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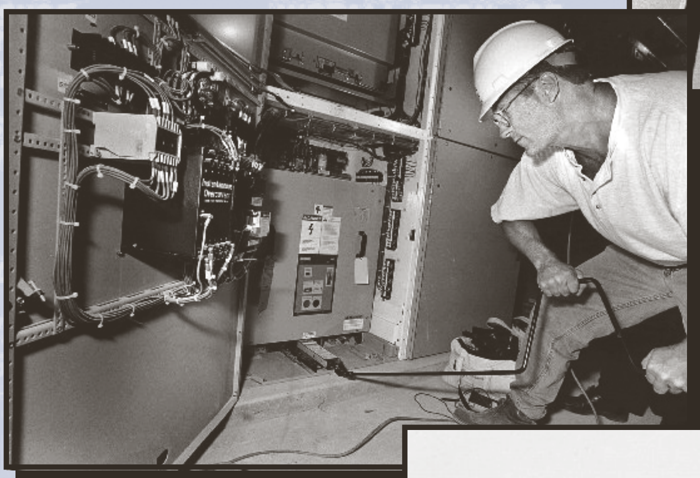
PROCEEDINGS OF A MEETING TO EXPLORE THE USE OF ERGONOMICS INTERVENTIONS FOR THE MECHANICAL AND ELECTRICAL TRADES



FEBRUARY 25-26, 2002

UA LOCAL 393
PIPE TRADES
TRAINING CENTER
SAN JOSE, CALIFORNIA

DEPARTMENT OF HEALTH AND HUMAN SERVICES
CENTERS FOR DISEASE CONTROL AND PREVENTION
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH

NIOSH

PROCEEDINGS OF A MEETING TO EXPLORE THE USE OF ERGONOMICS INTERVENTIONS FOR THE MECHANICAL AND ELECTRICAL TRADES

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February 25–26, 2002

DEPARTMENT OF HEALTH AND HUMAN SERVICES (DHHS)
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health (NIOSH)

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FOREWORD

Work-related musculoskeletal disorders (WMSDs) are a major cause of injury and illness in the construction industry. In the year 2000, according to the Bureau of Labor Statistics, WMSDs accounted for 28% of the injuries and illnesses resulting in days away from work for construction workers. Disabling WMSDs deprive workers of their livelihood and self-esteem and can turn the most common daily activity into a difficult and frustrating task. These WMSDs also place significant burdens on construction firms, especially smaller contractors, in the form of lost productivity and increased workers' compensation expenses.

The construction industry presents unique obstacles for contractors and workers interested in preventing WMSDs. These obstacles include a reliance on physical strength, traditional work methods, multiple employer work sites, and the continually changing work environment. Fortunately, mounting evidence suggests that many of the above risk factors contributing to the occurrence of WMSDs in the construction industry can be decreased and, in some cases, eliminated.

Despite an increasing interest in construction ergonomics, few studies report the results of ergonomic interventions intended for the mechanical and electrical trades. This document helps to fill that gap in knowledge. The document relates the practical experience and knowledge that a group of construction contractors and trades-people developed during their efforts to control workers' exposures to WMSD risk factors. The document describes specific tasks and the varying job conditions that increase a worker's risk of developing a WMSD and recommends preventive measures for contractors and trades-people.

The National Institute for Occupational Safety and Health (NIOSH), as the national agency responsible for occupational safety and health research, is committed to reducing the toll of WMSDs work-related musculoskeletal disorders on American workers. We look forward to continuing work with our public- and private-sector partners who have similar interests in protecting American construction workers.

John Howard, M.D.
Director, National Institute for
Occupational Safety and Health
Centers for Disease Control and Prevention

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MEETING SUMMARY

In February 2002, 60 researchers, contractors, and trades people representing the piping (or plumbing), heating and air-conditioning, and electrical sectors of the U.S. construction industry attended a meeting titled, Exploring Ergonomics Interventions in the Mechanical and Electrical Construction Trades in San Jose, California. The 2-day meeting was organized by researchers at the National Institute for Occupational Safety and Health (NIOSH). The meeting attendees consisted of 39 industry trades people and 21 researchers from academia and government. The affiliations of the 39 industry attendees are shown in Table Summary 1.

Table Summary 1. Affiliation of industry attendees

Stakeholder	Union	Contractor	Joint[1]
Electrical	3	7	1
Pipe	5	6	1
Sheet metal	2	6	1
Other[2]	1	4	2

[1] Joint Labor-Management organization.
[2] Construction industry representative not exclusively involved in mechanical or electrical specialties.

The format of the meeting included presentations describing work-related musculoskeletal disorder (WMSD) risk factors and injury or illness data for the mechanical and electrical trades, as well as trade-specific breakout sessions. Edited transcripts of the presentations with questions and answers are included in the proceedings as documentation of the meeting. The content, however, might not reflect current NIOSH policy or endorsement. This summary focuses on the activities and results of the three breakout sessions.

Breakout Sessions

Breakout sessions were organized for each of the three construction trades and specialties invited to the meeting (electrical, pipe, and sheet metal). 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 Summary 2), previously identified as presenting a high risk of developing WMSDs [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 reduce exposure to WMSD risk factors?

Table Summary 2. Job tasks discussed in breakout sessions

Job Tasks	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 and carry materials and equipment [1]	X	X	X
Cut, bend, align, and position conduit	X		
Pull electrical conductors (cable or wire)	X		
Welding		X [2]	X
Cut and 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

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 job tasks conducted by all three trades, although tasks unique to each trade were also discussed.

Drill Holes and Shoot Fasteners

Rotary hammer-drills are used to drill mounting holes for fasteners into concrete or metal (e.g., ceilings, walls, and metal beams) for 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 are task frequency (e.g., number of fasteners specified), 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 WMSDs 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 include 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 embedded concrete inserts to eliminate the need for drilling holes or shooting fasteners.

- *Additional interventions* discussed include improved tool design and the development of an adjustable stand to hold and advance a rotary drill during overhead drilling.

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 WMSDs include the neck and back, shoulders, upper extremities, and knees.

- *Variable conditions* that could 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 include 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 lighter system components.

- *Additional interventions* discussed include design of fixtures and attachments that can safely be used on person-lifts to hold and position system components.

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 by powered and non-powered equipment.

- *Risk factors* identified for manual material handling (MMH) include repeated handling, sustained and non-neutral postures (e.g., bend and twist), physical exertion, and contact stress.

- *Body regions* at risk of developing WMSDs include the back, shoulders, and 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 or 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 or magnetic handles), roller conveyors, rolling scaffold with hoist, and appropriate wheels (e.g., large diameter, hard material, bearings).

- *Additional interventions* discussed include color coding materials by weight and redesigned packaging (e.g., reduce weight and size, embedded handles).

Non-engineering interventions that were endorsed in all breakout sessions include worker training, job planning and organization, communication among contractors and trades, tool and equipment maintenance programs, and good housekeeping practices.

Job tasks unique to each trade were also discussed in the breakout sessions. Examples of trade-specific tasks include hand-bending conduit or pulling electrical conductors (electricians), trimming sheet metal (sheet metal workers), and joining pipe (plumbers and pipefitters). These tasks involve materials and/or tools unique to a specific trade. Engineering interventions that participants recommended to address associated risk factors include tools and equipment to reduce biomechanical stressors. Non-engineering interventions are 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 in facilitating the implementation of interventions. Early contractor involvement in a project (e.g., design-build contractors) could influence design decisions that, in turn, could reduce worker exposures to WMSD risk factors. Factors that influenced use of commercially available interventions include the start-up costs, effects on productivity, and craft traditions. Although there was a consensus regarding the need to evaluate the effectiveness of new interventions, many participants said they would use them after less rigorous personal or anecdotal verification.

Conclusion

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

- Workers employed in the electrical, pipe, and sheet metal trades are exposed to risk factors for WMSDs.

- WMSD risk factor conditions common to the three trades include MMH, work location (e.g., ceiling, floor), and the continuously changing building site.

- WMSD risk factor conditions unique to the three trades include the type of materials, tools, and equipment used.

- Ergonomic principles have informed the design and performance of commercial hand tools, but additional tool design is needed to reduce exposures to biomechanical stressors.

- Ergonomic interest in increasing worker productivity has resulted in greater use of powered equipment to transport materials and to lift and position workers and materials above floor level.

Interventions are not currently available for all high-risk jobs, and research should be directed to address this gap.

ABBREVIATIONS

AGC	Associated General Contractors
BLS	Bureau of Labor Statistics
CalOSHA	California Occupational Safety and Health Administration
CPWR	Center for the Protection of Workers' Rights
CSAO	Construction Safety Association of Ontario
CTS	carpal tunnel syndrome
DAW	day(s) away from work
^oC	degree(s) Celsius
^oF	degree(s) Fahrenheit
DOL	Department of Labor
eLCOSH	Electronic Library of Construction Occupational Safety and Health
EMG	Electromyogram
5 Ss	Sort, Set in order, Shine, Standardize, Sustain (Japanese methodology for a productive work environment)
FTW	full-time worker(s)
GC	general contractor(s)
GPS	global positioning system
HEPA	high-efficiency particulate air
HVAC	heating, ventilation, and air-conditioning
IBEW	International Brotherhood of Electrical Workers
IR	incidence rate
LTI	lost-time injury(ies)
MCA	Mechanical Contractors Association
MDAW	median days away from work
MMH	manual material handling
MSD	musculoskeletal disorder(s)
NAICS	North American Industrial Classification System
NASA	National Aeronautics and Space Administration
NECA	National Electrical Contractors Association
n.e.c.	not elsewhere classified
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
PAT	powder-actuated tool
PI	Prevention Index
PPE	Personal protective equipment
PVC	polyvinylchloride
SHARP	Safety and Health Assessment and Research for Prevention
SIC	Standard Industrial Classification
SMACNA	Sheet Metal and Air-Conditioning Contractors National Association
SMAP	Sheet Metal, Mechanical, Air-Conditioning and Plumbing Program
SMOHIT	Sheet Metal Occupational Health Institute Trust

SMWIA	Sheet Metal Workers' International Association
SOC	Standard Occupational Classification
SOII	Survey of Occupational Injuries and Illnesses
WC	Workers' Compensation
WMSD(s)	Work-related musculoskeletal disorder(s)
WSIB	Workplace Safety and Insurance Board

Glossary

Musculoskeletal disorder (MSD). A condition or disorder that involves the muscles, nerves, tendons, ligaments, joints, cartilage or spinal discs. These disorders are not typically the result of a distinctive, singular event, but are more gradual in their development. Thus, MSDs, are cumulative-type injuries.

Acute injury. A singular, traumatic event resulting in a disruption of tissues, resulting in pain. [Kumar 2001].

MSD risk factors. Actions or conditions that increase the likelihood of injury to the musculoskeletal system. Risk factors have components of duration, frequency, and level of exposure. Exposure to risk factors leads to discomfort and pain, which over time can lead to more serious disorders of the musculoskeletal system.

Ergonomics. A discipline or science of fitting workplace conditions and job demands to the capabilities of the worker. Many consider ergonomics a multidisciplinary field of applied science where knowledge about human capabilities, skills, limitations, and needs is taken into account when examining the interactions among people, technology, and the work environment. [Westgaard and Winkel 1997; Cohen et al. 1997].

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DEDICATION

This document is dedicated to the memories of Ms. Robin Johnson and Mr. Lloyd Williams. Ms. Johnson and Mr. Williams were early supporters of the meeting described in this document and both have met sudden and unexpected deaths. Ms. Johnson was the Director for the CNA Insurance Company's Loss Control Casualty Services in Chicago, Illinois. As an early supporter of the meeting, Robin quickly offered her advice and services. She prepared two presentations describing CNA's workers' compensation insurance data for the mechanical and electrical trades. Mr. Lloyd Williams was the Business Manager for Local Union #393, United Association of Plumbers, Steamfitters & Refrigeration Fitters in San Jose, California. Mr. Williams was a long-time supporter of occupational safety and health and agreed without hesitation to host the meeting in Local 393's state-of-the-art Pipe Trades Training Center. In addition, Mr. Williams arranged for training center staff to assist with various aspects of the program. Both Ms. Johnson and Mr. Williams provided significant support that rendered the meeting a success. Both are dearly missed by family, friends, and colleagues.

*United Association of Journeymen and Apprentices of the Plumbing and Pipefitting Industry

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BACKGROUND

Building and construction activities in the United States have historically been organized around the work of relatively separate crafts or trades. Presently, 19% of U.S. construction workers are represented by a trade union. Union membership for electricians, plumbers and pipefitters and sheet metal workers is higher than average at 38%, 31%, and 41%, respectively [CPWR 2002]. Plumbers, and pipefitters install piping or plumbing systems; sheet metal workers (mechanical trades) install heating, ventilation, and air-conditioning (HVAC) systems. Electricians install electrical conduit and wiring, fixtures, controllers, and switches. Workers in these trades must complete a 4–5 year apprenticeship program.

Although not much data exists, work-related musculoskeletal disorders (WMSDs) are a large problem for the mechanical and electrical trades. Approximately one-third of injuries and illnesses that resulted in at least 1 day away from work (DAW) for mechanical and electrical workers, were due to WMSDs caused by job strain [plumbers/pipefitters (40%), and HVAC system mechanics and sheet metal duct installers (31%), and electricians (34.9%)]. These data are from the U.S. Bureau of Labor Statistics' (BLS) 2000 *Survey of Occupational Injuries and Illnesses (SOII)* [BLS 2002a]. In Oregon, more than 50% of the workers' compensation (WC) claims for the mechanical and electrical trades in 2000 were for WMSDs caused by job strain (i.e., bodily reaction, overexertion, or repetitive motion) [OR DBCS 2002]. Rosecrance recently reported high prevalence rates (8.2%) for carpal tunnel syndrome (CTS) among apprentices working in the pipe, electrical, and sheet metal trades [2002a].

All Construction Work–Related Musculoskeletal Disorders (WMSDs)

WMSDs are injuries or illnesses of the muscles, tendons, joints, and nerves that are caused or aggravated by work. Some examples of WMSDs are: inflamed tendons or joints, elbow muscle and tissue inflammation (tennis or golfer's elbow), herniated disc, rotator cuff syndrome, carpal tunnel syndrome (CTS), and back or neck strain. Workers with jobs that include some combination of physical force, repetitive motion, awkward or static body postures, contact stress, vibration, or extreme temperatures are at increased risk of developing WMSD [Bernard et al. 1997; NRC 2001]. These problems can occur suddenly (an acute injury), or over some period of time (a chronic illness). Personal factors that can increase the risk of developing a WMSD musculoskeletal disorder include diabetes, obesity, and poor physical condition.

The actual number of WMSDs that occur each year is unknown. However, the BLS conducts an annual survey that indirectly estimates the occurrence of WMSDs. In addition to BLS reports, other sources of information concerning WMSDs include WC reports, clinical and epidemiologic studies, and worker symptom surveys.

U.S. Bureau of Labor Statistics (BLS)

The BLS SOII estimates the occurrence of work-related injuries and illnesses in the United States, using data from employers' records. Injury and illness cases are described by the following Code Titles: Nature of Injury or Illness, Part of Body Affected, Source of Injury or Illness, and Event or Exposure [BLS 2001].

The SOII does not have a specific classification for WMSDs, but the information about these cases can be derived from the survey by using two or more code titles. The BLS combines the Nature of Injury or Illness and the Event or Exposure code titles to represent WMSD cases. According to the BLS [2002b], musculoskeletal disorders (MSDs):

> ...include cases where the nature of injury is: sprains, strains, tears; back pain, hurt back; soreness, pain, hurt, except back; carpal tunnel syndrome; hernia; or musculoskeletal system and connective tissue diseases and disorders; and when the event or exposure leading to the injury or illness is: bodily reaction/bending, climbing, crawling, reaching, twisting; overexertion; or repetition. Cases of Raynaud's phenomenon, tarsal tunnel syndrome, and herniated spinal discs are not included. Although these cases may be considered WMSDs, the survey classifies these cases in categories that also include non-WMSD cases.

Incidence rates for construction workers' back and upper- and lower-extremities WMSDs exceed the national all-industries average [National Institute for Occupational Safety and Health (NIOSH) 1997]. Construction workers' rates of injuries and illnesses due to bodily reaction and overexertion consistently exceeded those in all private industries during the years 1994 to 2000 (Table 1). Within the construction industry, the Special Trades Contractors [Standard Industrial Classification (SIC 17)], which is the largest sector in the industry, usually reports higher rates of overexertion and repetitive motion injuries than does General Building Contractors (SIC 15) or Heavy Construction Contractors (SIC 16) [Occupational Safety and Health Administration (OSHA) 2003]. Repetitive motion injury cases among construction workers have historically been low, as seen by comparing Tables 2 and 3 [BLS 2002c]. One recent article report found that few apprentices seek medical attention for hand symptoms characteristic of CTS, suggesting that under-reporting of CTS is common in the construction industry [Rosecrance et al. 2002a]. Unfortunately, injuries and illnesses due to bodily reaction (e.g., bending, climbing, crawling, reaching, twisting) are not counted separately in the BLS annual profile summary tables of nonfatal injuries and illnesses involving DAW by selected worker and case characteristics and industry.

Table 1. Private industry and construction injury and illness rates[1] due to bodily reaction, overexertion, and repetitive motion

Year	Bodily Reaction: All Industries	Bodily Reaction: All Construction	Overexertion: All Industries	Overexertion: All Construction	Repetitive Motion: All Industries	Repetitive Motion: All Construction
2000	20.5	39.6	49.5	70.6	7.4	4.6
1999	21.1	37.6	50.8	68.7	8.1	6.0
1998	21.9	37.0	53.8	66.3	7.4	4.6
1997	22.9	38.8	58.8	85.2	8.7	5.4
1996	23.4	38.6	62.7	85.7	8.8	5.9
1995	26.1	45.5	68.7	94.2	10.1	7.8
1994	29.7	52.8	76.0	110.9	11.5	7.3

Source: BLS 2002c
[1]Rates per 10,000 workers for injuries and illnesses resulting in one or more DAW

Table 2. Construction industry injury and illness rates[1] due to overexertion

Year	General Building Contractors (SIC 15)	Heavy Construction Contractors (SIC 16)	Special Trades Contractors (SIC 17)
2000	57.2	59.0	74.4
1999	58.5	54.6	75.6
1998	67.3	62.5	66.9
1997	77.5	70.2	91.6
1996	72.6	61.9	96.4
1995	86.8	81.7	100.2
1994	95.3	84.8	123.6

Source: BLS 2002c
[1]Rates per 10,000 workers for injuries and illnesses resulting in one or more DAW

Table 3. Construction industry injury and illness rates[1] due to repetitive motion

Year	General Building Contractors (SIC 15)	Heavy Construction Contractors (SIC 16)	Special Trades Contractors (SIC 17)
2000	4.6	2.7	5.0
1999	4.8	3.0	7.1
1998	5.7	2.4	4.8
1997	3.9	5.0	6.0
1996	5.6	4.0	6.5
1995	8.0	7.1	8.0
1994	8.8	4.9	7.4

Source: BLS 2002c
[1]Rates per 10,000 workers for injuries and illnesses resulting in one or more DAW

In the United States, total recordable work-related injuries and illnesses declined during the past 10 years. Construction injuries and illnesses also declined during this period, although much of the decline has been for less serious cases not resulting in lost work time [Webster 1999]. The reduction has not been steady, and between 1996 and 2000, all specialty groups experienced a rate increase in work-related injuries and illnesses at some time (Table 4).

