Mechanical and Electrical Construction Trades - WMSD Risk Factors and Interventions

Jim Albers, Cherie Estill, and Leslie MacDonald
National Institute for Occupational Safety and Health
Cincinnati, Ohio, USA

A meeting was organized by NIOSH in February 2002 to explore the current use and future development of ergonomic interventions for the electrical and mechanical construction trades. Attendees included contractor and trade representatives, as well as researchers from academia and government. Meeting in small groups, participants identified task-specific WMSD risk factors and how varying conditions affect a WMSD risk. Participants also identified high risk tasks needing an effective ergonomic intervention.

Background

Building and construction activities in the United States historically have been organized around the work of relatively discreet crafts or trades. Currently thirteen construction craft or trade unions represent construction workers. Plumbers/pipefitters and sheet metal workers, respectively, install piping/plumbing systems and heating, ventilation and air conditioning (HVAC) systems; electricians install electrical conduit and wiring, fixtures, controllers, and switches. Workers in all three trades must complete a four to five years apprenticeship program. Union membership density for electricians, plumbers & pipefitters, and sheet metal workers is, respectively, 38%, 31%, and 41%, compared to 19% for all construction workers (CPWR, 2003).

Although the data are limited, WMSDs are a significant problem for the mechanical and electrical trades. Data from the U.S. Bureau of Labor Statistics (BLS) Survey of Occupational Injuries and Illnesses (SOII) for 2000, shows that injuries/illnesses resulting from bodily reaction, overexertion, or repetitive motion accounted for 43%, 58%, and 45% of all WMSDs resulting in one or more days away from work (DAW), respectively, for electricians, plumbers and pipefitters, and HVAC system mechanics and sheet metal duct installers (BLS, 2002). In 2000, these same events accounted for more than 50% of the workers compensation claims for the mechanical and electrical trades in Oregon (OR DBCS, 2002). Rosecrance (2002) recently reported high rates of carpal tunnel syndrome (CTS) among apprentices working in the pipe, electrical, and sheet metal trades.

Introduction

Sixty researchers, contractors and trades people representing the piping/plumbing, heating and air conditioning, and electrical sectors of the U.S. construction industry attended a meeting titled "*Exploring Ergonomic Interventions in the Mechanical & Electrical Construction Trades*" in San Jose, CA. The two day meeting was organized by researchers at the National Institute for Occupational Safety and Health to identify task-specific WMSD risk factors and the interventions currently used to reduce those risks. Researchers also expected to identify gaps in knowledge that could be addressed in the future. The affiliations of the 39 industry attendees are shown in Table 1. Twenty-one researchers from academia and government also attended the meeting.

Table 1
Affiliation of Industry Attendees

Stakeholder	Union	Contractor	Joint*
Electrical	3	7	1
Pipe	5	6	1
Sheet Metal	2	6	1
Other**	1	4	2

* Joint Labor-Management organization.
** Construction industry representative not exclusively involved in mechanical or electrical specialties.

The format included presentations describing WMSD risk factors and injury/illness data for the mechanical and electrical trades, as well as trade-specific break-out sessions. This summary focuses on the activities and results of the three breakout sessions.

Breakout Sessions

Breakout sessions were organized for each of three construction trades/specialties invited

Table 2
Job tasks discussed in breakout sessions

Job task	Electrical	Pipe	Sheet Metal
Drill holes and shoot fasteners[1]	X	X	X
Place and install mechanical and electrical systems[1]	X	X	X
Lift & carry materials and equipment[1]	X	X	X
Cut, bend, align, & position conduit	X		
Pull electrical conductors (cable or wire)	X		
Welding		X[2]	X
Cut & trim sheet metal duct joints			X

(1) Similar tasks with different titles were combined.
(2) Discussed in the pipe trades session as 'joining' pipe, but discussion not completed.

to the meeting. Industry representatives were assigned to the session of their respective trade or specialty. Other stakeholders were assigned to a session according to their knowledge or interest in a trade. Participants were asked to answer the following questions related to job tasks (Table 2) previously identified as presenting a high risk of developing a WMSD (Everett, 1997).

