shooting hangers in place in ceiling sprayed with mineral wool	Mineral wool
5/14/92	Painters	Rolling, brushing, and spraying paint	Pigments, solvents
5/14/92	Roofers	Spreading bituthane primer on roof	Xylene
5/14/92	Ironworkers	Cleaning metal surfaces	Stoddard solvent
5/14/92	Cement finishers, laborers	Using asphalt thinned with stoddard solvent to set stepping stones	Asphalt, stoddard solvent
5/14/92	Laborers	Dry-sweeping construction debris	Dust

Appendix D. Exposures Observed During Walk-Throughs of IAM Project (page 3 of 7)

Date	*Craft*	*Process*	*Exposure*
5/14/92	Drywall hangers	Cutting and installing drywall using utility knife and screw gun	Ergonomic stress
5/14/92	Drywall finishers	Sanding drywall joint compound	Gypsum dust, ergonomic stress
5/14/92	Telephone workers	Shooting cable hangers with ramset	Mineral wool fibers
5/14/92	Tile setters	Troweling, grouting, and setting tiles	Acids, cement (wet and dry), knee and wrist strain
5/14/92	Sprinkler filters	Using pipe threading machine	Oil mist
6/9/92	Painters	Applying Shur-stik 111 wall adhesive for upholstered wall	
6/9/92	Insulators	Installing fiberglass batts	Fiberglass
6/9/92	Laborer	Dry-sweeping	Dust
6/9/92	Laborer	Chipping concrete with pneumatic chipping hammer	Vibration, Noise, Dust
6/9/92	Carpet layers	Installing carpet with adhesives. Cleaning glue off carpet	VM&P naptha, Methanol, Ethylane Glycol, 1,1,1-Trichloroethane, and other solvents
6/9/92	Ironworkers	Welding steel stairs in enclosure designed to protect finished surfaces from sprarks	Welding Fumes
6/9/92	Terrazzo workers	Installing terrazzo floor system	Acid, Solvents, Epoxy Resins, Dust, Knee and Wrist strain
6/9/92	Cement finishers	Cutting and laying stepping stones	Asphalt Fumes, Dust, gasoline vapors, noise

Appendix D. Exposures Observed During Walk-Throughs of IAM Project (page 4 of 7)

Date	*Craft*	*Process*	*Exposure*
2/12/91	Drywallers	Shooting metal place with Hilti gun, cutting studs with chop saw	Noise
2/12/91	Roofers	Installing built-up roof	Asphalt fFumes
2/12/91	Glaziers	Cutting and drilling 1/8" aluminum sheets	Noise
2/12/91	Laborers	Dry sweeping	Mixed dust
2/12/91	Carpenters	Chipping concrete slab with electric chipping hammer	Vibration, nise (103-113 dBA)
2/12/91	Steamfitters	Welding 1½" carbon steel pipe	Welding fumes — iron, manganese, gases
2/12/91	Laborers	Using pneumatic chipping hammer to break up concrete stair steps	Noise (108-111 dBA)
2/12/91	Steamfitters	Using 5 percent silver solder to braze copper pipe and cut galvanized decking out of way of pipe riser	Welding and soldering fumes
2/12/91	Drywallers	Using adhesives and caulking	Solvent vapors
2/12/91	Sprinkler Fitters	Disturbing insulation to install sprinklers	Mineral wool
2/12/91	Electrician	Disturbing insulation to pull cables	Mineral wool
2/12/91	Steamfitters	Cleaning and soldering copper joints	Solvent vapors, Soldering fumes
10/24/91	Pipefitters	Greasing threads of bolts for pipe clamps	Victaulic (lubricant)
10/24/91	Marble Workers	Caulking kerf anchor of exterior marble sheets	Silglazen
10/24/91	Ironworkers	Using as adhesive for joining exterior metal panels to structural steel	JS-773

Appendix D. Exposures Observed During Walk-Throughs of IAM Project (page 5 of 7)