Table 4. Special trades contractors (SIC 17) injuries and illnesses rates[1] due to overexertion

Year	Plumbing & HVAC	Painting, etc.	Electrical	Masonry, Stone, etc.	Carpentry & Floor	Roofing, Siding, etc.	Concrete Work	Water Well Drilling
2000	76.3	64.5	71.1	102.2	64.4	78.7	77.6	166.1
1999	85.0	34.9	56.4	93.6	93.5	105.8	72.0	85.9
1998	68.9	61.8	50.4	96.4	74.9	89.3	79.2	145.3
1997	103.1	53.3	63.6	116.2	99.9	121.8	77.1	108.4
1996	90.4	103.2	83.0	137.3	96.1	127.0	90.3	164.4

Source: BLS 2002c
[1]Rates per 10,000 workers for injuries and illnesses resulting in one or more DAW

The declining injury and illness rates in the construction industry have occurred simultaneously with the increasing average number of DAW for lost-time cases (Table 5).

Workers' Compensation (WC)

Workers' compensation data provides more detailed information than is available in the BLS statistics. However, care must be taken when using or comparing WC data collected from different states because programs differ significantly. For example, the period that workers must be out of work before their cases will be counted as a lost-time injury or illness ranges from three to seven days, depending on the state [AFL–CIO 2001]. The lack of standard case definitions from multiple states presents problems for interpretations of state-generated data and comparisons of state-specific data [NRC 1987].

In the state of Washington, for instance, a worker must be out of work for four or more consecutive days before the case is classified as a lost-time injury or illness for WC purposes [Center for the Protection of Workers' Rights (CPWR) 2002]. However, the BLS SOII estimates are based on one or more DAW due to all injuries and illnesses. In 1998, Washington's State Fund WC program reported 16% more lost-time construction injuries and illness than were reported by the BLS SOII for that state, despite Washington's more restrictive lost-time case definition and the exclusion of cases involving workers employed by self-insured contractors [CPWR 2002]. An analysis by Silverstein et al. [1998; 2000] of Washington State's WC claims for the years 1990–1998 found that four construction sectors—wood frame building construction; roofing; wallboard installation; and building construction, not otherwise classified—were among the top 10 industries with the highest Prevention Index (PI) scores for neck, back, and upper extremity WMSDs. The PI utilizes both the total number and the rate of injuries/illnesses in an industry to prioritize intervention activities among all industries.

Table 5. Average number of DAW [1] for private and construction industry injuries and illnesses

Year	All Private Industry	General Building (SIC 15)	Heavy Construction (SIC 16)	Special Trades (SIC 17)
2001	5	8	8	8
2000	6	8	10	8
1999	6	6	9	7
1998	5	7	9	7
1997	5	8	7	8
1996	5	7	9	7

Source: BLS 2002c

[1]Average number of DAW for all injuries and illnesses resulting in at least one DAW

In Washington, nearly all of the construction industry sectors, (shown in Table 6), ranked among the top 25 industries in need of intervention to prevent neck, back, or upper extremity WMSDs.

Research Studies

Several types of studies—including epidemiological studies and laboratory studies, and ergonomic job assessments—have been used to identify jobs that pose an increased risk of developing WMSDs. Epidemiological studies have been used to look for association between risk factors and health outcomes and may compare the injury and illness experience of one group against the experience of another. Laboratory studies have been used to measure the strain on individuals while they are exposed to physical stressors designed to mimic stressors found in industry, such as lifting heavy objects. Ergonomic job assessments are conducted at a job site and have been used to identify and measure recognized WMSD risk factors.

Epidemiological studies report a positive association between construction work in general, and the development of musculoskeletal problems [Damlund et al. 1986; Hildebrandt 1995; Ueno et al. 1999; Welch et al. 1995; Palmer et al. 2001]. Other epidemiological studies have reported increased WMSDs among workers in specific construction occupations, such as concrete reinforcement [Riihimaki et al. 1989], bricklaying [Heuer et al. 1996], carpentry [Luoma et al. 1998], carpet and floor laying [Thun et al. 1987; Kivimaki et al. 1994], and painting [Stenlund et al. 2002].

Table 6. Washington State construction industry sectors ranking in top 25 industries needing interventions to reduce upper extremity WMSDs (1990–1998)

SIC	Industry Description	Neck	Back	Upper Extremity
152	General building contractors—residential buildings	X	X	X
154	General building contractors—non-residential buildings	X	X	X
162	Heavy construction, except highway and street construction	X	X	
171	Plumbing, heating and air conditioning	X	X	X
172	Painting and paper hanging	X		
174	Masonry, stoneware, tile setting and plastering	X	X	X
175	Carpentry and floor work	X	X	X
176	Roofing, siding, and sheet metal work	X	X	X
177	Concrete work	X	X	X
179	Miscellaneous special trades contractors	X	X	X

Source: Silverstein et al., 1998; 2000

Worker Symptom Surveys

Surveys have been administered to construction workers in the United States and elsewhere to estimate the prevalence of WMSDs in the industry. (In this context, prevalence refers to the percentage of workers reporting a WMSD during a 12-month period given the number of workers at risk in the industry.) Cook et al. [1996] found that 70% of active construction workers, representing 13 trades, had reported "job-related ache, pain, discomfort, etc." during the previous year, and 32% of these workers had reported "visiting a physician" for the symptoms. In the same survey, more than 40% of workers also reported symptoms occurring during the previous year for the neck (42%), shoulders (42%), wrist/hands (43%), and knees (46%). Surveys administered to estimate the prevalence of WMSDs have been shown to be reliable and can be used to estimate the occurrence of WMSDs among construction workers [Baron et al, 1996; Booth-Jones et al. 1998; Rosecrance et al. 2002b].

Mechanical and Electrical Trades and WMSDs

Bureau of Labor Statistics Injury and Illness Statistics

In 2000, construction workers' median number of DAW for a lost-time injury or illness ranged from 8 days (SIC 15 and SIC 17) to 10 days (SIC 16), compared to the 6-day median DAW (MDAW) for all private industry workers [BLS 2002a]. Tables 7–10 show that WMSDs often result in a much larger MDAW. In 2000, BLS estimated that the injuries and illnesses incurred by 38.2% of electricians (Table 7), 40% of plumbers and pipefitters (Table 8), 36.9% of HVAC system mechanics (Table 9), and 36.9% of sheet metal duct installers (Table 10) were, as a result of events or exposures associated with WMSDs. For all private industry in 2000, WMSDs were 34.7% of all DAW injuries and illnesses, and the MDAW was seven days [BLS 2002c].

Table 7. Electricians (SOC [1] 575)—WMSDs in 2000 number and MDAW [3] by event/exposure

Code	Event/Exposure	Cases[2]	MDAW[3]
061	Rubbed, abraded, or jarred by vehicle or mobile equipment vibration	92	3
20	Bodily reaction and exertion, unspecified	93	70
211	Bending, climbing, crawling, reaching, twisting	741	13
220	Overexertion, unspecified	355	42
221	Overexertion in lifting	885	5
222	Overexertion in pulling or pushing objects	981	20
223	Overexertion in holding, carrying, turning, or wielding objects	649	40
229	Overexertion, not elsewhere classified	179	20
230	Repetitive motion, unspecified	122	22
	Total	**4,098**	

Source: BLS 2002a

[1] The Standard Occupational Classification system is "used by all Federal statistical agencies to classify workers into occupational categories for the purpose of collecting, calculating, or disseminating data" [BLS 2003]

[2] Journey-status electricians (SOC 575) in 2000 incurred an estimated 11,740 injuries and illnesses. However, only 10,706 injuries and illness were reported for electricians that identified an event or exposure associated with an incident [BLS 2002a]

[3] Median DAW

Table 8. Plumbers, pipefitters, and steamfitters (SOC [1] 585)—WMSDs in 2000 (number and MDAW [3] by nature of injury and event/exposure)

Code	Event/Exposure	Cases[2]	MDAW[3]
211	Bending, climbing, crawling, reaching, twisting	603	5
220	Overexertion, unspecified	260	3
221	Overexertion in lifting	1,860	10
222	Overexertion in pulling or pushing objects	396	12
223	Overexertion in holding, carrying, turning, or wielding objects	357	16
229	Overexertion, not elsewhere classified	172	34
232	Repetitive use of tools	103	30
	Total	**3,751**	

Source: BLS 2002a

[1] The Standard Occupational Classification system is "used by all Federal statistical agencies to classify workers into occupational categories for the purpose of collecting, calculating, or disseminating data" [BLS 2003]

[2] Journey-status plumbers, pipefitters, and steamfitters (SOC 585) incurred an estimated 9,379 DAW injuries or illnesses in 2000. However, only 8,693 injuries and illness were reported for plumbers, pipefitters, and steamfitters that identified an event or exposure associated with an incident [BLS 2002a]

[3] Median DAW

Table 9. Heating, air-conditioning, and refrigeration mechanics (SOC[1] 534) — WMSDs in 2000 (number and MDAW[3] by nature of injury and event/exposure)

Code	Event/Exposure	Cases[2]	MDAW[3]
211	Bending, climbing, crawling, reaching, twisting	557	9
220	Overexertion, unspecified	227	1
221	Overexertion in lifting	589	9
222	Overexertion in pulling or pushing objects	149	10
223	Overexertion in holding, carrying, turning, or wielding objects	407	5
	Total	**1,928**	

Source: BLS 2002a

[1] The Standard Occupational Classification system is "used by all Federal statistical agencies to classify workers into occupational categories for the purpose of collecting, calculating, or disseminating data" [BLS 2003]

[2] Journey-status heating, air-conditioning, and refrigeration (HVAC) mechanics (SOC 534) incurred an estimated 5,973 DAW injuries and illnesses in 2000. However, only 5,375 injuries and illness were reported for heating, air-conditioning, and refrigeration (HVAC)mechanics that identified an event or exposure associated with an incident [BLS 2002a].

[3] Median DAW

Table 10. Sheet metal duct installers (SOC[1] 596)—WMSDs in 2000 (number and MDAW[3] by nature of injury and event/exposure)

Code	Event/Exposure	Cases [2]	MDAW [3]
211	Bending, climbing, crawling, reaching, twisting	322	15
221	Overexertion in lifting	314	6
222	Overexertion in pulling or pushing objects	102	13
223	Overexertion in holding, carrying, turning, or wielding objects	160	10
	Total	**898**	

Source: BLS 2002a

[1] The Standard Occupational Classification system is "used by all Federal statistical agencies to classify workers into occupational categories for the purpose of collecting, calculating, or disseminating data" [BLS 2003]

[2] Journey-status sheet metal duct installers (SOC 596) incurred an estimated 3,248 DAW injuries or illnesses in 2000. However, only 2,434 injuries and illnesses were reported for sheet metal duct installers (SOC 596) that identified an event or exposure associated with an incident [BLS 2002a]

[3] Median DAW

Workers' Compensation and Insurance Reports

Data from both state WC systems and insurance providers can be used to document the incidence, nature, and costs of WMSDs for the mechanical and electrical trades. Earlier, an analysis of Washington State WC data was described. In 2000, Oregon's WC program reported that construction sector injuries and illnesses due to bodily reaction, overexertion, and repetitive motion accounted for compensable claims for electricians (52%), plumbers and pipefitters (57%), and duct installers and sheet metal workers (57%) (Table 11).

Private sector insurance companies that provide WC coverage to employers are another potential source of information concerning WMSDs for the mechanical and electrical trades. CNA Insurance workers' compensation data for the electrical and mechanical trades were presented at the 2-day meeting and are described in Session 1, Presentations 2 and 3.

Research Studies

Studies identifying WMSDs among construction workers in the electrical, pipe, and sheet metal trades are shown in Table 12. Rosecrance [2002a] found a high (8.2%) prevalence rate of CTS among more than 1,100 apprentices in the electrical, pipe, sheet metal, and operating engineering trades in the United States. All cases had a median nerve abnormality affecting a single nerve trunk, and hand-wrist symptoms consistent with CTS. Less than 12% of the apprentices with CTS had received medical attention for the condition. These results suggest that under-reporting of CTS is common in the construction industry.

Table 11. Number of disabling claims by occupation and accident or exposure/event Oregon, 2000

Occupation of claimant	All claims	Bodily reaction[1]	Over-exertion	Repetitive motion	WMSDs as % of all claims
Electrician	253 (100%)	63 (24.9%)	50 (19.8%)	18 (7.1%)	131 (51.8%)
Plumber, pipe fitter	169 (100%)	31 (18.3%)	51 (30.2%)	15 (8.9%)	97 (57.4%)
Metal duct installer & Sheet metal worker	75 (100%)	16 (21.3%)	23 (30.7%)	4 (5.3%)	43 (57.3%)

Source: OR DBCS 2002

[1] Bodily reaction includes "bending, climbing, crawling, reaching, and twisting" [BLS 2002b]

In 1997, CNA Insurance and the Sheet Metal and Air Conditioning Contractors National Association (SMACNA) contracted an ergonomic consulting firm to conduct an ergonomics evaluation of shop and job site sheet metal tasks. Three sheet metal tasks in the knocking area of a fabrication shop and six tasks on construction job sites were evaluated. Among the findings reported, six tasks were assigned high injury risk scores and four were assigned moderate injury risk scores. In all six cases, the back was the body part at high risk of being injured. These ratings were attributed to workers' repeated, sustained forward and lateral bending, twisting, and forceful exertions. Table 13 summarizes the evaluation.

Table 12. Studies reporting WMSDs in the mechanical and electrical trades

Trade	Problem
Electrical	A case-control study of the relationship between occupation and upper-extremity MSDs found electricians were significantly over represented among orthopedic clinic patients [English et al. 1989]. Electricians reported a high prevalence of symptoms—especially back and hand-wrist symptoms—which occurred more than three times during the past year, or lasted more than 1 week [Hunting et al. 1994].
Pipe	Dutch plumbers were found to have a relatively high rate of back pain [Hildebrandt 1995]. Swedish pipefitters and welders had a high risk of knee-joint lesions [Ritz and Brunnholzl 1988].
Sheet metal	Relationships were found between work activities and MSDs in a small study of disabled sheet metal workers. Hanging duct was strongly associated with both neck and shoulder symptoms [Welch et al. 1995].
Across trades	Welding was found to possibly cause development of inflamed shoulder tendons, resulting in pain and tenderness, and restricted movement [Petersen et al. 1981]. Shoulder muscles were heavily loaded when the arm was elevated, and strain on the supraspinatus muscle (muscle which allows shoulder movement) in overhead work was an important factor contributing to prolonged shoulder disability [Herberts et al. 1984]. Study confirmed that subjective symptoms and physical signs related to the shoulder were more common among the welders [Torner et al. 1991]. A field study found that workers installing ceiling fittings were at risk of developing chronic shoulder pain due to inflamed tendons of their rotator cuff [Sporrong et al. 1999].

Worker Symptom Surveys

In a survey of construction workers conducted by the University of Iowa, workers answered questions about the “ache, discomfort, and pain” they experienced for various body regions during the previous 12 months [Cook et al. 1996]. The results for respondents from the mechanical and electrical trades are shown in Table 14. Sheet metal workers reported higher than average prevalence rates for the neck, back, elbows, wrists, and hands. Plumbers and pipefitters reported more knee problems than average. (Prevalence refers to the proportion of workers reporting a WMSD during a 12-month period given the number of workers at risk in the industry.

Preventing WMSDs

WMSD risk factors can be addressed by using the occupational health and safety hierarchy of controls [NIOSH 1997]. While administrative controls and personal protective equipment have been used to reduce workers’ exposures to WMSD risk factors, these strategies have serious limitations, because they do not directly address the source of the exposures. Engineering control technologies that eliminate or modify WMSD risk factors related to tools and equipment, building and construction materials, and work processes or practices have a better chance of generating lasting benefits.

Table 13. Ergonomic assessment of sheet metal work

Task	Body Part Affected	Overall Risk Rating[1]
Lifting ductwork onto lift assists or jack[2]	Back	9
Knocking fittings using tinning hammer[3]	Back	8
Knocking fittings using air hammer[3]	Back	8
Cutting ductwork using manual shears	Back	8
Assembling or connecting ductwork on the floor	Back	8
Assembling fittings on the job site	Back	7
Drilling holes for upper hanger attachment	Neck	6
Securing lower hanger attachment	Neck, back	6
Welding (lifting)	Back	6
Welding (sitting)	Back, hand/wrist, legs	5

Source: CNA 2002

[1]The likelihood of an ergonomically related injury occurring for a specific task was scored from 0 to 10 as follows: 7–10 = high injury risk and 4–6 = moderate injury risk

[2]Risk factor: physical force required to lift, push and pull ductwork

[3]Risk factor: awkward trunk posture due to the overall working height

Table 14. Mechanical and electrical trades reported job-related symptoms during past 12 months (1994–1995)[1]

Trade	Neck	Upper Back	Low Back	Shoulder	Elbows	Wrist/ Hands	Hips/ Thighs	Knees	Ankles/ Feet
Electricians (n=375)	37.3	27.1	66.8	37.2	19.8	43.7	17.2	46.0	31.6
Plumbers/pipefitters (n=667)	42.8	29.6	69.4	40.6	21.8	43.2	16.7	51.9	31.9
Sheet metal workers (n=384)	44.8	35.1	74.0	40.9	30.7	50.0	18.7	47.2	31.1
All surveyed (n=2518)	41.9	29.6	69.9	41.6	25.1	42.8	21.1	46.2	30.9

Source: Cook et al., 1996
[1]All values are the percent of workers reporting "ache, discomfort, or pain"

Eliminating and reducing WMSD risk factors in the construction industry presents obstacles not found in most industries, including the absence of permanent work-stations, lack of control over the task location, continuously changing surroundings, and congested multi-employer work sites prone to communication and coordination problems [Schneider and Susi 1994]. In spite of these drawbacks, many engineering interventions have been developed and evaluated for various trades or specialties in the construction industry. NIOSH researchers reviewed the literature for ergonomic interventions developed for construction. Evaluated interventions were identified for:

- **Equipment** [de Jong and Vink, 2002; de Jong and Vink 2000; de Looze et al. 2001; Everett 1993; Hecker et al. 2001; Holmstrom 1987; Mirka et al. 2000; Sillanpää et al.1999].

- **Tools** [Cederquist and Ortengren 1985; de Looze et al. 2001; Hecker et al. 2001; Kilbom et al. 1993; Mirka et al. 2000; Ortengren et al. 1991; Strasser et al. 1996; Village et al. 1993; Wos et al. 1992].

- **Work Practices** [Hecker et al. 2001; Imbeau et al. 1998; Li 2000; Vink et al. 1997].

Interventions that have been evaluated and are used by the electrical, pipe, or sheet metal trades are shown in Table 15. Although many more potential interventions have been proposed, most have not been subjected to any type of evaluation [Schneider 1995].

One mechanical specialty—heating and air conditioning—was found to be proactive in working on ergonomics. The Sheet Metal Occupational Health Institute Trust (SMOHIT)—a joint labor-management organization between SMACNA and the Sheet Metal Workers' International Association (SMWIA)—published Physical Stress Injuries: Reducing Injuries through Ergonomics in 1999 [SMOHIT]. This educational program was developed for apprentices and journey-status sheet metal workers. The multi-media training program includes engineering and administrative controls to reduce exposures to WMSD risk factors in fabrication shops and construction sites, including practical recommendations from contractors. Although the materials have been widely disseminated in the unionized sector of the industry, the extent to which the recommendations have been implemented by contractors and workers is not known.