- What are the potential hazards associated with each task?
- Do varying job conditions/context increase or decrease the potential hazard?
- What ergonomic interventions are available and utilized? Has the intervention been shown to be effective?
- What tasks lack an ergonomic intervention to eliminate or attenuate exposure to WMSD risk factors?

Results

Time constraints prevented participants in each breakout session from thoroughly answering all questions related to the tasks they discussed. There were also differences regarding the amount of time a trade/specialty spent on a specific question. The results described below apply to similar tasks conducted by all three trades, although tasks unique to each trade were also discussed.

(1) Drill holes/shoot fasteners

Rotary hammer-drills are typically used to drill mounting holes into concrete or metal ceilings and walls to attach mechanical or electrical system hangers and equipment. Fasteners are shot directly into concrete or metal using a powder actuated tool (PAT).

- *Risk factors* for WMSDs identified for the task were task repetition; physical exertion; repeated and sustained non-neutral postures; tool reaction forces (e.g., vibration, torque, and impact); and contact stress.
- *Body regions* identified to be at risk of developing a WMSD are the neck and back; shoulders; upper extremities; and knees.
- *Variable conditions* that can modify the actual hazard are the work location (e.g., ceiling, floor); substrate; tool type, age and maintenance; characteristics of the job (e.g., number of holes, etc); and site management (e.g., planning and communication).
- *Engineering interventions* in use included ergonomically improved tools (e.g., strip trigger, balanced, low vibration, and clutch driven); extension pole for PATs; and mechanical lifts for overhead work. One available upstream design improvement identified was the use of embedded concrete inserts to eliminate the need to drill holes or shoot fasteners.
- *Additional interventions* discussed included improved tool design and the development of an adjustable stand to hold and advance a rotary drill during overhead drilling.

(2) Place and install mechanical and electrical systems

Commercial and industrial mechanical and electrical systems are supported by hangers, tracks, or trays attached to ceilings or walls. Powered screw guns and manual tools are used to assemble hanging systems and tighten the fasteners that secure the

mechanical and electrical system components. System components must be lifted, positioned and held in place when they are attached to the hangers, tracks or trays. Workers sometimes need to manually position and hold components they are securing.

- *Risk factors* identified for the task are task repetition; repeated and sustained non-neutral body postures; tool reaction forces; physical exertion; and contact stress.
- *Body regions* at risk of developing a WMSD include the neck and back; shoulders; upper extremities; and knees.
- *Variable conditions* that can modify the actual hazard are the work location (e.g., ceiling, floor); standing on ladders; dimension and weight of components; job characteristics (e.g., number of hangers); and available work space.
- *Engineering interventions* in use included ergonomically improved tools (e.g., strip trigger, balanced, low vibration, and clutch driven); slip-on fasteners for threaded rod; drill bit extender; mechanical lifts for workers and material; fixtures for placing system components; and the use of lighter system components.
- *Additional interventions* discussed included design of fixtures and attachments that can be used safely on person-lifts to hold and position system components.

(3) Lift and carry materials and equipment
Building materials and equipment used to assemble mechanical and electrical systems must be unloaded, stored until needed and transported to the location where they will be used. Material handling (e.g., lift, carry, hold, push, and pull) can be done manually or with the use of both powered and non-powered equipment.

- *Risk factors* identified for manual material handling include repeated handling; sustained and non-neutral postures (e.g., bend and twist); physical exertion; contact stress.
- *Body regions* at risk of developing a WMSD include the back; shoulders; upper extremities.
- *Variable conditions* that can modify the actual hazard include location and means of storing equipment (e.g., ground vs. racks); availability and condition of mechanical lift devices; condition of floors, walkways, and ground surfaces; hand-to-object coupling; and work on multiple floors/levels.
- *Engineering interventions* include material handling equipment (e.g., pallet jack, forklift, dolly, etc.); push/pull rolling stock (e.g., pipe rack); manual handling devices (e.g., double hook, shoulder pad, sling, suction/magnetic handles); roller conveyors; rolling scaffold with hoist; and use of wheels with bearings.
- *Additional interventions* discussed included color coding materials by weight; and redesign packaging (e.g., reduce weight/size, embeded handles).