Date	*Craft*	*Process*	*Exposure*
10/24/91	Ironworkers	Using silicone to caulk joints between exterior metal panels	
10/24/91	Marble Workers	Using skil saw to shave underside of granite sheet	Granite dDust
10/24/91	Electricians	Using to glue PVC pipe joints	Whitlam PVC cement
10/24/91	Laborer	Using chipping hammer (electric motor with chisel) on concrete wall to receive marble	Concrete dust
10/24/91	Mason	Cutting block with radial arm saw	Cement dust
10/24/91	Various crafts	Paint spray used by various crafts for layout	Paint mists, organic vapors
10/24/91	Plumbers and electricians	Cleaning PVC pipe with purple primer before gluing. Work is often done in ditches	Organic vapors
10/24/91	Mechanics	*A/W Hydraulic Oil 32 used by elevator mechanics	Petroleum oils
10/24/91	Plumbers	Using taramet to sauter copper pipe	Soldering fumes (copper and zinc)
10/24/91	Plumbers	Using Nokorode to make solder stick to copper pipe surface	Zinc chloride
10/24/91	Plumbers	Using SLIC-TITE glue on pipe threads	Organic vapors
10/30/91	Granite workers	Using polyurethane construction sealant to waterproof bolt hole	
10/30/91	Marble workers	Caulking kerf anchor of exterior marble sheets with Silglazen	
10/30/91	Ironworkers	Using JS-773 adhesive for joining exterior metal panels to structural steel	

*These products were not in use during our walk-through, but were pointed out to us by crafts working at the site.

Appendix D. Exposures Observed During Walk-Throughs of IAM Project (page 6 of 7)

Date	*Craft*	*Process*	*Exposure*
10/30/91	Ironworkers	Using Sil Pruf to caulk joints between exterior metal panels	
10/30/91	Marble workers	Using skil saw to shave underside of granite sheet	Granite dust
10/30/91	Masons	Cutting block with radial arm saw	Cement dust
10/30/91	Various crafts	Aerosolized paint spray used by various crafts for lay-out	Paint miss
10/30/91	Roofers	Using Bituthene P-3000 (a synthetic rubber Soln in organic solvent) to waterproof subgrade walls	Xylane vapors, asphalt skin contact
10/30/91	Laborers	Dry sweeping insulation waste	Mineral wool dust
10/30/91	Pipefitters (welders)	Welding carbon-steel	Welding fumes
11/13/91	Pipefitters (welders)	Installing carbon steel pipes for chiller system	Welding fumes
11/13/91	Laborer	Waterproofing elevator pit with two-part system. Mixture is painted on. Cement-based dry component. Acrylic resin liquid component	Organic vapors
11/13/91	Carpenters	Drilling into concrete	Concrete dust
11/13/91	Drywallers	Cutting drywall	Gypsum dust
11/13/91	Ironworkers	Using Sil Pruf caulk joints of aluminum window frame	
11/13/91	Various crafts	Disturbing fireproof insulation to work on surfaces	Mineral wool
11/13/91	Masons	Block laying, mortar mixing	Cement (skin-wet mortar inhalation-dry cement)

Appendix D. Exposures Observed During Walk-Throughs of IAM Project (page 7 of 7)

Date	***Craft***	***Process***	***Exposure***
11/13/91	Laborers	Patching over snap-ties with wet mortar, mixing dry components	Wet cement skin contact
11/13/91	Laborers	Dry sweeping and scraping concrete and debris (insulation, trash, etc.)	Dust
11/13/91	Insulators	Applying thermal insulation batts to exterior of duct work	Synthetic fibers
11/22/91	Insulators	Coating insulation tape with Foster 30-35 Tite Fit coating	Organic vapors
11/22/91	Insulators	Wrapping duct with batt insulation using Foster 85-20 Adhesive	Organic vapors
11/22/91	Elevator mechanics	Filling hydraulic shafts with AW Hydraulic oil 32	
11/22/91	Plumbers	Soldering copper pipe with Nokorode Flux-Taramet solder	Zinc chloride, Copper fumes
11/22/91	Carpenters	Laying out footers	Lime dust
11/22/91	Carpenters	Cutting plywood	Wood and resin dust
11/22/91	Laborers	Dry sweeping	Mineral wool and nuisance dust
11/22/91	Laborers	Using chipping hammer	Concrete dust
11/22/91	Ironworkers	Mounting window frames and caulking with JS 773 Butyl Sealant Sil Pruf waterproofing	
11/22/91	Ironworkers	Ironworkers	Welding fumes
11/22/91	Sheet metal workers	Hanging duct from ceiling (involving disturbance of fireproofing)	Mineral wool dust
11/22/91	Drywallers	Cutting metal studs with electric saw	Metal dust