Table 15. Reported WMSD risk factor interventions for the mechanical and electrical trades

Job	Intervention	Benefit	Source
Fitting drain pipes	Lifting strap	Less strain on lower extremities, neck & shoulder	Sillanpää et al. 1999
Operate powder-actuated tool (PAT) overhead	Tool support stand	Forces at thumb & elbow reduced by 800%	Wos et al. 1992
Driving screws	Cordless screw driver & screw gun	Reduced forearm rotation and force	Ortengren et al. 1991
Manual transport of materials	Wheeled transport devices	Reduced lifting & carrying	de Jong & Vink 2002
Field assembly, welding, etc.	Stands and portable benches	Reduced kneeling and trunk flexion	de Jong & Vink 2002
Floor level assembly	Wheeled floor-level assembly seat	Reduced kneeling	de Jong & Vink 2002

SESSION 1: MUSCULOSKELETAL DISORDERS (MSDS) AND SOFT TISSUE INJURIES IN THE TRADES

1–1 MSDs and Injuries Among Workers in the Mechanical and Electrical Trades
John Rosecrance, Assistant Professor
Department of Occupational and Environmental Health, University of Iowa, Iowa City, IA

1–2 MSDs in the Sheet Metal, Mechanical, Air-Conditioning, and Plumbing Trades
Tom Soles, Executive Director
Market Sectors, SMACNA (Sheet Metal and Air-Conditioning Contractors National Association)

1–3 MSDs in the Electrical Trades
Robin Johnson, Director
Loss Control Casualty Services, CNA Insurance Company

1–4 Non-Traumatic Lost-Time Injuries in Ontario
Peter Vi, Ergonomist
Construction Safety Association of Ontario, Canada

[Please note: The following presentation summaries are transcriptions from the 2-day meeting. These transcriptions have been edited and reworded for clarity of meaning. The presentations, including questions and answers, are included in the proceedings as documentation of the meeting. The content, however, might not reflect current NIOSH policy or endorsement.]

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SESSION 1: PRESENTATION 1-1
MSDS AND INJURIES AMONG WORKERS IN THE MECHANICAL AND ELECTRICAL TRADES

John Rosecrance, Assistant Professor
Department of Occupational and Environmental Health, University of Iowa, Iowa City, IA

Construction is the most dangerous occupation in the country. Six percent of the U.S. workforce works in construction, yet construction workers represent 23% of occupational deaths (Figure 1-1.1).

Approximately three construction workers die every day due to occupational injuries.

Of all industries, the construction industry has the second highest incidence rate of occupational illnesses and injuries. Manufacturing has the highest. The incidence rate in construction has been declining over the last five years, as it has been in all industries. In 1996, there were 10 injuries or illnesses per 100 full-time workers (FTW), and in 2000, there were 8.2 injuries or illnesses per 100 FTW (Figure 1-1.2). This data includes both recordable injuries and illnesses.

Low-back problems are considered injuries, whereas the repetitive strain types of disorders, such as CTS or shoulder strain, are categorized as illnesses.

If we look at rates of lost workdays from strains and sprains, and compare all industries with construction and manufacturing, we see that construction has a much higher rate than the others: 122.6 per 10,000 FTW vs. 86.6 per 10,000 FTW for manufacturing (Figure 1-1.3).

Lost workdays from low-back injuries are also high at 68.8 per 10,000 FTW (Figure 1-1.4).

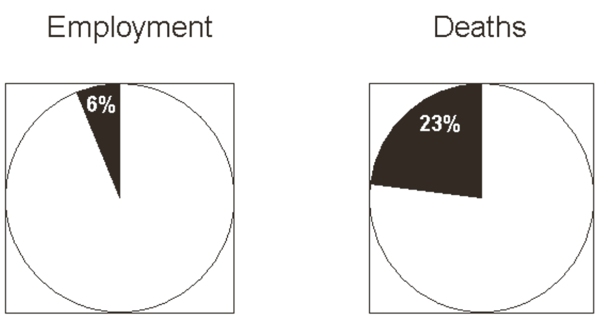


Figure 1-1.1. Construction employment vs. deaths
BLS 2001

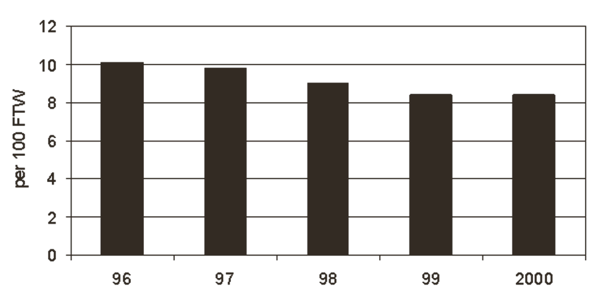


Figure 1-1.2. Non-fatal workplace injuries and illness
BLS 2001

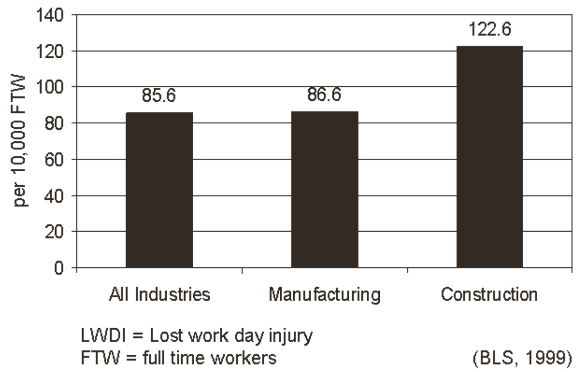


Figure 1-1.3. Lost work days due to sprains and strains in 1998

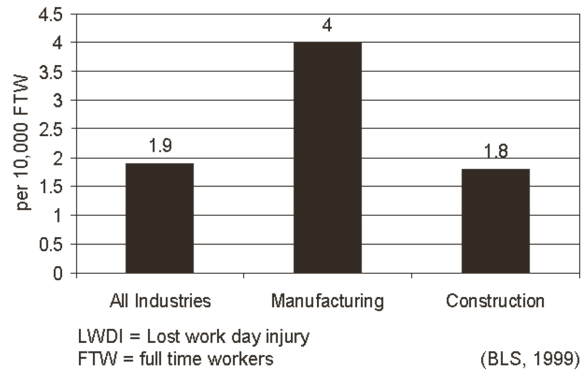


Figure 1-1.5. Lost work days due to carpal tunnel syndrome in 1998

CTS more lost workdays overall than any other type of injury or illness; the median case is out of work for 30 days. The BLS [1999] reports a higher CTS rate in manufacturing, than construction (Figure 1-1.5).

Some sources for occupational injury and illness data are the OSHA 200 and 300 logs, Ontario Injury Atlas [Construction Safety Association of Ontario (CSAO) 2002] data, and self-reported symptom survey data. See also Scott Schneider's "Musculoskeletal Injuries in Construction: A Review of the Literature" (2001). *Applied Occupational and Environmental Hygiene*.

The body part injured most often in construction is the low back. Shoulders, knees, and hand-wrist combination are the other body parts injured most often.

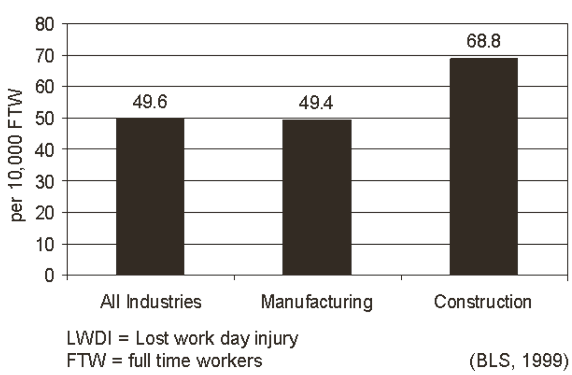
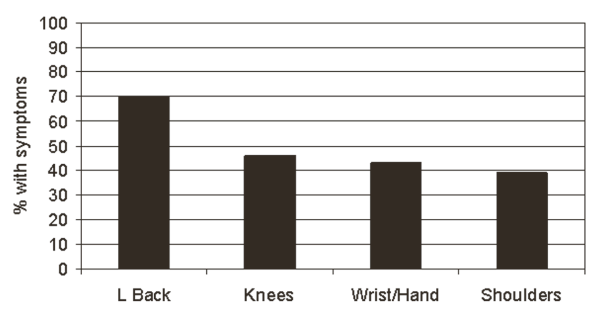


Figure 1-1.4. Lost work days due to low back injuries in 1998



(Cook et al, 1996)

Figure 1-1.6. Prevalence of MSDs by body area for mechanical/electrical trades

The Iowa survey [Cook et al. 1996] asked journey-level construction workers whether they had experienced work-related pain in the last year. These are symptom data, which are self-reported rather than medical diagnoses or disorder data. The following responses were provided by electricians, plumbers and pipefitters, and sheet metal workers: low back, 70%; knees, 45%; wrist/hand, 42%; and, shoulder, 39% (Figure 1-1.6).

The survey also asked whether they had seen a doctor for their symptoms in the last year. Workers reported visiting a doctor for their symptoms the following percent of the time: low back pain, 33%; knees, 7%; shoulders, 12%; and, wrist/hand, 8% (Figure 1-1.7).

A study concluded at the University of Iowa [Rosecrance et al. 2002a] found a high prevalence of CTS among construction apprentices (8.2%) compared to the findings of other studies. (Fig. 1.1-8).

The percentage of people in different population groups with CTS is 3.5% for the Swedish general population and 1.7% for the Swedish population under 45 years old [Atroshi et al. 1999]; 2.5% for U.S. computer operators [Stevens et al. 2001]; and 2.1% for U.S. construction workers [Tanaka et al. 1994].

The University of Iowa study [Rosecrance et al. 2002a] included nerve conduction studies and hand exams conducted by physical therapists using construction apprentice symptom reports. This study indicates that CTS is a problem in construction—not just among computer operators.

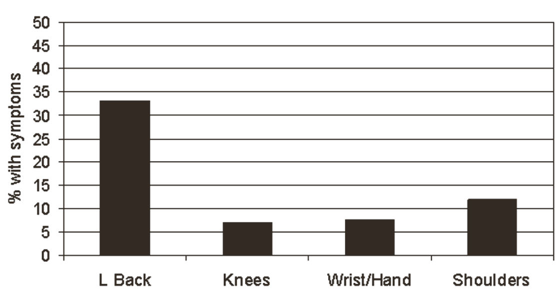


Figure 1-1.7. Percentage of individuals seeking medical attention for MSDs by body area

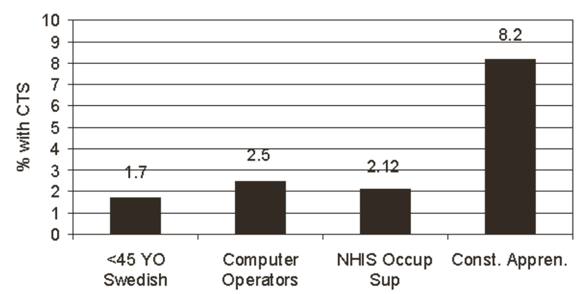


Figure 1-1.8. Prevalence of carpal tunnel syndrome

Work activities that can cause or contribute to MSDs include carrying or lifting heavy materials; awkward or cramped positions (the floor seems to be the workbench for many workers); holding the same position for long periods; bending or twisting back; forceful exertion; repetition (this may be a problem); vibration; and the environment, such as cold temperatures. Other work activities that may cause or contribute to MDSs are illustrated below (Figures 1-1.9–1-1.12). Other contributing factors are obesity, smoking, age, other disease, and general health status.

In summary, a large proportion of construction workers develop MSDs. MSDs are associated with physical aspects of construction, and they are different for different trades. Laborers and ironworkers have much higher rates of low back pain. Operating engineers have lower incidences of all problems. People who work on the floor have more knee problems. Construction workers continue to work when injured; they work in pain. They often do not see a doctor for their symptoms (e.g., numbness or tingling for various economic and psychosocial reasons.

Figure 1-1.9. Carrying or lifting heavy materials

Figure 1-1.11. Working in an awkward position for shoulder/wrist/hand

Figure 1-1.10. Using the floor as a workbench

Figure 1-1.12. Working in an awkward position for wrist

SESSION 1: PRESENTATION 1-2
MSDS IN THE SHEET METAL, MECHANICAL, AIR-CONDITIONING, AND PLUMBING TRADES

Tom Soles, Executive Director

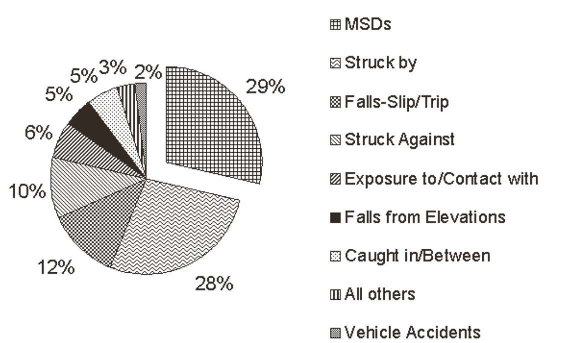
Market Sectors, Sheet Metal and Air-Conditioning Contractors National Association (SMACNA)

Thanks to Robin Johnson, Vice-President of CNA Insurance Company, for supplying the below data. The following data were taken from a review of almost 20,000 WC claims, representing $113 million in paid and reserved claims, reported to CNA Insurance Company for a 3-year period (1999–2001) [CNA 2002]. The claims involve 3,200 contractors who are part of a program CNA calls SMAP (Sheet Metal, Mechanical, Air Conditioning, and Plumbing Program).

SMACNA Statistics

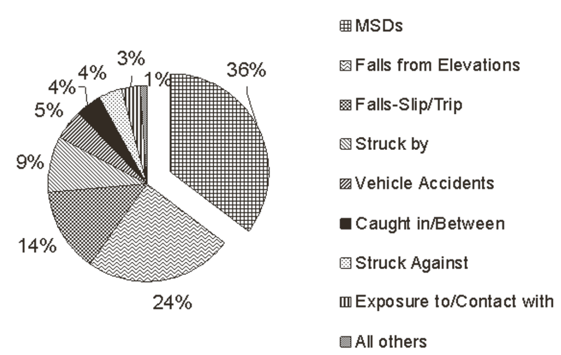
MSDs in the CNA data include: cumulative trauma disorders, ergonomic injury or illnesses, carpal tunnel, trigger finger, sciatica, tendonitis (inflamed tendons), “carpet layer’s knee”, vibration syndrome, and tension neck syndrome. Over the three years studied, MSDs represented 29% of all WC claims and 36% of the costs (Figures 1–2.1 and 1–2.2).

When my colleagues on the management side of the industry say MSDs do not exist—I think the facts clearly show otherwise. I will relate frequency (number of occurrences) to severity (dollars spent) throughout the presentation.



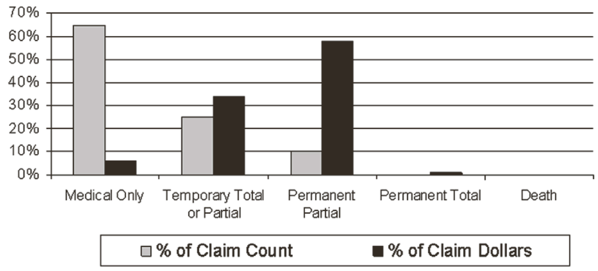
(CNA, 2001)

Figure 1-2.1. Mechanical Trades WC Claims (% of WC Claims)



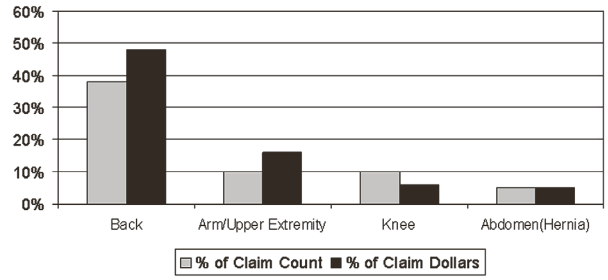
(CNA, 2001)

Figure 1-2.2. Impact of MSDs on Mechanical Trades: Percent of WC Claim Dollars



(CNA, 2001)

Figure 1-2.3. Impact of MSDs on Mechanical Trades: Percent Claim Count and Dollars by Disability Type



(CNA, 2001)

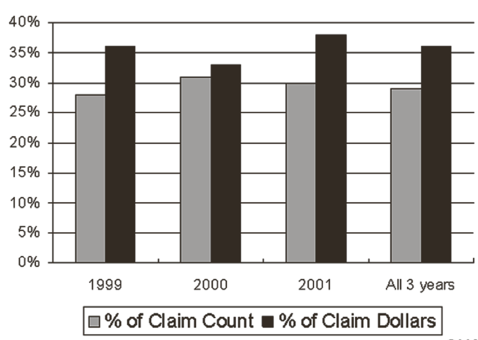
Figure 1-2.5. Impact of MSDs on Mechanical Trades: Part of Body Most Affected by MSDs

Percentage of MSDs by Disability Type: Figure 1-2.3 uses state WC criteria to define different degrees of disability. The largest percentage in terms of claim count is medical only, followed by temporary total or partial, and permanent partial.

Severity of MSDs: The severity of MSDs increased 5% from 2000 to 2001, although claim frequency remained fairly consistent (Figure 1-2.4). We can expect the figures for 2001 to increase further, as those claims mature. An adage within the insurance industry is that, "The longer a claim is open, the more expensive it gets."

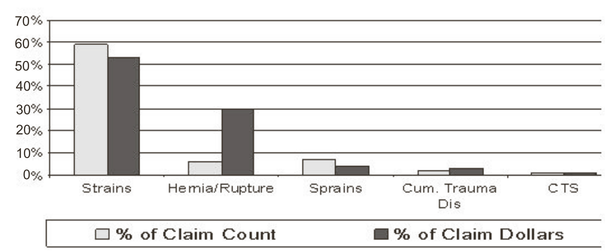
Body Parts Affected: The back is the body part most affected by MSDs, in terms of both cost and frequency. Arms, knees, and hernia are also affected by MSDs, though they are affected less frequently and result in less dollars spent in claims (Figure 1-2.5).

Types of MSDs: Strains are the type of MSD resulting in the highest cost and frequency of WC claims. Although hernias only account for 6% of WC claims, they are an expensive item. There are few claims and claim dollars spent for carpal tunnel syndrome (Figure 1-2.6).



(CNA, 2001)

Figure 1-2.4. Impact of MSDs on Mechanical Trades: Percent of WC Claims and Cost (1999–2001)



(CNA, 2001)

Figure 1-2.6. Impact of MSDs on Mechanical Trades: Types of MSDs (1999–2001)

Median Days Away from Work (MDAW): In Figure 1–2.7, sheet metal workers represent the Standard Industrial Classification (SIC) or North American Industrial Classification System (NAICS) [2003] category, which is used for workers who only perform shop work. Heating, air-conditioning, and refrigeration mechanics showed the highest rate of DAW for MSD cases in 1999 [BLS 2001].

Average Cost of MSDs, 1996–2001: Figure 1-2.8 shows the average cost of MSD claims for 1996 to 2001. As previously discussed, the claims for 2001 have not yet matured, so the cost of claims for 2001 could be quite high, as in 1998. MSDs are expensive injuries and reflect ultimately what an employer's insurability is, and what his WC premiums are going to be.

Costs of MSD Claims for Different Body Parts: Rotator cuff injuries are quite expensive, as are hernias and lower back problems. (Figure 1-2.9)

Frequency and Cost of Claims by Type of MSD: Figure 1-2.10 shows the average cost per claim by type of MSD. Strains account for 59% of MSDs, and 53% of the claim dollars spent.