Non-engineering interventions that were endorsed in all breakout sessions included worker training; job planning and organization; communication among contractors/trades; tool and equipment maintenance programs; and good housekeeping practices. Tasks unique to one trade were also discussed in each breakout session. Examples of unique tasks include hand bending conduit or pulling electrical conductors (electricians); trimming sheet metal (sheet metal workers); and joining pipe (pipefitters). These tasks involve building materials and/or tools unique to a specific trade.

Engineering interventions that participants recommended to address associated risk factors included the use of tools and equipment with improved ergonomic design. Non-engineering interventions were similar to those previously described.

Discussion
Participants agreed that the mechanical and electrical trades are at risk for developing WMSDs and identified interventions

currently available to attenuate certain recognized risk factors. Site management and work organization were considered critical to reducing many problems, as well as implementing interventions. Early contractor involvement in a project (e.g., design-build contractors) can influence design decisions that can reduce workers' exposures to WMSD risk factors. Participants believed the introduction and acceptance of interventions were sensitive to the initial costs, affects on productivity, and workers' craft traditions. Although there was a consensus regarding the need to evaluate the effectiveness of new interventions, many participants said they would use them following less rigorous personal or anecdotal verification.

Conclusion

The discussions and recommendations that occurred during the course of the breakout sessions and the plenary sessions suggest the following conclusions:

- Workers employed in the electrical, pipe, and sheet metal trades are exposed to risk factors for WMSDs.
- WMSD risk factors common to the three trades include manual material handling, working at ceiling and floor levels, and the continuously changing building site.
- WMSD risk factors unique to each trade include the use of different materials and tools.
- Ergonomic principles have informed the design and performance of hand tools, but more needs to be done.
- Productivity concerns have led to greater use of powered equipment to transport materials and to position workers and materials above the ground.
- Interventions are not currently available for all high risk jobs and research should be directed to address this gap.

Acknowledgements

The authors want to acknowledge the early assistance provided by the following individuals: Tony Barsotti (Hoffman Construction); Robert Elkins (UA* Local 393 Pipe Trades Training Center); Steve Hecker (University of Oregon); Robin Johnson (CNA Insurance); Phil Lemons (Streimer Sheet Metal); Bert Mazeau (Rosendin Electric); David Potts (National Electrical Contractors' Association); Bill Rhoten (UA); John Rosecrance (University of Colorado); Scott Schneider (Laborers Health & Safety Fund); Tom Soles (Sheet Metal & Air Conditioning Contractors National Association) and Lloyd Williams (UA Local 393). Special thanks to Tony Barsotti, Billy Gibbons (DGI), and Steve Hecker for facilitating breakout sessions. (*United Association of Journeymen & Apprentices of the Plumbing & Pipe Fitting Industry.)

References

BLS [2002] BLS SOII Case and Demographic data provided by BLS to NIOSH in Excel spreadsheet.

CPWR [2002] The Construction Chart Book: The U.S. Construction Industry and Its Workers. Center to Protect Workers' Rights, Silver Spring, MD.

Everrett J [1997] Ergonomic Analysis of Construction Tasks for Risk Factors for Overexertion Injuries. NIOSH Grant 5 R03 OH03154-02, Technical Report UMCEE 96-27. Department of Civil & Environmental Engineering, University of Michigan, Ann Arbor.

OR DBCS [2002]. Table 14: Number of disabling claims by occupation and accident or exposure event. Oregon Depart of Business and Consumer Services. Accessed 12/2002 at www.cbs.state.or.us/.

Rosecrance JC, Cook TM, Anton DC, Merlino LA [2002] Carpal Tunnel Syndrome Among Apprentice construction Workers. Am J Ind Med 42: 107-11.

The Ergonomics Society of Korea
128-8 Yeongeon-dong, Jongno-gu
Seoul 110-770, Korea
TEL +82-2-744-7700 (ext 117), FAX +82-2-744-9055
esk@idas.ac.kr
http://www.esk.or.kr

IEA 2003

August 24-29, 2003

PROCEEDINGS OF THE
XVth Triennial Congress of the
International Ergonomics Association
and
The 7th Joint Conference of
Ergonomics Society of Korea / Japan Ergonomics Society