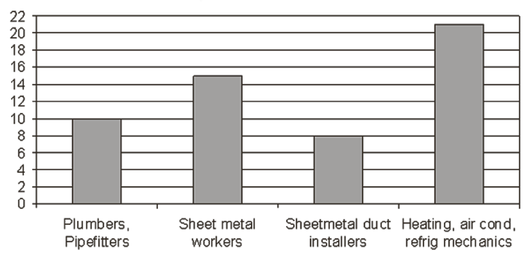


Figure 1-2.7. Impact of MSDs on Mechanical Trades: Median number of days away from work for MSD cases (1999)

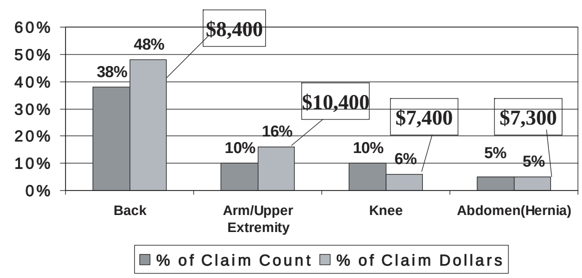
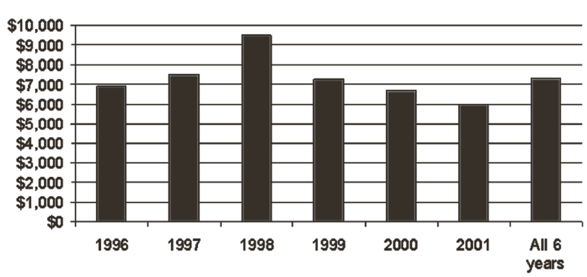
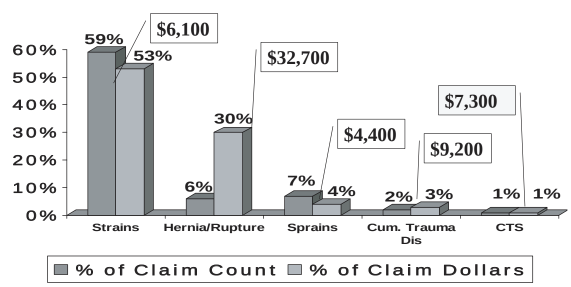


Figure 1-2.9. Impact of MSDs on Mechanical Trades: Average Cost of Claims by Body Part



(CNA, 2001)

Figure 1-2.8. Impact of MSDs on Mechanical Trades: Average Cost of MSD Claims (1996-2001)



(CNA, 2001)

Figure 1-2.10. Impact of MSDs on Mechanical Trades: Average Cost of Claims by Type of MSD

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MSDS IN THE ELECTRICAL TRADES

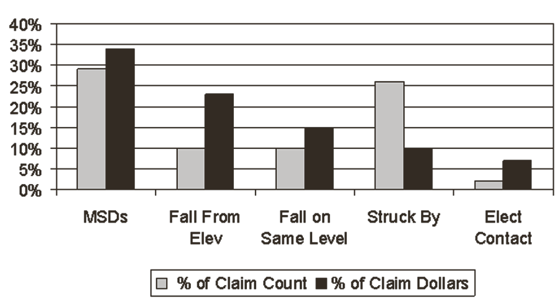
Robin Johnson, Director
Loss Control Casualty Services, CNA Insurance Company

If any of you receive visits from safety people in your insurance company, I'm the person at the home office who is responsible for directing the services they provide to you, from a WC standpoint and a general liability standpoint.

I will highlight some of the differences between the MSD statistics for electrical trades and the sheet metal trade statistics that Tom Soles presented. The information I will present is taken from a review of about 13,000 WC claims totaling $76 million, reported in 1999–2001 by about 2,100 electrical contractors who participate in our company's electrical contractor's business insurance program. The program is endorsed by both the Independent Electrical Contractors Association and the National Electrical Contractors Association [CNA 2002].

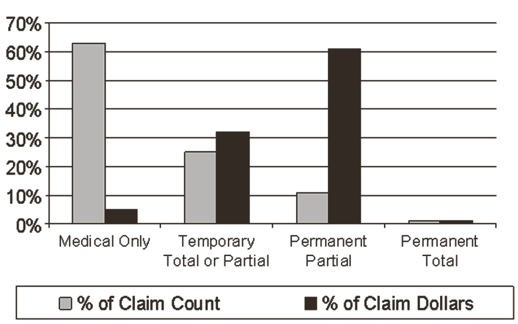
MSDs are the leading type of WC claim reported by electrical contractors, accounting for 29% of all claims in the 3-year period studied (1999–2001), and 34% of all dollars spent (Figure 1-3.1).

The good news is that 63% of WC claims for electrical contractors are medical only. In other words, there is no lost-work time. Twenty-five percent of the claims involve temporary partial or total disability. The permanent partial category, depending on state law, involves situations where workers are off work for more than a year, or have lost partial function of one of their members—a hand, an elbow—or some of the mobility in their back. Those disability types represent only 12% of all MSD losses, but 61% of the cost (Figure 1-3.2).



CNA, (2001)

Figure 1-3.1. Impact of MSDs on Electrical Trade: Frequency and WC Cost of MSDs (1999-2001)



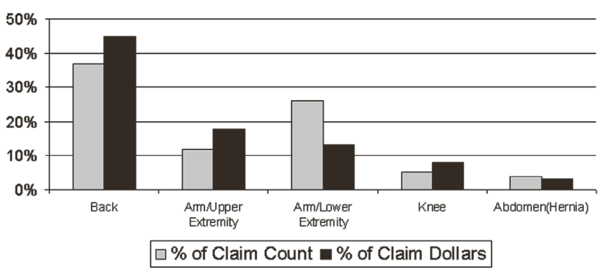
(CNA, 2001)

Figure 1-3.2. Impact of MSDs on Electrical Trade: Percent Claim Count and Dollars by Disability Type

The back was the body part most frequently affected by MSDs, representing 37% of all MSD claims and 45% of the associated costs. Lower arm injuries—from the elbow down—were the second most frequent claim (26%) (Figure 1-3.3).

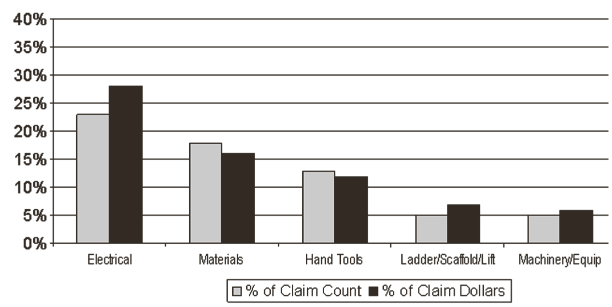
Strains—injuries to the muscles or tendons—accounted for 58% of all MSDs reported from 1999 to 2001. These were followed by hernias, sprains (injuries to ligaments), and CTS, or other cumulative trauma disorders, such as tendonitis (inflamed tendons) and epicondylitis (inflamed muscle and tissue around the elbow). The frequency of CTS was slightly higher than in the sheet metal trade statistics discussed in the previous presentation (Figure 1-3.4).

The most frequently reported source for MSDs was working with electrical components, such as wires and cables, outlets, junction boxes, and transformers. These injuries were followed by non-electrical construction materials and hand tools. Handling ladders or scaffold components accounted for 5% of the claims (Figure 1-3.5).



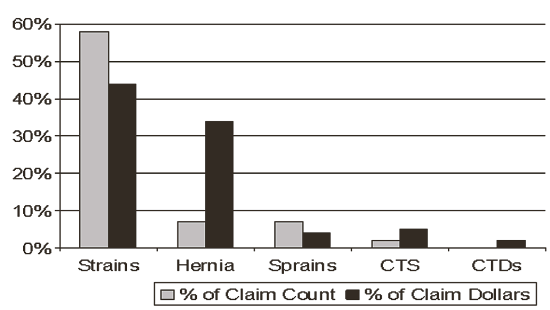
(CNA, 2001)

Figure 1-3.3. Impact of MSDs on Electrical Trades: Part of Body Most Affected by MSDs



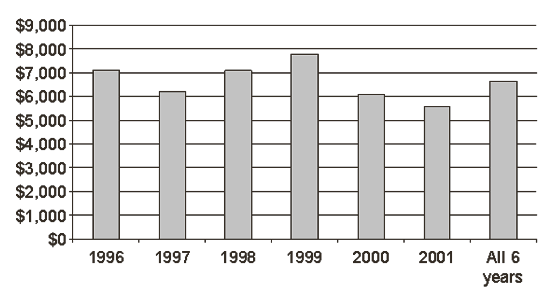
(CNA, 2001)

Figure 1-3.5. Impact of MSDs on Electrical Trade: Percent of Claims and Claim Dollars by Source of MSD



(CNA, 2001)

Figure 1-3.4. Impact of MSDs on Electrical Trades: Types of MSDs (1999-2001)



(CNA, 2001)

Figure 1-3.6. Impact of MSDs on Electrical Trade: Average Cost of MSD Claims (1996-2001)

In 1999, the MDAW for cases involving MSDs were eight days for journey-status electricians, and six days for apprentices.

According to Figure 1-3.6, the average cost of MSD claims peaked in 1999. However, many of the MSD claims reported in 2000 and 2001 may eventually be higher figures. The average cost of one MSD claim for 1996 to 2001 is $6,650. When you think about the cost of your premiums, you can look at it as a percentage of that figure, to see the impact of one claim.

The good news is that 77% of MSD claims are under $2,500. Sixteen percent (16%) of claims cost between $2,500 and $24,999, and 6% cost between $25,000 and $99,999. Only 1% of claims are over $100,000. This figure has been consistent over the last three years (Figure 1-3.7).

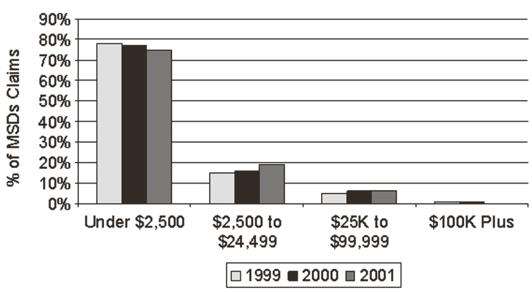
Discussing the difference in cost of MSD claims by type of disability would be useful if you were trying to convince someone to buy a particular type of material handling equipment. For example, a medical only disability MSD claim (i.e., hernia) had an average cost of $600 ($100 less than the sheet metal figure). However, the cost of a permanent total disability MSD claim (also a hernia) averaged $169,000.

Upper and lower extremity injuries accounted for the highest average costs per MSD claim, followed by back injuries. The average claim costs for knee injuries for electrical workers are about half of what we see in the sheet metal trade (Figure 1-3.8).

The MSD type with the highest average cost per claim was cumulative trauma disorder, followed by hernia. The costs for CTS and cumulative trauma disorder claims were much higher for electricians than for sheet metal workers (Figure 1-3.9).

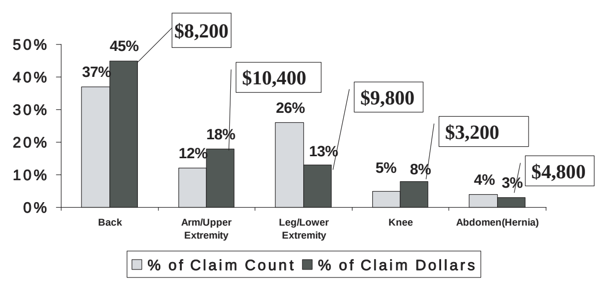
Following, are two examples of large MSD claims in which an ergonomic intervention might have prevented the losses.

An electrician injured his back while trying to move a transformer that was



(CNA, 2001)

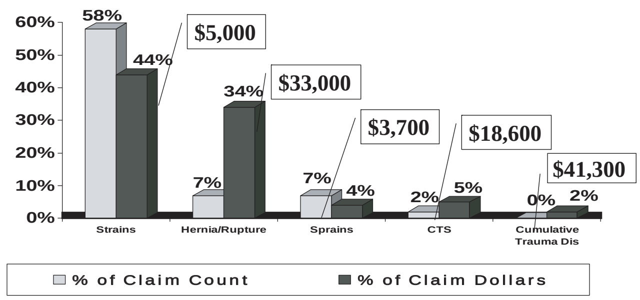
Figure 1-3.7. Impact of MSDs on Electrical Trade: Average Cost of MSD Claim by Cost Range



(CNA, 2001)

Figure 1-3.8. Impact of MSDs on Electrical Trades: Average Cost of Claims by Body Part tight against the wall to access the electrical panel behind it. He lifted the transformer, and his supervisor tried to slide a pry bar beneath it. The pry bar broke. The transformer slipped and jerked the electrician's arms and back. This injury resulted in an MSD claim reserved at $450,000.

In the second example, a 52-year old electrician had been employed by a contractor for 25 years. The employee was using a 1" EMT bender to bend a piece of 1" pipe for a conduit when he felt a snapping sensation in his right shoulder. The employee injured his rotator cuff, resulting in an MSD claim currently reserved at $260,000.



(CNA, 2001)

Figure 1-3.9. Impact of MSDs on Electrical Trade: Percent of Claims and Claim Dollars by Type of MSD

SESSION 1: PRESENTATION 1-4
NON-TRAUMATIC LOST-TIME INJURIES IN ONTARIO

Peter Vi, Ergonomist
Construction Safety Association of Ontario (CSAO), Canada

The Construction Safety Association of Ontario (CSAO) is a labor-management organization funded by the Ontario WC system. CSAO provides free job hazard prevention services to all workers and contractors in Ontario [CSAO 2002]. Having worked in both manufacturing and construction, I can say that prevention is much harder in construction, and there are many opportunities for improvement.

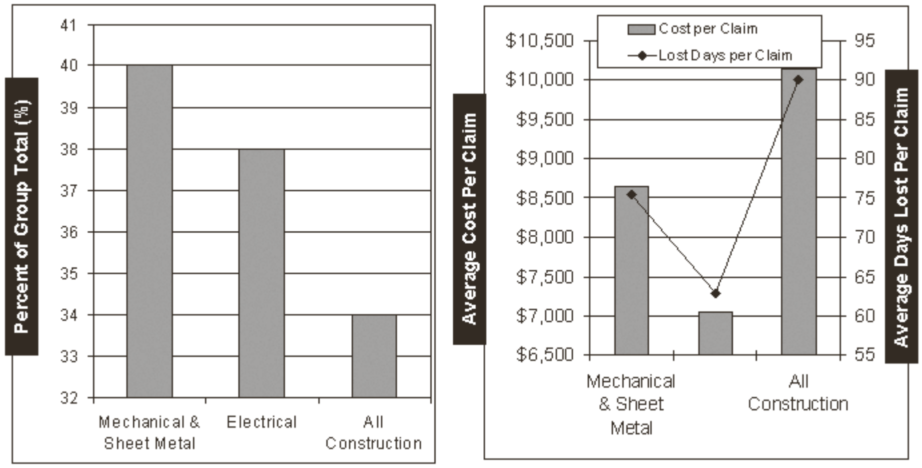
A non–traumatic injury is one caused by overexertion, awkward posture, repetition, or a combination of these. (A traumatic injury is defined as a slip and fall, being struck by an object or against an object, or a motor vehicle accident.)

The source of the data for this presentation is the Ontario Workplace Safety and Insurance Board (WSIB) accident information obtained from workers and employers from 1996 to 2001. The costs are in Canadian dollars.

In the mechanical and sheet metal trades, 40% of all lost-time injuries (LTI) were the result of non-traumatic injuries; in electrical, 38%; and in all construction, 34%. The average cost per claim was $8,700 for mechanical and sheet metal trades; $7,000 for the electrical trades; and $9,000 for all construction occupations. The numbers of lost days for the three trades were 75 (mechanical and sheet metal), 63 (electrical), and 90 (all construction) (Figure 1-4.1).

Figure 1-4.2 shows the categories of causation for MSDS: overexertion, awkward posture, and repetition. The bottom four categories shown are forceful exertion. The next three categories up are repetition. Awkward postures consist of bending, climbing, etc. Bodily reaction is a combination of repetition and awkward posture. Bodily reaction and exertion combine all three factors (repetition, awkward posture, and exertion).

The grey bar represents mechanical trades, and the black solid bar is electrical trades. Mechanical trades seem to have a higher number of injuries related to higher forces than the electrical trades do: for overexertion, it is 13% vs. 10%; for overexertion due to lifting, it is 7% for mechanical trades vs. 5% for electrical. However, there are more injuries for overexertion due to pulling or pushing in the electrical trades, than for the mechanical trades. If you look at repetition injuries, the two trades are about the same. For awkward posture, the percentage of injuries is higher for the electrical trades. Moreover, the number of bodily reaction injuries is almost the same.



*LTI = Lost-Time Injury

CSAO, 2002

Figure 1-4.1. Non-traumatic lost-time injuries by construction sectors in Ontario from 1996–2001.

Overall, mechanical trades have a slightly higher risk of injury than electrical trades, because of the overexertion–lifting and applying more force.

In Figure 1-4.3, we see LTIs by source of injury. For both trades, awkward postures cause more non-traumatic LTI than materials. If awkward postures are reduced, the load on the back will be reduced.

While the injury rate is low for younger workers, the highest rate of injury is in the 30-40 year-old age group for all trades. Non-traumatic LTI for MSDs decrease as workers get older, since older workers tend to get better jobs. This relationship (an inverted U), however, does not hold true for traumatic injuries (Figure 1-4.4).

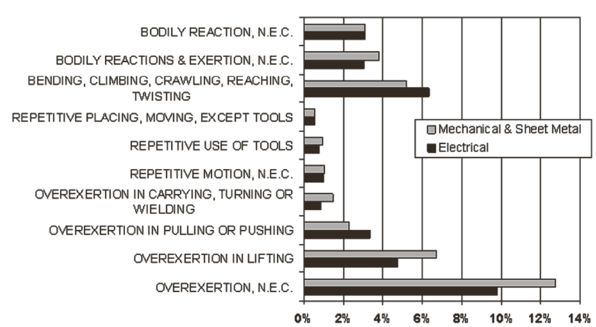


Figure 1-4.2. Detail non-traumatic lost-time injuries

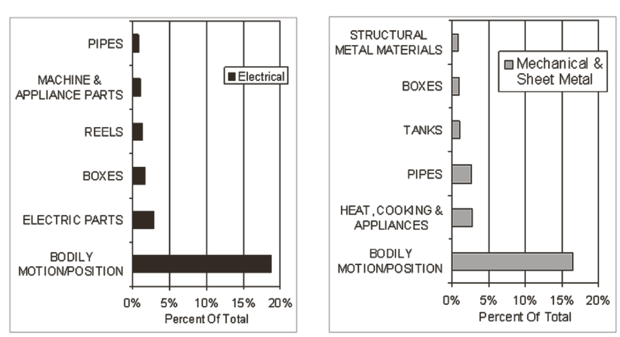


Figure 1-4.3. Non-traumatic lost-time injuries by source of injury

For workers under age 30, the number-one reason for traumatic injuries is struck by object. For older workers, the number of falls increases, the older the workers become.

During the years 1996–2000, there was a consistent decrease in the rate of injuries per million hours worked. Injuries for the mechanical and electrical trades follow the same pattern (Figure 1-4.5). In the previous five years, there was also a gradual decline.

Questions from Presentation 1-4

Question for Peter Vi: About the age distribution—How much of a survivor effect is there? People who are injured may drop out of the trades. The roofers are looking at this, and the laborers want to.

Answer: It's correct that as the age group gets older, the number of LTIs do decrease–the overall number. That could be because many are gone. However, these figures are percentages for each age group, so they are independent of whether there is a dropout rate or not. It is related to the fact that older workers have better jobs, with less exertion.

Question for Peter Vi: About Figure 1-4.5: Are we perhaps shifting the cost of these injuries back to the employer and not onto the insurance, through our return-to-work programs, which become effective loss-management tools, but may not necessarily reflect the decrease in injuries to workers that the data seem to represent?

Answer: These are about the rate of accepted claims, so the figures are independent of whether workers go back or not. They represent a minimum of one day's loss of work. The submission rate is dependent on workers and doctors, whether both see the injury as work-related. If you graphed claims submission rate by itself, independent of the administration of the workers' compensation system, the submission rate would be decreasing. Is that because of lack of education—that workers don't understand injuries are work-related? I doubt it. There is a lot of education out there. Claims management may be a factor, but not so large a factor. There is also a decrease in injuries that do not result in time–off work, but do require medical aid. So, numerous data indicate that these data are real, not an administrative cause, but a real

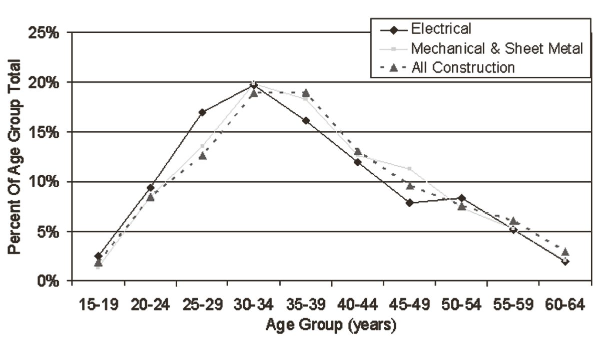


Figure 1-4.4. Non-traumatic lost-time injuries by age groups

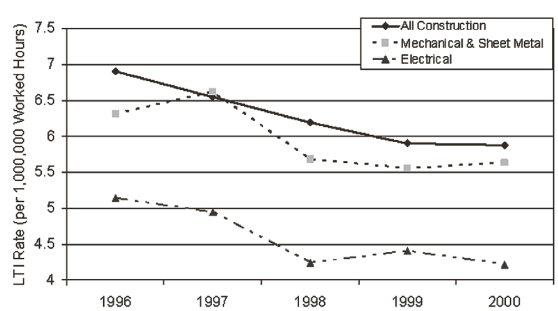


Figure 1-4.5. Non-traumatic lost-time injuries by year

improvement in the industry. This situation has occurred not only in construction, but also in all industries.

Question for Peter Vi: Does anyone know whether many workers get easier jobs as they get older?

Answer: I don't think there are any studies that suggest that.

Comment from Scott Schneider: I think there is a progression in careers. Apprentices are given the hardest jobs to do, a "baptism by fire". And people do learn better ways to do things. Studies of carpet layers using knee kickers show that experienced workers use a lot less force. Toward the end of their careers, people with 20–30 years in the trade do become upper-level journey people and supervisors, but there are only a small number of those. No one has really documented accommodations as workers age. It's a good question.

Response from Peter Vi: Masonry workers in Ontario have one of the highest rates of non-traumatic LTI. They lift massive blocks. I observed older workers asking others to help them lift, but the younger ones would lift the blocks by themselves. We need more studies.

SESSION 2: INTERVENTIONS CURRENTLY USED IN THE TRADES TO CONTROL MSDS AND SOFT TISSUE INJURY RISK FACTORS

2-1 Interventions Used in the Electrical Trade Soft Tissue Injuries Project
Bert Mazeau, Corporate Safety Director
Rosendin Electric, San Jose, California

2-2 Ergonomic Injuries, Repetitive Motion Trauma, WMSDs, and Soft Tissue Injuries
Mike Murphy, Safety Coordinator
National Electrical Contractors Association-International Brotherhood of Electrical Workers (NECA-IBEW) Electrical Training Center, Portland, Oregon

2-3 Construction Ergonomics: A Participatory Process
Tony Barsotti, Safety Director
Hoffman Construction, Portland, Oregon

2-4 Ergonomics Intervention in the Pipefitting Industry
Joe York, Journeyman Training Coordinator
UA Apprenticeship Steamfitter/Pipefitter, Oregon

2-5 Interventions Currently Used in the Trades to Control MSDs and Soft Tissue Injury Risk Factors
Part 1, Successful Sheet Metal Interventions to Control MSD Risk Factors at Streimer Sheet Metal Works, Inc.
Phil Lemons, Safety Coordinator
Streimer Sheet Metal Works, Inc., Portland, Oregon

Part 2, Streimer's Ergonomic Intervention to Facilitate Ductwork Assembly
Kelly True, Project Manager
Intel D-1-D Project, Streimer Sheet Metal Works, Inc., Portland, Oregon

2-6 Training Tools for Owners, Contractors, and Workers
Charles Austin, Industrial Hygienist
Sheet Metal Occupational Health Institute Trust (SMOHIT), Alexandria, Virginia

2-7 An Ergonomic Evaluation of a Mechanical Contractor Shop for Compliance With the Washington State Ergonomics Rule
Peregrin Spielholz, Ergonomist
Safety and Health Assessment and Research for Prevention (SHARP) Program, Washington State Department of Labor & Industries

[Please note: The following presentation summaries are transcriptions from the 2-day meeting. These transcriptions have been edited and reworded for clarity of meaning. The presentations, including questions and answers, are included in the proceedings as documentation of the meeting. The content, however, might not reflect current NIOSH policy or endorsement.]

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SESSION 2: 2-1
INTERVENTIONS USED IN THE ELECTRICAL TRADE SOFT TISSUE INJURIES PROJECT

Bert Mazeau, Corporate Safety Director
Rosendin Electric, San Jose, California

The general risk factors for soft tissue injuries are force, lifting, pushing and pulling, awkward postures, cramped work area, repetitive work, and contact stress. Tasks in the electrical trades that can involve these risk factors include:

- Twisting wire nuts on wire ends;
- Installing conduit overhead and to the floor line (there is a lot of overhead work in the trade);
- Pulling wire;
- Installing light fixtures;
- Moving and installing switch gear, transformers, and generators;
- Bending conduit; and,
- Drilling into ceilings and floors.

Rosendin Electric focuses on the pre-job planning process to address lifting and body positioning. As part of the pre-task plan, we use a soft tissue protection plan and a safe lifting plan. For anything weighing over 50 lb, we develop a safe lifting plan for the crew, and the crew signs off on it. In the soft tissue protection plan, we identify types of hazards, the body position, the exposure, the control measures, and the personal protective equipment requirement.

Another thing we do is prefabrication of assemblies. This can be done in the shop, on tabletops with stools, to minimize strains. We can assemble them in large quantities and then ship them out to a job site, rather than having on-site people assemble them in ones and twos.

For New Hires

Hand tools are generally provided by employees. We check a person's tools to determine whether they are adequate for the job. When tools are first purchased, they are bought by a low-wage apprentice, and they carry them as long as they can. They seldom get ergonomically-designed tools. We interview new hires using an experience and training form. The person lists the types of training they have had on various tools and equipment, such as scissor lifts and benders. The form helps us decide where to place that person. New hire orientation is key: our training deals with soft tissue injuries and proper lifting techniques. At our weekly tailgate meetings, these things are discussed again, so that we can re-train people who are not doing things the proper way. Our training reaches both supervisors and employees. Quarterly supervisors' meetings target these areas. This year's target areas are MSDs and cuts to the hands. We have had an ergonomist and physical therapists come in, to provide information to the supervisors.

Awkward Body Positions

It is not always possible to engineer things in this business, but we try. Here are examples of the types of situations people get into.

In the following picture, (Figure 2-1.1) a worker is handling a piece of pipe that weighs 110 lb. It was team-lifted into position. He is in cramped quarters, under a building, down on his knees, in the dirt. It is an awkward position for his back and shoulders.

Our company tries to set up pre-job stretching, warm-ups, and pre-task stretching, to get the person warmed up for the particular task they will be doing.*

Our company uses scissor lifts a tremendous amount. We try to get people to position the platform at the proper level, so they do not have to overly extend their arms. We also use fiberglass ladders rather than wood. Fiberglass ladders result in less rattling and shaking, and fewer falls, and they are lighter.

The worker in the picture below (Figure 2-1.2) is working extremely hard. The crew came by and assisted him; five people pulled on that rope.

The following picture (Figure 2-1.3) shows a worker installing pipe on a deck. The worker is securing the pipe with wire. His position is tough on his back, and he is not wearing kneepads. One thing our company uses in this situation is plastic tie-wraps instead of wire, to allow the concrete to be poured. We also instruct workers to change positions frequently.

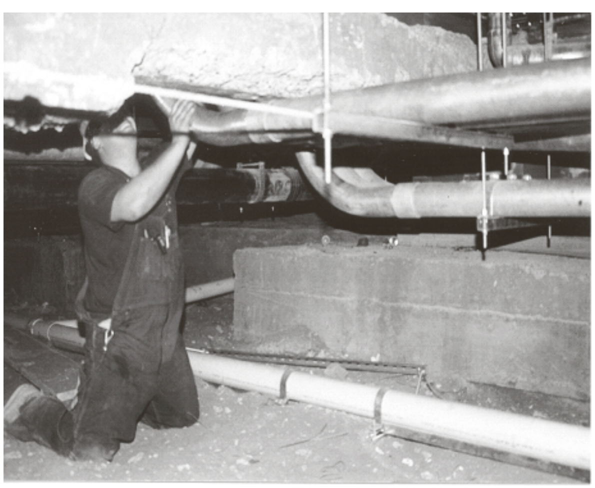

Figure 2-1.1. Worker installing pipe

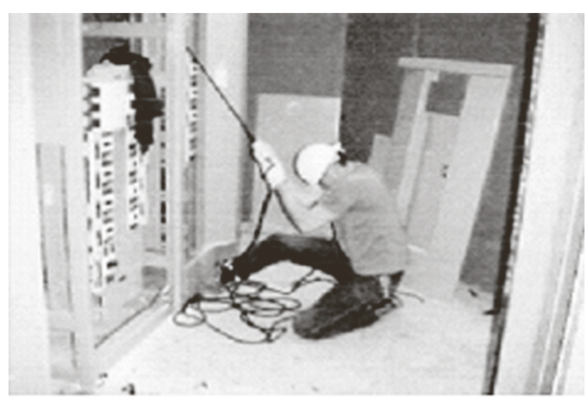

Figure 2-1.2. Worker tugging on rope

*The effectiveness of stretching exercises in preventing injuries from work has not been proven. For more information on this topic, see Hess et al., 2003.

Equipment and Materials

Different types of ergonomic equipment are available for pulling conductors (e.g., wires and cables), and much more power can be used. The picture below (Figure 2-1.4) shows a cable tugger/cable puller. This piece of equipment can do a lot of the work. In addition to the cable pullers, our company also uses cable feeders.

The following picture (Figure 2-1.5) shows a creeper, which is something we designed for a particular job in tight quarters. We built this creeper for the individual. It has an adjustable backrest and neck and lumbar supports. The worker was able to change positions, and he is wearing kneepads. The worker could get off the creeper at times. We also had a material cart attached, that he could bring with him.

The next picture (Figure 2-1.6) shows an elevated reel, an intervention a general foreman devised. We raised this reel of wire to give it a gravity feed, rather than having to pull it off a reel on the ground. One person can work the elevated reel.

Our company is trying to work smarter, not harder. Nobody in the business should have to give up their body.

Body Savers

Following are some tools and equipment that can reduce exposures to work-related WMSD risk factors:

- Ratchet sets, instead of openend wrenches. These are especially helpful when you are putting together heavy things, such as switchgear and other large objects

Figure 2-1.3. Worker installing pipe on deck

Figure 2-1.4. Worker operating cable tugger/puller

- Fixture lifts, so the worker does not have to lift and hold the fixture;
- Scissor lifts to give the worker a mobile platform on which to work;
- Power tuggers;
- Multi-ton rollers to move switchgear and heavy objects around without making a worker pull the entire crew over to “muscle” something up;
- Air packs (which are like air tables) on which a heavy object can be placed and moved around with a flow of air;
- Cordless (battery) screwdrivers. It takes 10 partial wrist twists to put on a wire nut. A worker can use an adapter on a battery; screwdriver—all the worker has to do is hit the trigger and it turns the wire nut onto the wire;
- No tool belts. Our company uses carts instead. The worker can take his tools, connections, and pipe with him;
- Forklifts, including reach forks;
- Cranes;
- Pipe racks. We put pipe on racks instead of on the floor;
- Wire feeders; and,
- Battery drills.

Questions from Presentation 2-1

Question for Bert Mazeau: How do workers react to your implementation?

Answer: It runs the gamut. Some say pain and aches are part of the trade. Younger journeymen and apprentices seem more interested. More information is available to them through their newsletters and journals.

Question for Bert Mazeau: Have lost-time injuries (LTI) decreased?

Answer: To some extent. It’s a little too early to tell. We use leading indicators observations—to see how people are performing. The lagging indicators are the metrics. Over time, we will get a better feel for it.

Figure 2-1.5. Worker using customized creeper

Figure 2-1.6. Elevated reel to assist installation

Session 2: Presentation 2-2
Ergonomic Injuries, Repetitive Motion Trauma, WMSDs, and Soft Tissue Injuries

Mike Murphy, ***Safety Coordinator***
National Electrical Contractors Association-International Brotherhood of Electrical Workers (NECA–IBEW) Electrical Training Center, Portland, Oregon

I work for 4,000 journeymen, 600 apprentices, and 125 contractors. I work for both the contractors and the union. The contractors pay my wages; the unions ask me to do things.

At an OSHA hearing on ergonomics, the president of an Idaho logging company testified about the reason her company did not need an ergonomics standard. She said their people do not have to quit work due to ergonomics, because their major problems are caused by chainsaws—the stress and the vibration. She talked about the choker setters (the people who operate the big equipment). She was defining soft tissue injuries, but she had no idea that what she was describing was exactly what the hearing was about. That is the same problem we have with our contractors. We try to make them understand the frequency of soft tissue injuries—that the biggest amount of money paid out is for soft tissue injuries.

The workers in NECA-IBEW are asking each of our employers to voluntarily fill out an Injury/Illness Report Form, and the majority of our employers are turning in the forms. We have been able to show our employers where the injuries are, which are the same as what has been reported here today.

What we are doing to correct the problem is a boot camp for new apprentices. Two weeks prior to going on a job site, we bring them into the training center. We teach them how to use hand tools, and how to use their bodies. We furnish tool belts: two pouches with a belt and suspenders. We buy their hand tools—ergonomic ones—screwdrivers that fit their hands a lot better, and wire strippers. The apprentices can show the journeymen on the job site. We have found this is a cultural thing. We get resistance from the journeyman: “This is the way I’ve done it for 20 years, and I’m going to do it this way for another 10 or 15 years.”

At our last Trust meeting (I work for four employers and four union people), they agreed that for one day in a two-week period, we would bring in a doctor and a person who deals with ergonomic injuries, and go through range-of-motion testing for all apprentices. The apprentices can learn what restrictions they have, and what they can do to overcome problems they might have. The majority of accidents happen to apprentices, or people who have been in the trade less than five years. Those are the reversible injuries. Older workers, with at least 15-years of experience, have cumulative injuries to their backs, knees, hips, and shoulders. We make an example of them, by showing them to the apprentices. We will say, “You’re working with Charlie—He never climbs a ladder. He can’t. His knees are shot. He does all the work on the ground; you do all the work in the air.” Of course, we talk to Charlie beforehand. So, the apprentices see what has happened to a person who has been in the trade for 20 or 30 years.

We were recently awarded a grant from Oregon OSHA to do an ergonomics study at two job sites. We will buy battery-powered hand tools for the workers and watch them for 8 to 12 months to see what changes occur. We will talk to them about what hurts, why, and what tasks make them hurt.

We are using job hazard analyses done by Rosendin Electric and other employers. Through our monthly joint safety committee meetings, we hope to take these ergonomic changes to all 125 employers.

Questions from Presentation 2-2

Question for Mike Murphy: Did you have to get approval from management for boot camp? Who’s paying for it?

Answer: It’s paid for by the industry on a cents–per–hour basis. It came out of the necessity to have a trained workforce when they went on the job site, so they knew about the noise and the constant motion. The average age when apprentices start is 22 to 23; they have been working in stores or going to school. They are not used to the hazards of the job site. We were having apprentices injured immediately when they went on the job site, just from the confusion. We’re trying to take that confusion out of the job site.

It was hard to sell to employers. They didn’t want it because of cost. Now they rave about it. It is saving them money. It has cut down on injuries. Apprentices are more productive, and they are not borrowing tools from journeymen. They know how to handle tools, how to bend conduit, and how not to hurt their body when they are bending conduit. We work with them on pulling wire, and make sure they understand the safety rules. They can train the journeymen that it is not a safe condition. They can say, “I’ve been told by Mike Murphy this is an unsafe condition, and I do not have to do it.”

The other thing the training trust—JATC—has given me: If I go on a job site and there is intimidation of an apprentice to do something unsafe, I can take that apprentice out of that shop and put him in a shop I know is safe. If the employer gives me problems, I take all the apprentices out of that shop, and the employer doesn’t get an apprentice for two years. So, the employers pay attention.

We’re also changing to a day-school concept—so we have apprentices eight hours at a time, instead of three hours on two nights a week.

SESSION 2: PRESENTATION 2-3
CONSTRUCTION ERGONOMICS: A PARTICIPATORY PROCESS

Tony Barsotti, ***Safety Director***
Hoffman Construction, Portland, Oregon

I'm a "hybrid person", who bridges between the employer and the worker. I'm a pipefitter by trade. Eight years ago, I went to work for Hoffman Construction. My experience is mostly in high-tech work, including Intel, an owner with multiple capital projects and a commitment to creating an injury-free work environment. An integral part of changing the industry is the support of the owners.

One of the biggest challenges we have faced in the years of working with the University of Oregon on a CPWR grant [funded by the NIOSH] has been, "What is it that keeps us from implementing these things?"

We have wrestled with the blend between specific techniques and tools, versus changing the work practices. I will talk most about work organization and the challenges to implementing solutions to musculoskeletal exposures. The challenge is not about what can be done. There are so many areas where we can make changes right away. It is about understanding the barriers that keep us from making changes.

To be successful, the process has to be participatory and involve the whole gamut of people who are involved in the project. The process is what counts. (Figure 2-3.1) The means will determine the ends.

We are asking people to be involved. We cannot succeed without the full knowledge and experience of everybody who is part of the organization. We cannot adapt to the changing environment without using the experience of the crews and the front-line supervision. The industry is one of the last bastions of the "command-and-control" chain of command. We have to let go of some of that if we are asking people to participate and create win-win situations.

I brought with me a job hazard analysis for piping contractors and some analysis of their injuries, leading to some improvement plans we can look at in the breakout session.

The movement to develop a job hazard analysis and apply it to the job site is a good thing. The job hazard analysis has replaced the company safety manual as something the company has on their shelf. It exists as a document. In the compliance mode of, "I won't get into trouble because I have it." That is a good achievement, but it is not a living document that is part of the way the organization breathes, that is available as people are working on a project.

We are moving into the next phase, what we call an activity hazard analysis. This is the next step in the process, in which we want each organization to look at the specific scope of work, the specific environment, and the specific schedule. What are the activities and what are the hazards? What are the engineering controls, and what are we going to ask the workers to do through use of personal protective equipment (PPE) to control those hazards?

Many musculoskeletal exposures are common across the trades (Figure 2-3.2).

Barriers to Change

The level of understanding of risk factors for MSDs is high, but people are not necessarily seeing all of the risk factors. Even among safety professionals, there are so many other safety-related things to look for, that the person is not focused on the body position, the awkward posture, and how long they are doing it. This is because the person is still having to look at whether they are tied off, wearing their safety glasses, the housekeeping, and how their cords are strung. Even safety professionals may still be trying to figure out how many feet of pipe they got in today, or if they are making their units this week. It is a much further distance to see and understand these risk factors. Therefore, we have lots of work ahead of us to popularize these MSD risk factors.

Fast-paced projects challenge how communications flow inside organizations and across organizations on a multi-employer work site. We find people who constrict information for control purposes. Planning is a great tool, but what counts is who participates in the planning and when, in order to ask the right questions as decisions are made.

There is a general paradigm shift going on in society. The old views limit our ability to use the knowledge of the people who are doing the work: they are hierarchical; they do not support participatory notions. There is a competitive view, which is very different from what Bert Mazeau talked about in Presentation 2-1. People might have a great new approach, but they do not want to share it because it gives their company a

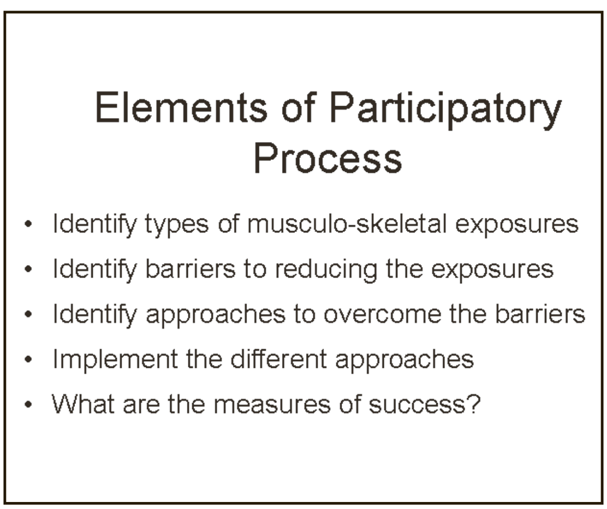

Figure 2-3.1. Elements of participatory process

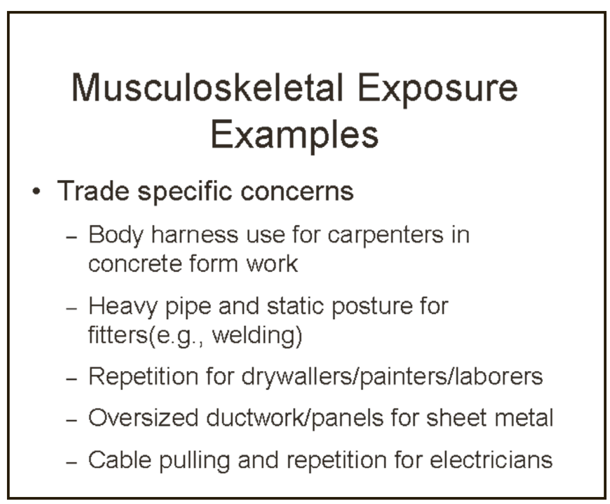

Figure 2-3.2. Musculoskeletal exposure examples

competitive advantage on the next bid. We have some progressive contractors who understand interdependence, and that we all go forward on a rising tide. However, we have other contractors who take the short view and advance their own interests in a short time frame. Lump sum bidding (which we are not going to change overnight) gets in our way. We are trapped in a project-to-project mentality.

We have taken some strides in bringing people into the process earlier, so that we are using the knowledge and experience not only of the crews and individuals, but also of the organizations, in the planning and the sequencing of the project itself. This means the design is better, since it considers constructing issues. The design considers how the job is set up, and where the materials and the lay-down areas are. These things can only happen when we have the right people involved at the times in the process when key decisions are being made.

We have to address the tension between a competitive environment, and one of collaboration and cooperation. In the field, cooperation gets the work done. We cannot impose this as another appendage, or another program. It won’t work. It has to grow as a more organic model. If we are into empowerment, we have to let the organizations shape this process, so they can see how to make it work with their people. These concepts allow each of our organizations to become what they actually can be, so they must be participants in shaping the process.

The foreman-crew relationship is critical. If 95 out of 100 conversations with the foreman is about progress and production, and management talks with them about general safety concerns (let alone musculoskeletal injury) once or twice in 100 times, it is clear that production is what is important to management.

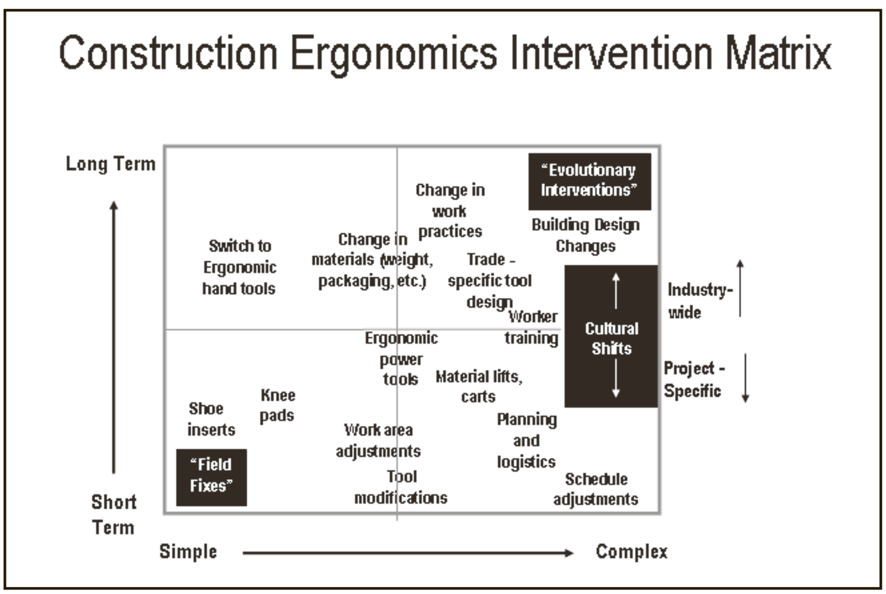

Figure 2-3.3. Construction ergonomics intervention matrix

The foreman-crew relationship is much more in our control than we appreciate. Figure 2-3.3 shows the interventions on a continuum of short-term to long-term, and of the complexity of the solutions. The interventions available to the crew, or to the foreman or general foreman, or even to the general superintendent are still the field fixes (see lower-left corner). Project specific interventions are shown in the bottom half of the matrix.

The industry-wide interventions (upper half) require our organizations to participate earlier in the process. Constraints are built in by decisions made earlier. They affect what is available for the crews on the construction sites. The industry-wide issues will take us a lot more time to achieve. We have to work in all of these quadrants at the same time. There is a tendency to work only in the field fixes, asking, “What is available for the crews right now?” and, “What can they do differently?” If we are not working in all of the quadrants simultaneously, we are going to restrict what is available to the crews right now.

Measures of Success

The notion of measuring performance is also changing. Figure 2-3.4 lists ways to measure success.

It is a good idea to always measure how we are doing against our plan. We should not be so worried about our results, because by the time we get the results, it is already too late to make changes. Instead, we should consider how we are doing along the way with these interventions.

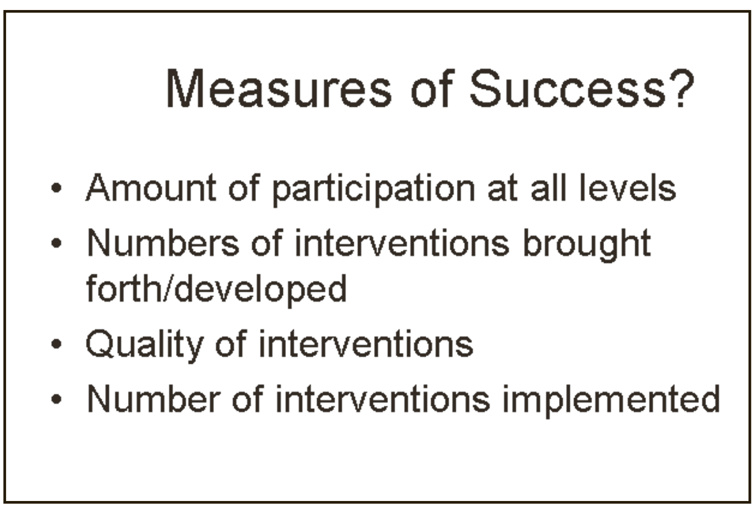

Figure 2-3.4. Measures of success

Ergonomic Interventions in the Pipefitting Industry

Joe York, ***Journeyman Training Coordinator***
UA Apprenticeship

In Local 290, I am responsible for training 5,000 people. I'm like a superintendent of schools: I hire the teachers and create the curriculum. Our area is bigger than Silicon Valley in terms of the number of tech plants. The majority of work our people are doing now is in high-tech industry.

The first class our people go through is use and care of tools. This is their introduction to ergonomics.

I have an unusual background. My father was a pipeliner, my mother was an Indian, and we traveled around the country in the late '40s and early '50s following the work on pipelines. In those days, pipeliners did not have much in the way of safety. They had only one thing that was necessary, and that was to do a day's work for less than a day's pay. What you got off for lunch was one glove. They did not have toolbox meetings or things like that, and people were killed. I have been on many, many projects where people died.

Today, we have finally become aware that people need to have some longevity in their work. I started welding while I was in high school. I have worked virtually all over the country. I thought I would talk about the pipeline industry and some of the changes that have occurred in ergonomics.

When I learned what ergonomics was, I discovered that I have been a friend of ergonomics all my life. I did not know it at the time. In fact, ergonomics has been around forever. Ten thousand years ago, my people went out to hunt the woolly mammoth, and they used spears to chuck at them.

Somebody came along and said, "If we put this device on the end of this thing, we will call it an "atlatl", and we can throw this thing at four times the speed we can chuck a regular spear. We do not have to get so close. It is a little bit safer." Then somebody else said, "Yeah, but if we take a stick and tie a string across it, we can fling arrows at them, and we can arch it out there; we do not have to be nearly as close."

In archery today, we have a compound bow. A bow rated at 70 lb draw weight will mechanically diminish the amount of weight by as much as 30% to 60%. The mechanical advantage gained is an ergonomic bonus: if you are only holding 30%, you can hold that for a long time and look around. Not only that—there is a device that hooks onto your hand called a release, and it snaps onto the string. If I were shooting an ordinary bow, I'd be pulling it back this way. With this device, I can pull it back like so, and turn. If you notice, when your hands are normal—like this—when you bring your hand up—like so—that is not the normal way to pull a bow. However, with the quick-release, you can roll it around, and this causes a lot less stress. So if you shoot an arrow about five bazillion times, it may keep you from having carpal tunnel.

When I first started welding, I was pretty small, so my arm was not as long as the welding rod. The contractor's main idea was to get as many pipeline welds as he could in a day, to make him more money. So I learned to put the rod in the stinger, bend it, and rip it around like so. That sounds easy. Then I could bend it at an angle, and then I could reach down and weld. Over a period of time I probably bent a boxcar load of those rods around, and it wasn't until John came along that I knew that carpal tunnel existed, and that I was probably at great risk.

We have a symbiotic relationship with the industry's contractors. They must provide us with a safe working environment. They must provide us with the tools, the equipment, and the materials so we can do a productive job. We have to make the attempt to do that job in a professional manner, in a way that we are not going to get hurt.

Several years ago, one of our young men, Donald Dunn, leaned a ladder against a fiberglass tank. The ladder slid off and it killed him. Because the engineers had engineered away the apparatus that was supposed to contain the ladder for support, his wife received a fairly large stipend. She blessed the Local 290 training center with a trust, of which Tony Barsotti and I are a part. We have been holding the Donald Dunn Memorial Seminar for 5 years. We have made every effort to involve ergonomics in our program.

Billy Gibbons has opened the eyes of many contractors in the high-tech industry to the knowledge that working safe can also be a production thing. If you do not have lost-time injuries (LTI), you can get work done sooner, faster, better, and at less cost.

Our people can retire at age 55. We do not really want them to, but if they have soft tissue injuries, it becomes imperative that they do retire, which means they take away from their retirement accounts for many more years than if they had lived to be an old person before they retired.

In 1960, my younger brother, 16 years old, had his leg cut off on a pipeline. He wanted to become a welder like his father and the others members of his family. He couldn't climb ladders, he couldn't work off forklifts, he couldn't even get around the project, and so he ended up becoming a wire welder on a station where the pipe rolls around. Moreover, because of that, it wore him out. Ergonomic interventions that are available now would have enabled him to work several years longer. The industry has learned to weld wire on the top of the big pipe, so the worker is in a position like so. My brother developed his skills to the point where he was a valuable asset to the contractor. He got to be the best wire welder in our local. He learned to weld down on the side, where it was more comfortable.

We did not know, then, that the National Aeronautics and Space Administration (NASA) was going to invent a product that would make really soft material—a lot of things that affect ergonomics today have come from NASA. A good example is orbital welding machines. We use them in the high-tech industry; we use them in the food industry and in pharmaceuticals. We will also be using them in hospitals. We will weld copper with them in the next five years. Automatic welding machines also came from the trickle-down effect from NASA.

I worked in Prudhoe Bay, Alaska, at -80^{o}F. Ordinary rubberized material cannot be used there. A regular cord will snap into two pieces. NASA developed material that was first used for seals on the space shuttles. Now, this material is used for coating on electrical connections.

(*Presentation slide not available.*) On my rig, I do pipeline welding. This slide shows two welders taking a test. Each of their welds will be X-rayed. That is an inside line-up clamp—those things are fantastic. They have been around a long time, but not at this level. I have pictures from back in the 1960s of 30 guys pulling on a rod to pull that thing up a hill. Nowadays, these things are automatic. They have air to them; they run right out; they will punch the pipe out to be perfectly round; and it gives these guys an opportunity to weld in a manner.

(*Presentation slide not available.*) This is called a stinger lead, and because that material is coated with the same material that was developed for NASA, over a period of an 8- to 12-hour day, the worker is going to have less fatigue. His quality of welds will be maintained.

(*Presentation slide not available.*) Notice a mud board there. I built myself a ladder. In most areas where fitters are encouraged by the employer to provide themselves with a safer way to do something, our guys are very creative.

If you ever visit Kinetics, a high-tech fabrication shop in Wilsonville, Oregon, you can see people working in a clean-room environment. (*Presentation slide not available.*) You will see all kinds of inventions these gentlemen have made to make it easier for them—clamping devices, material handling, bending and fabrication jigs. And, because it is easier, production increases. But contractors do not want you to learn what they can do, because you will become a competitor for them.

(*Presentation slide not available.*) Already on the market, are all kinds of tools that are ergonomically designed. This is a 3/8-inch ratchet. It does not have much leverage on it, but after I break the bolt free, I am going to leave the Craftsman in the toolbox and use something like this. It will fit in my pocket, but more than anything else, it fits in my hand. Sandvik, in the Portland area—a usual participant at our Donald Dunn seminar—makes all kinds of ergonomic tools. These kinds of tools will promote ergonomics in our field.

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SESSION 2: PRESENTATION 2-5
ERGONOMIC INTERVENTIONS IN THE SHEET METAL INDUSTRY
PART 1: SUCCESSFUL SHEET METAL INTERVENTIONS TO CONTROL MSD RISK FACTORS AT STREIMER SHEET METAL WORKS, INC.

Phil Lemons, ***Safety Coordinator***
Streimer Sheet Metal Works, Inc., Portland, Oregon

Streimer Sheet Metal is probably the smallest group presenting today, compared to these great organizations and universities. I will bolster our position by talking for the group of contractors throughout the state of Oregon; 29 companies that are part of our local Sheet Metal and Air-conditioning Contractors' National Association (SMACNA) chapter.

When I got the call from Jim Albers, I took the idea to the SMACNA safety committee. I talked to people in the member companies and came up with seven or maybe eight people who had a general awareness that performing certain jobs would increase the risk of musculoskeletal injuries. Less than one-third of the contractors have a designated safety officer, and half of those are part-time.

Those of us active in safety areas did further research. Some of the things we are doing are:

- Promoting the Sheet Metal Occupational Health Institute Trust (SMOHIT) stress management book [1999]. We have a complete program at the association level, promoted throughout the state and at job sites.

- Submitting a proposal to Oregon OSHA for a grant to copy the electricians' proposal from Mike Murphy to increase SMACNA awareness of MSDS, so that members can identify it and have some tools available.

Here are some of the things that have been done in Oregon. Most of these we have done at our company:

- Placed scrap tables beneath all shears, bringing scrap closer to the worker for both clean up and recycle.

- Designed and built handles that easily snap onto the top of these heavy steel tables, allowing them to be pulled to a vertical position to get them out of the way for further clean-up, or moved back so we can get by the shear.

- Built and installed exterior wheels for manual blade movement on our shear. Prior to this, we had to take up the housing; a man had to get down on his knees on a concrete floor and jimmy the pulleys to slowly move the shear blade to get it to incremental positions for maintenance. Now, we have eliminated that by installing a 14-inch-diameter steel wheel on the outside, which turns the material inside the housing. It is much safer, as well as much better physically, to do that job standing up.

- Modified all portable welders with pull-down ramps so oxygen and acetylene tanks roll on and off the welder, eliminating the need to ever lift these tanks, which can be quite heavy, even when empty.

- Modified our cylinder storage room areas to eliminate lifting of the tanks, as well.

- Purchased handcarts specifically for transportation of acetylene and oxygen tanks.

- Built drill bit extensions for overhead work, to keep the tool and the workers' hands below their shoulders, primarily at the waist. We have various lengths of drill bit extensions.

- Built various, specifically sized tools for safe removal of system components and high-efficiency particulate air (HEPA) filters at our high-tech plants and for other often awkward or heavy maintenance items.

- Built various types and sizes of scissor lift attachments to reduce or eliminate manual material handling (MMH), primarily for our architectural division, which puts panels on the outside of buildings.

- Converted all work tables in the shop and field into rolling tables.

- Modified our chemical process tasks (bonding processes to join sections of round fiberglass pipe, or duct) so the work can be done near waist height.

- Changed to using carts, and away from using tool bags.

- Built and utilized push sticks for placement of overhead electrical cords, to eliminate ladders as much as possible on that task.

- Modified Rubbermaid™ tool carts with taller handles, eliminating bending.

Three primary factors prevent ergonomics from getting more into the mainstream of our daily work in the shop and the field:

1. The reluctance on our workers' part to change work practices, especially those who are older or who have trained younger workers that this is the way to do a job. So, we are looking for interventions earlier on, primarily through our joint apprenticeship

and training center. We are seeing a lot of resistance to embracing ergonomic solutions.

2. Fear at management level that introducing ergonomics will generate more claims and costs than it will prevent. We see a lot of misunderstanding at the owners' and managers' level in many companies.

3. In Oregon, there is a lack of regulatory requirement. In other words, the "hammer" isn't there.

Finally, speaking for our company, the one big thing that will get us over the hump is safety plus productivity. We have to combine these as two sides of the same investment dollar. One task I'm working on this year is a training program for foremen to help them recognize basic risk factors in ergonomics and to adjust basic work practices, or to order engineering adjustments, as necessary, consistent with their needs to maintain high levels of productivity and low cost. We are not getting foremen to make changes if they think it is going to make the bottom line look bad. So, we are getting top management support; we are getting permission for them to do this. We think in the long run we are going to find a number of areas where we can make tremendous strides that are low-cost and high-impact.

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SESSION 2: PRESENTATION 2-5
ERGONOMIC INTERVENTIONS IN THE SHEET METAL INDUSTRY
PART 2: STREIMER'S ERGONOMIC INTERVENTION TO FACILITATE DUCTWORK ASSEMBLY

Kelly True, ***Project Manager***
Streimer Sheet Metal Works, Inc., Portland, Oregon

Introduction by Phil Lemons: Kelly has 15 years' experience with Intel projects, and with crew sizes up to 130 workers. He is working on the largest semi-conductor facility (aka, "fab") that Intel has ever built, where he does research on ergonomic interventions on this campus, along with Billy Gibbons and Steve Hecker. In 1996, our program got going because of a report that Billy Gibbons and Steve Hecker did for us.

We have come up with several devices to get our work done in a safe fashion. One came from the craft folks and the project superintendent—a fine example of what you can do if everyone on the project is involved. That is one of the keys to success.

One of the definitions of ductwork is a lot of air with a little bit of metal around it. Typically, a duct job comes out from the shop assembled, and you are in a material-handling mode getting it from the delivery truck into the building, and then to the place where you have to install it. On this project, due to site logistics, we were faced with constraints on moving in material. So, Project Superintendent Dave McBride wanted to put ductwork together out in the field. I thought it would be inefficient. I had ergonomic concerns, and there were weight limitations. I said, "If you can do it safely without putting anyone at risk, productively, [and] without exceeding the 35 lb weight limitation that we have on site, I'll take a look at it." He surpassed all of my expectations.

Otherwise, the person uses an air hammer, which requires a significant amount of force. With an electric one, your hands are in a more ergonomically desirable place, and you need to put less pressure on the ductwork to put it together.

Figure 2-5.1 shows a typical joint of duct. It usually comes out in an L shape, or there might be four rails that you have to put together. At the bottom, are the feet of the duct-handling device that the crew devised, which I will be describing.

In Figure 2-5.2, the duct seams are tacked together. The base plate and riser are part of the crew's duct-handling device.

Figure 2-5.3 shows the strut piece with the top portion of the clamp of the device. Normally, the duct would be put together in the shop, requiring several people to manhandle these pieces. Workers are on

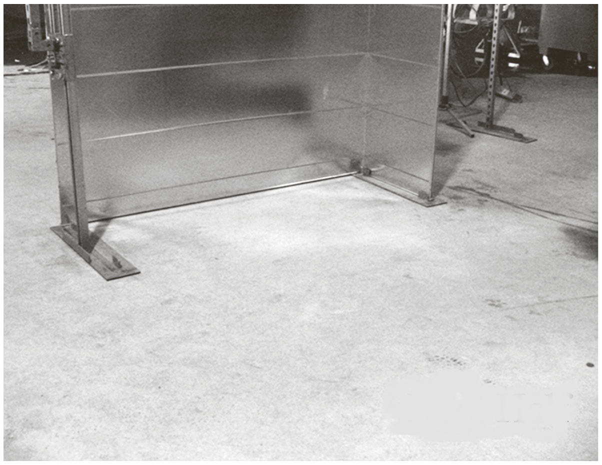

Figure 2-5.1. Typical joint of duct (duct half)

Figure 2-5.3. Clamp device

their knees a lot while pounding the sections together. They turn big pieces over and are at risk for strain, stress, and pinch points. Some of this ductwork is 10 foot wide by 36 inches, and it would require a wide-load permit to ship it out to the work site.

Figure 2-5.4 provides a good idea of what the duct-handling device looks like. There is a top clamp, a bottom clamp, and a pivot. Brackets with some simple hardware are available–Unistrut™ parts and clamps—common materials, which are easily obtained.

Overhead is a beam that is hooked up to a hoist, which is attached to the embedded strut on this particular job. It could be done with an A-frame, or something else. However, this beam allows those arms to telescope in and out to accommodate different widths of duct. So the workers get the ductwork into this device, hold it into place, and tack the sides together.

The duct is picked up, pivoted, and then placed on the cart shown in Figure 2-5.5, which is on rollers. It puts the assembly work at a desirable height, so the workers do not need to stoop over, or bend down

Figure 2-5.2. Tacking duct together

Figure 2-5.4. Setting up the clamp

on their knees to tack the corners. Plus, they do not have to handle the weight.

Figure 2-5.6 shows another example of setting a Pittsburgh seam: You have a male part that goes into the female part, and you have an edge you hammer over, which clasps them together. This is a modified mason's tool, in which the worker is setting the Pittsburgh seam. It has a nice, ergonomically-designed handle and a guard to keep the worker from smashing his hand. Typically, the worker has to hit a very small target.

Figure 2-5.7 shows the duct-handling device. The workers opted for an overhead control. You reach up for a short duration to activate the hoist, and then lift up the duct. One person can do the task, and we rotate this job. To move some of this ductwork with Streimer's weight limitations would take up to eight people, just to flop it over. So from a productivity standpoint, it is much more efficient. You can see how easily it pivots and can be placed back onto the work cart.

In Figure 2-5.8, the worker is essentially putting this corner piece in, which can be done either on the horizontal, or on the flat. The workers mostly prefer to have that on the ground when they set the corner in, and hammer those edges over to lock that into place.

Figure 2-5.5. Horizontal assembly

Figure 2-5.6. Setting a Pittsburgh seam

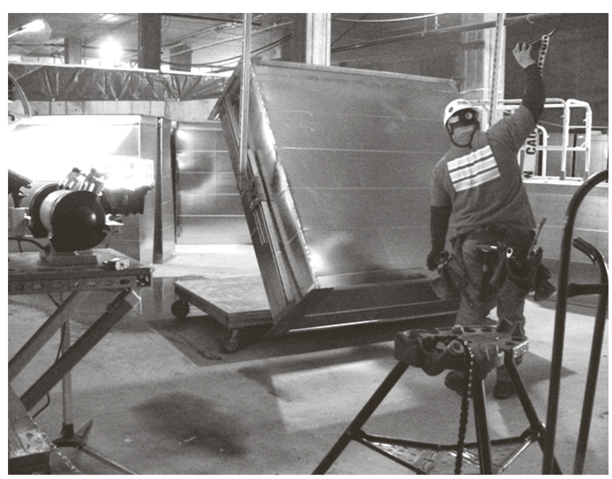

Figure 2-5.7. Pick-up and rotate duct

In Figure 2-5.9, the workers opted to go with the hand truck to move the joint of duct out, once the upper portion of the device was raised out of the way. They pulled the jointed duct out and could take it into the work area. They left the larger pieces lying horizontally on the cart, pushed the cart directly out to the job area, grabbed it with the forklift, raised the duct up into the work space, attached it, and hung it.

This duct-handling device was a brilliant idea devised by the crew and the superintendent. They have all bought into it and offered suggestions on how to improve it. They like it because it doesn't burn them out at the end of the day. They can do a considerable amount of work safely and feel more productive. Their estimates were 30% to 50% productivity gain because of reduced head count and impact to crews. The device wasn't very expensive—about $750, not including the cost of the hoist.

When we reduced the ergonomic risks, we created some mechanical ones. To mitigate those, we instituted a daily checklist to review the equipment and make sure the cable, hoisting system, and fasteners were all secure and tight.

We also did some operator training. The operator worked with a partner, until he understood the proper operation of the device.

In summary, it is a simple device, made from common materials, and is easily transportable. It is an effective way to get the job done safely on the job site, when conditions are normally a little more difficult.

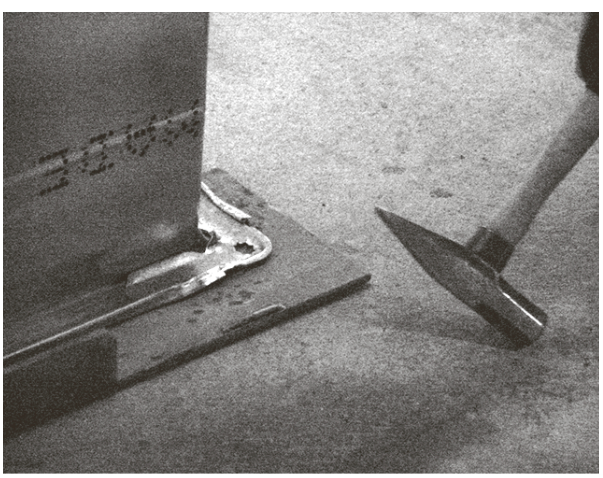

Figure 2-5.8. Corner Installation

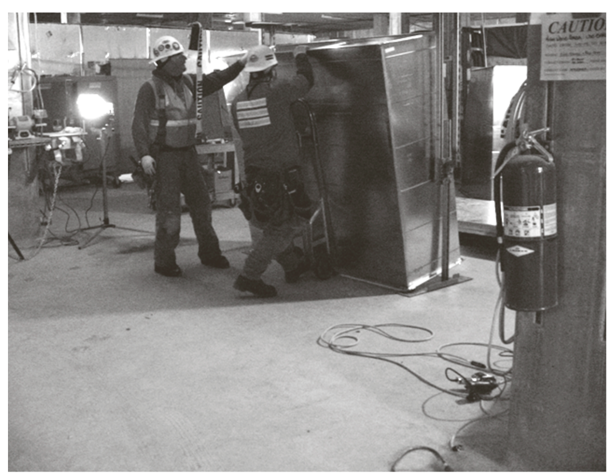

Figure 2-5.9. Removing the completed duct

Training Tools for Owners, Contractors, and Workers

Charles Austin, ***Industrial Hygienist***
Sheet Metal Occupational Health Institute Trust (SMOHIT), Alexandria, Virginia

I will talk about the ergonomic interventions on which SMOHIT is working. When I started working there five years ago, training primarily came from the workers or from the contractors' own training programs, or the owners might also take part in developing materials. When we developed materials just for workers, they did not deal with the issues of the contractors or the owners. We tried to develop programs that could speak to each group. The Physical Stress Management Program [SMOHIT 1999] came out of this effort to involve all three groups. We also worked with the insurance company—Robin Johnson (CNA Insurance) worked with us—as well as Phil Lemons (Streimer Sheet Metal), and also James Struthers.

The package includes a CD-ROM with PowerPoint®, a booklet on warm-up and stretching*, and a booklet on talking points for training. At the back of the booklet is a list of various control measures for the sheet metal industry.

We developed a program called Sound Advice [SMOHIT 2002]. We took research information and put it in chart form, so that workers can use it out in the field, or for pre-planning before starting the job. With this chart, a worker can determine, at a certain decibel level, what the risk level would be after 10 years. In the back of the booklet, are common tools with which sheet metal workers work. The chart indicates, "If you wear no hearing protection, this is the decibel level. If you wear earmuffs, this is your decrease."

Owners know what tools they are going to use on a job; they can use this chart and preplan what kind of safety equipment will be needed.

One of our biggest projects was developing a welding chart. First, we catalogued the whole sheet metal industry. We had applications from food service to structural steel—every part of a sheet metal job is catalogued in this chart. With that, I listed all the health symptoms and all the material that goes into welding, so an owner or a contractor could say, "We are going to work in carbon steel with this kind of electrode. We know the gases we are going to work with; we know the contaminants; we know the non-gas sources." What I have here is a coded system that will tell the workers the health

*The effectiveness of stretching exercises in preventing injuries from work has not been proven. For more information on this topic, see Hess et al., 2003.

effects of those particular things. We know if the work involves a potential respiratory exposure, or skin exposure. Then, in the back of the booklet, they can pre-plan what type of controls can be implemented. So, the tools and interventions are hands-on materials that can be used before the work is started, during the work, and even after. We created a large and a small chart.

The focus for our interventions is two-pronged. One is to incorporate contractors, owners, insurance companies, and workers into every project. The other is to have it interactive, so that results can come out of the field research that I perform.

For the hearing chart, I did real-time monitoring on 20 tools that are most commonly used in the sheet metal industry. We are going to try to measure all the tools, so we can say, "If you work with this tool, you will need earmuffs and plugs."

We have an interactive CD that goes along with a chart that simulates hearing loss. It shows, for example, how it sounds to have 25-decibel hearing loss. It also does risk analysis and can be geared toward the individual person. You can put in your age, you can search for a particular tool, and it will tell you what type of protection you need.

I will go over part of the CD we created on physical stress management—the task and methods section. We wanted to develop a chart of information gathered in the field. So, we looked at all possible tasks in forceful exertion, and on the chart we tell the workers what they can do onsite or before the job starts. It is the same for sustained postures—twisting, reaching, and bending. Methods of control are the following: (1) Reposition the body to a more neutral posture. We might show on the chart what is considered a neutral posture. (2) Select tools that reduce awkward posture. We have some pictures that show some tools and correct postures that might be used.

Here are some controls for some common problems:

- Repetitive motion (such as constant lifting and placing of ductwork): Use a mechanical lift device.

- Hammering in awkward posture: Use spring-loaded hand tools with protective grips. This is done in our apprenticeship program, so that from the first year, the person will be exposed to ergonomics. When they become a journey person they will have a background in the methods of control.

- Extreme climates: Increase or decrease air temperature.

- Improperly designed tools: Use tools that reduce wrist deviation. Also, use tools for their intended tasks.

- Increased work pace: Better job planning and communication. Inventory and inspect tools and equipment. Coordinate better with other construction crafts, which is important in pre-planning the job.

The reason we did the welding chart is that welding cuts across all trades. The chart can be used for all crafts and will help in pre-planning control methods.

Questions from Presentation 2-6

Question for Charles Austin: On noise measurements on the tools: did you take the information back to the manufacturers, or give them a chance to promote their tool if it doesn't produce a lot of noise, or make them think about designing tools that don't produce as much noise?

Answer: When the manufacturers determine noise levels, they don't actually do it in a work environment, and we found that their levels were much lower than what we measured out in the field in actual use. This wasn't something they wanted to hear, because just about every tool was above 90 or 80 decibels. The few manufacturers we did contact did their measurements in more of a laboratory setting, so when they saw our measurements, it was disheartening.

Question for Charles Austin: Did you have any system for labeling the tools as to the different noise levels? So that people have a choice.

Answer: No, we just went to different shops and picked out the tools that are used the most, and the brand names that are used. In the sheet metal industry, there are one or two manufacturers. That's an excellent idea: look at what other tools are out there. The last thing we want to do is implement hearing protection. The first thing should be engineering controls, if that's possible.

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SESSION 2: PRESENTATION 2-7
AN ERGONOMIC EVALULATION OF A MECHANICAL CONTRACTOR SHOP FOR COMPLIANCE WITH THE WASHINGTON STATE ERGONOMICS RULE

Peregin Spielholz, ***Ergonomist***
Safety and Health Assessment and Research for Prevention (SHARP) Program, Washington State Department of Labor & Industries.

Washington State has (had[1]) an ergonomics rule, and we have done 24 or 25 public demonstration projects in respect to the rule. I will talk about a project we did with a large mechanical contractor, McKinstry Co. McKinstry is a mechanical contracting shop that does sheet metal, pipefitting, and plumbing. A lot of this information is on the Internet, and all of these reports can be downloaded [SHARP 2001].

In the Washington State Ergonomics Rule, there is first a Caution Zone level. That is the level where most ergonomists consider there might be risk factors—such things as back bending or kneeling for 2 hours a day—things commonly seen in checklists. The company must provide ergonomics awareness training and look at jobs further to see if they have risk factors at the Hazard Zone level.

The Hazard Zone level usually represents twice as much exposure to a given risk factor as at Caution Zone level. At Hazard Zone level, the company must implement controls to mitigate the risk factors, as long as it is technologically and economically feasible.

We looked first for Caution Zone risk factors and then looked further to see what higher-level risk factors and solutions needed to be implemented.

Caution Zone Risk Factors in the Shop

- Hand Repetition > 2 hrs
  - Air Bending/Crimping
  - Assembly
  - Plumbing Fabrication
- Neck Bending > 2 hrs
  - Fab/Assembly Heavy Gauge
  - Welding

Figure 2-7.1. Caution zone risk factors in the shop

[1]Voters in the State of Washington passed an initiative on November 4, 2003 to repeal the Washington State Department of Labor and Industries ergonomics rule, effective December 4, 2003.

This is what we found in the Caution Zone: hand repetition in sheet metal assembly jobs, especially where workers were putting together smaller duct work and smaller fittings, which involved hand crimping and hammering. There was also significant neck bending, while they were working on welding and heavier gauge material (Figure 2-7.1).

At Hazard Zone level, we found things in the office controllable. The only things we found that would be classified under the Hazard Zone were very intensive data entry, where someone is normally keying all day in awkward postures.

In the sheet metal shop, the only area we found that could possibly be at the Hazard Zone level was hand repetition, when putting together some of the smaller parts. This was only on a limited basis (Figure 2-7.2).

Solutions for Hazard Zone Jobs

Office: Provide what most employers now provide as standard equipment: adjustable chairs and keyboard trays.

Assembly Shop: Only one time did I notice someone hammering together parts all day. Normally, a work-cell process would be used, in which a worker does each stage of the process. But, this day somebody was out sick, they had a big job and were behind, and someone was stuck doing this all day. The company implemented a policy that in these situations, they would enforce a rotation schedule. Figure 2-7.3 lists some of the solutions for Hazard Zone risk factors.

We ended up documenting best practices that the company had already implemented. One reason we did the study at McKinstry is that they are a progressive company and had already implemented many of the solutions. They have been very helpful in sharing their information with other contractors and with SMACNA.

Control Lifting Hazards: McKinstry Company has a policy that nobody can lift over 50 lb. To back that up, they provide a way for workers to do the work: cranes to lift pipe, hand trucks, holding jigs, cranes, and hand cranks they can use to get material up or down from tool shelves (Figure 2-7.4).

Welding Controls: Welding has many potential problems, and even with their

Hazard Zone Risk Factors

- Intensive Keying with awkward posture > 4 hrs
  – Payroll Entry
  – Invoice Entry
- Hand Repetition > 6 hrs
  – Assembly Area

Figure 2-7.2. Hazard zone risk factors

Solutions for Hazard Zone Risk Factors

- Office Jobs
  – Provide adjustable keyboard trays, chairs with armrests and document holders
    - Removes awkward posture without support and ability to vary posture
- Assembly Shop Job
  – Hand repetition > 6 hrs very infrequent
    - Administrative control implements a policy that no one assembles one small part intensively more than one day per week or more than 4 hours per day

Figure 2-7.3. Solutions for Hazard Zone risk factors

Control of Lifting Hazards

- 50 lb Lifting Limit Company Policy
- Use of Cranes, Carts, Lifts, Hand Trucks and Holding Jigs

Figure 2-7.4. Control of lifting hazards

controls, McKinstry has possible issues. They have set up the workshop so that heavy pieces are lifted by overhead cranes. They lift directly onto a holding jig, attached to a workbench. The jig rotates so they can attach the part to it, rotate the part around and weld it, and then re-attach it to the overhead crane and lift it into a parts bin. They never have to hold the part or maintain the weight of a part. This eliminates gripping and lifting problems. Figure 2-7.5 lists these welding controls.

Welding Controls

- Control of Heavy lifting and gripping > 10 lbs with awkward posture
- Use of overhead cranes to move parts
- Provision of rotating holding jigs and stands

Figure 2-7.5. Welding controls

Plumbing Controls

- Control of awkward postures, kneeling and squatting, heavy lifting
- Pre-assembly of sub-systems at bench height
- Assembly on rolling carts and use of crane

Figure 2-7.6. Plumbing controls

Plumbing Controls: Figure 2-7.6 refers to a pre-assembly of plumbing components for a bathroom and lists some plumbing controls. The entire assembly is being built on a workbench, instead of doing it on site. The workers build the assembly on a frame (with wheels) on the workbench, and then lift it by crane onto the floor. They will roll it into a cart, onto a truck, and will then lift it by crane into a building, and roll it directly into place. It allows people to do the work at bench height, with all of their tools right there, and in a more comfortable environment than on site.

Sheet Metal

- Control of awkward body postures, squatting, and kneeling
- Use of waist-level carts for working surface and material movement

Figure 2-7.7. Sheet metal controls

Sheet Metal Controls: All sheet metal is stored at waist height on carts. It is moved from cutting machines on the carts, by sliding. Normally, the material is never lifted. If it is lifted, it usually involves two people. Much of the work is also done on these carts. The only other thing we noted, which the company is now going to start doing, is to provide carts of different heights for different workers. They may also provide carts that can be adjusted. Figure 2-7.7 lists sheet metal controls.

Field Installation: We have done less work in the field. Figure 2-7.8 shows a picture of field installation. In the field, workers have been putting together duct pieces in 50 to 60 lb sections. It is usually done with two people and is always lifted into place with a hand crank lift. However, the availability of this device has not eliminated the need to sometimes lift and move these pieces manually.

McKinstry Ergonomics Process: As part of the project, McKinstry Company developed a written program and its own internal checklist. They also have detailed descriptions of every job in their union categories. This information is available on the Internet at *www.lni.wa.gov/wisha/ergo.*

Washington State has completed similar projects in many different trades, including drywall, masonry, carpentry, rebar, and concrete finishing. These Demonstration Project documents can be accessed on the Internet at *www.lni.wa.gov/wisha/ergo/demoproj.htm.*

Figure 2-7.8. Field installation

SESSION 3: CONTROLLING MSDS AND SOFT TISSUE INJURY RISK FACTORS

3-1 The Hierarchy of Controls for Ergonomic Solutions in Construction
Scott Schneider, Director of Health and Safety
Laborers Health and Safety Fund of North America (A Joint Labor-Management Fund)

3-2 Developing Ergonomic Interventions in Construction
Billy Gibbons, Ergonomist
Doyle & Gibbons, Salem, Oregon

3-3 Developing and Implementing Ergonomic Interventions
John Rosecrance, Assistant Professor
Department of Occupational and Environmental Health, University of Iowa, Iowa City, IA

[Please note: The following presentation summaries are transcriptions from the 2-day meeting. These transcriptions have been edited and reworded for clarity of meaning. The presentations, including questions and answers, are included in the proceeding as documentation of the meeting. The content, however, might not reflect current NIOSH policy or endorsement.]

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Session 3: Presentation 3-1
The Hierarchy of Controls for Ergonomic Solutions in Construction

Scott Schneider, ***Director of Health and Safety***
Laborers Health and Safety Fund of North America (A Joint Labor-Management Fund)

Many exciting things are going on in construction ergonomics, and we need to figure out ways to make them widely available.

These things are not necessarily new. Maybe what's new is how we now think about these controls systematically. We use these ideas in training. We ask, "What's an engineering control; what's an administrative control we could use for this job?" We walk people through it, and it expands their horizons. When before, they were thinking, "There is nothing you can do about it," or, "We will just give the guy some kneepads." If you go through the hierarchy of controls, you can get people thinking.

The types of controls we use are the following:

- Eliminating or substituting the process
- Ergonomically-designed tools
- Changes in work practices
- Administrative controls
- Personal protective equipment (PPE)
- Training
- Stretching*

This is the classification we have been using, and I'll talk about each of these.

The best solution is to eliminate exposure to the risk factors. However, that may mean eliminating jobs because you mechanize, and now you have only one person, where before you had five. Sometimes you can do a process change that makes the job easier by doing it differently.

We've heard some examples here today. Prefabrication is an example. Another example occurred on the Central Artery project in Boston, on which Mark Noll was working. The workers were drilling overhead to put in a dropped ceiling and had to drill hundreds of holes overhead. They decided that on the next tunnel, the hangers would be built into the pour. They saved thousands of hours of overhead drilling. Tony Barsotti was talking about the same thing at Intel, where they are making process changes.

To reduce or eliminate material handling, you can plan where materials are to be used, where they will be delivered, and how they are going to be stored. We saw this earlier today with pipe racks (e.g., storing pipe at waist height).

*The effectiveness of stretching exercises in preventing injuries from work has not been proven. For more information on this topic, see Hess et al., 2003.

Mechanization Using Carts, Dollies, or Cranes: These three trades (electrical, plumbing and pipefitting, and sheet metal) are usually working in a building that is finished, and you have flat surfaces on which to roll carts and dollies.

New Materials That Are Easier to Handle: You can use fiberglass, instead of wooden ladders.

Suggestions from audience: (1) Aluminum handles for pipe wrenches; (2) lightweight concrete blocks; (3) fiberglass conduit, rather than aluminum or galvanized; (4) anti-vibratory plastic hammers, instead of sledgehammers.

Power Tool Instead of a Hand Tool: As batteries get lighter, smaller, and stronger, it is easier to switch to power tools. Using scissor lifts for overhead work is becoming much more common. Workers can substitute powered or cordless screw guns, instead of hand-cranking (Figure 3-1.1). These tools are very inexpensive now. It does not change the skill of the job; it just makes it easier. Five or ten years ago, these tools were not being used. When they became less expensive, they became more widely used in the industry.

Ergonomically Designed Tools: Tools are now designed to require less force. They reduce awkward postures, and you can work from standing height (e.g., in roofing for putting decking together, or for rebar tying). Some tools reduce overhead reach, such as extenders for drilling. The tools reduce contact stress, so they are more comfortable for your hand. Sit-stand stools can be used for welding. If you are welding in one posture all day, there are static posture issues.

Handles: Handles can be added for carrying materials. Many handles are available for carrying drywall, particleboard, plywood, or sheet metal. Generally, they are not that expensive. Sometimes there is a premium for ergonomically designed tools, but they are not that much more expensive. If they are relatively inexpensive, and they are easy to use, they are going to become very popular. Figure 3-1.2 shows a pipe wrench with an ergonomically designed handle.

Figure 3-1.3 shows magnetic sheet lifters for moving sheet metal. The worker can attach the lifter and carry the sheet metal much more easily.

Figure 3-1.1 Substitute powered/cordless screw-guns

Figure 3-1.2 Ergonomically designed wrench

Work Practice Changes: Bring things up to waist height on worktables. Learn from experienced workers. They have figured out easier, smarter ways to do things, and they can transfer those skills and knowledge to younger workers.

Make Administrative Changes: Administrative changes include job rotation, rest breaks, and special instructions for handling heavy objects.

For example, I fly a lot and see these tags to put on bags, which tell airline personnel—This is a heavy bag. At least the tag warns somebody before they lift it. In some cases, the weight is written on it. Figure 3-1.4 shows an example of an airline baggage warning tag.

When we make sheet metal ductwork, it comes from the shop with a label that tells dimensions and gauge, and where it is supposed to go. Can we not also program that computer to spit out the weight and put that on the label, as well? I do not know if anybody's tried that. In Holland, they use a system with glasswork, where the pieces are labeled with the weight and a sticker, either green or red. If it is less than 20 kg (44 lb), it has a green sticker, meaning the worker can lift it by himself. If it is red, he needs to get help. Another administrative control is a weight limit. We have heard somewhere in the range of 35-50 lbs, depending upon the amount and awkwardness of the lifting being done. This is a useful intervention. A number of companies do this, and it is has had a big impact.

Personal Protective Equipment (PPE): There is a lot of kneeling involved in several of the trades. The new kneepads are much more comfortable and easier to use than older versions.

Kneepad pants have a pocket in the pants leg for the pads. They are not very expensive and work pretty well. Figure 3-1.5 shows a picture of Snickers kneepad pants. Shoulder pads are available for carrying materials on the shoulders. Shoulders are a nice way to carry things, because the

Figure 3-1.3 Magnetic sheet lifters

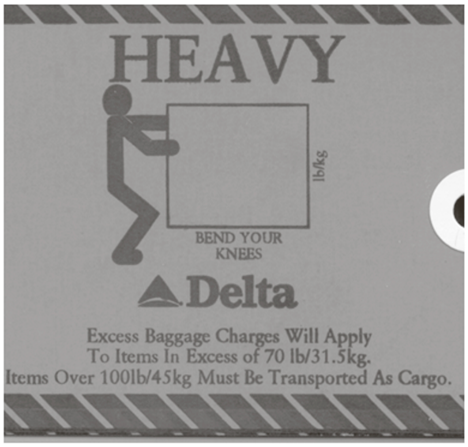

Figure 3-1.4 Airline baggage warning tag

object is closer to your center of gravity. Unfortunately, the worker does not have a lot of padding there, and can get contact stresses. The shoulder pad is a simple intervention (Figure 3-1.6).

Neck pillows attached to suspenders are used in Europe for people doing overhead work. They are similar to the pillows people use when flying, to lean against to sleep. Neck pillows are not used in the United States.

Standing on concrete for more than three hours a day is harmful for a worker's back. Some interventions are matting, which is used on the Intel job site, or shoe inserts (Figure 3-1.7). We do not recommend back belts, because there is no evidence to show they prevent injuries.

Training: We have developed programs for the laborers. I worked on a program several years ago for the building trades, which is available to all of the apprenticeship schools for all 14 trades. Training programs are generally awareness programs, to make people aware of what the risk factors are—the hazardous tasks. We encourage people to brainstorm about how to make the job easier, and what solutions already exist. They can do a lot of sharing.

We prioritize the solutions: We ask which would give us the most bang for the buck, which would be easiest to implement, which ones are simple to do with materials here on the site, and which ones are harder to get going?

How then do we evaluate these solutions to see if they are really helpful or not? That is the area where we are lacking. We need to see which solutions are best and then publicize that information. NIOSH wants to do with that with the control technology assistance for the construction industry project.

Figure 3-1.5 Snickers kneepad pants

Figure 3-1.6 Shoulderguard for carrying

Stretching exercises are becoming very popular.** They have been popular in the northwest for years. Ten years ago (1992), Brian Clark at Hoffman published a magazine article about people at a Hoffman site doing stretching exercises. I called Brian, and that is how we got started on this Intel project. Hoffman has been doing stretching exercises for a long time, and the workers there like it.

On one project, Hoffman estimated that the cost of having the whole crew stretch for 10 minutes a day would be $2 million over the life of the project, but the owner believed it would have a big payback. Steve Hecker has done work on the impact of stretching programs [2001]. I think stretching is probably helpful, but it is no 'silver bullet,' and not the same as making ergonomic changes—but I think it helps. Figure 3-1.8 shows a work crew performing stretching exercises.

Questions from Presentation 3-1

Question for Scott Schneider: You said back belts were not helpful. I think you're referring to the NIOSH study showing there's no evidence. I think there's continued work in that area, so I don't think the final chapter is written. You talked about kneepads, shoulder pads, neck pillows, and shoe inserts. Can you cite published literature that shows that those do have benefit, or are you just using some sense and your experience?

Answer: There's published literature that shows that matting—not necessarily shoe inserts—will reduce your risk of back problems. For the other ones, what we do know is that they reduce contact stress, whereas back belts don't do that. Back problems are not a contact stress injury.

I've thought about what evidence you would need to show that a kneepad will

Figure 3-1.7 Shoe inserts

Figure 3-1.8 Work crew performing stretching exercises

**The effectiveness of stretching exercises in preventing injuries from work has not been proven. For more information on this topic, see Hess et al., 2003.

reduce your risk of knee injury. NIOSH was looking at this problem, but the man who was looking at it, Dr. Tanaka, retired. In terms of shoulder problems, I don't think we need a $50,000 study to show that shoulder pads are helpful. They reduce contact stresses, and it is not an expensive intervention. I guess you could argue that if it gives people a false sense of security, they'll carry more, but I feel comfortable recommending shoulder pads even though there aren't randomized, controlled studies to back up the effectiveness of their use.

Question for Scott Schneider: I wanted to pursue the point about training and see if you were aware of any follow-up studies that show any real benefit. There's a long history of training programs in the building trades that tell people to bend their knees and keep their backs straight, and nobody pays attention and they go back to working the way they have to, or are used to doing. Are there any actual outcome studies showing any effectiveness of training?

Answer: There's been a lot of research on the effectiveness of occupational health and safety training, though not specifically on ergonomics. There is a very good review of the literature published by NIOSH [Cohan and Colligan 1999] about four years ago. Alex Cohen and Mike Colligan looked at all the studies on the effectiveness of safety and health training, and they did include ergonomics, though it wasn't in the building trades. I think the training programs in the building trades act more as an awareness mechanism, because the workers by and large do not have a lot of control over their own jobs. They do have some control, but we are really focusing more now on supervisor and foreman training, in terms of actually making changes.

Rod Wolford and Marilyn Larson did a study looking at the effectiveness of training on health and safety for the painters union in Alaska, Washington, and Oregon [Wolford et al. 1997]. They did find a positive impact, but the NIOSH report is comprehensive.

SESSION 3: PRESENTATION 3-2
DEVELOPING ERGONOMIC INTERVENTIONS IN CONSTRUCTION

Billy Gibbons, ***Ergonomist***
Doyle & Gibbons, Salem, Oregon

I'll start with a "pet peeve." One of the reasons we have such a hard time getting people on the ergonomics "bandwagon" is that just the word, "ergonomics" (if they even know what it means or have had some history with it) leaves a "bad taste in their mouths." We have to own some of that responsibility. When we call things ergonomic disorders, ergonomic injuries, ergonomic risk factors—there are no such things. If you subscribe to the camp that I subscribe to, "ergonomics" is the solution. It is *not* the problem. We should talk about ergonomic principles, ergonomic interventions, ergonomic applications, and ergonomic design; then, we can "turn the tide."

Ergonomics looks at all of the factors in the workplace. People want to know engineering solutions. Ira asked about the effectiveness of training. These things do not stand alone. Training, engineering—all of these things that ergonomics looks at have to stand together. Training is just helping to establish a baseline on which you can get people speaking the same language, so that you can then do the real work of intervention. With just training itself, you may not get anything. Engineering—I know a company that spent $25,000 on an intervention that nobody would touch, because of the process they used to develop it. So, ergonomics looks at all of these factors in the workplace-layout of the work, housekeeping, tools and equipment, specific work methods, and pace of the work. We also can't ever under-estimate the importance of the design of the structure the worker is putting together. We are barely scratching the surface of the role of architects, engineers, and designers in constructibility.

Figure 3-2.1 shows an electrician's tool bucket on wheels. At the Hanford Hotel, where we are staying, there is a general contractor who is just finishing construction there. He had a tool bucket. It was really a cart, a big plastic storage container.

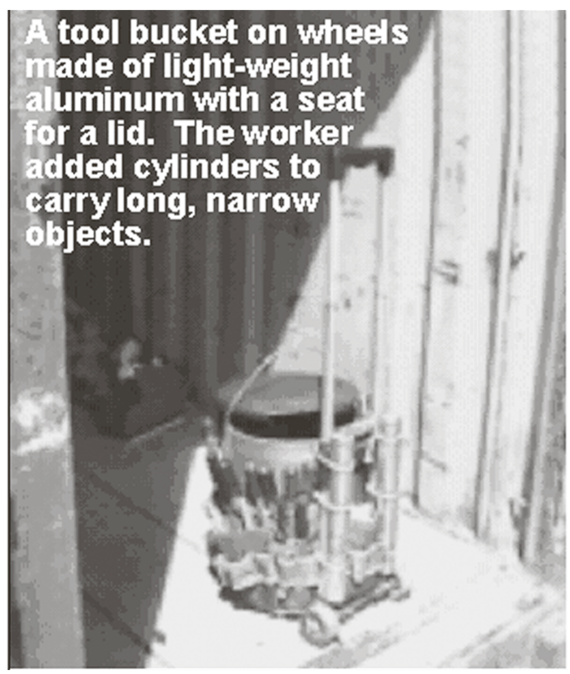

Figure 3-2.1 Tool bucket on wheels

The toolbox lifted off at the top, which was the lid, and it was on wheels on the back. If you pulled out this handle and lifted up, the entire tool chest moved on wheels. The general contractor purchased it at Home Depot, which is also where this one was purchased. If you are doing outlets or something below waist height, you can sit on it. This particular electrician attached these cylinders to hold things that are long and narrow.

Concepts I'd like to discuss:

1. ***Involve People in the Work.***

2. ***Develop in Real Time:*** That means you cannot go off-line for three or four days and go do some interesting research. You have to respond and maintain the interest of the people who are going to give you the solutions, which are the craft people and the people in the field. Get back to them, keep them notified of the progress you are making, ask them, run suggestions by them, operate in very real time. Your interventions, if you are operating on a project—just right here, right now, walking through and looking at risk factors and trying to solve problems—you have got to operate like this (snaps fingers).

3. ***Think Outside the Box:*** You must think outside of your trade, your industry, and your region. Share and disseminate information.

In the upper right-hand corner there is a screw gun extension for carpenters' to use if they are doing form work (*slide not available*). A carpenter developed this tool. The electrical application would be a drill overhead. I see these more and more, where you can set them up like a reverse drill press on a scissor lift or a platform that drills up, so you do not have to hold it up here.

4. ***Look Upstream Before Looking Downstream:*** It "cracks me up" that we are so focused on the behavior of workers. What would be more difficult—developing a jig (or fixture) or changing somebody's behavior? When was the last time you altered somebody's behavior? That is a complex undertaking. But being creative and innovative, getting people to put their ideas together and come up with a solution, that is easy stuff. We need to shift away from "what they are doing right here, right now," to upstream planning and development.

Figure 3-2.2 is a picture of modularizing sheet rock, an upstream idea. These people went to 2 x 8's; usually it is 4 x 12's.

Figure 3-2.2. Modularizing sheet rock

They modularized it and eliminated all the material handling, except for what goes on in the shop where they put the modules together. Now, they just hang them with cranes, and it is all brought in on a flatbed.

5. ***Look into Resources—Vendor Resources:*** Supply houses may have things on the market that you have not seen. "Cruise" through hardware stores, home improvement stores, and material handling companies. Tony and I called a material handling company about a particular problem. They prototyped us something, and then came out and helped us solve our problem.

Go outside the work environment entirely. We have gotten some "cool" grips in bicycle shops. For painting 14 feet overhead, you might come up with a flag holder.

I would like to leave you with a challenge. We are at various stages of dealing with this issue. In some states we are in a compliance mode, or are reacting to injuries and trying to figure out what to do next. Some of us are in a prevention mode. However, we are not going to get any dramatic solutions until we move away from prevention to a mindset of innovation—creating environments where people work to create and innovate. For example, someone was trying to figure out how to build a building 25% faster. You will not get improvements in productivity or quality by asking a construction worker to hammer 25% faster or to cut sheet metal 25% faster. Innovation and, likewise, innovation in ergonomics will come upstream: how we look at our work, plan our work, and design our work in different ways. We must have cultures that innovate.

You have to be careful about what your people create. They are installing these panels overhead (*picture not available*), so they put very lightweight poles in the corner of each scissor lift that are spring loaded. They have a cushion that goes across this 2 x 4, so as not to dent the sheet metal. There are really two things: there is this part that raises the panel up and holds it against the ceiling so that you eliminate overhead lifting, and there is this bit extension, which was welded onto the end of the extension here, so that it can be held here and eliminate this. Now you can purchase these things, but at the time this was done, you couldn't find this bit extension. The workers had to put a sleeve over the top of it to keep it from spinning in their hands.

Here are some great material-handling devices (*picture not available*). The workers are using this Genie lift to hold ductwork in place, so they will not only install it with the lift, but work on it when it is on the lift. They do not have to work on the ground. It is a work platform. Here is a modification to keep it from rolling.

This is a fitter intervention (*picture not available*). The worker is holding a pipe reamer; he had to ream several thousand pieces of this polyvinylchloride (PVC) pipe. We had deviation, so this is what they whipped up: a drill bit. This is a whole classification of ergonomics interventions —anything you can attach to a drill. The workers had a coupler that bolted onto the drill, which fit the size of the PVC pipe. They took the pipe reamer and a pipe stand and bolted it down here. Did it reduce the number of times they had to do this? No, but it certainly made their work much easier. They were incredibly proud of this intervention.

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SESSION 3: PRESENTATION 3-3
DEVELOPING AND IMPLEMENTING ERGONOMIC INTERVENTIONS

John Rosecrance, *Assistant Professor*
Department of Occupational and Environmental Health, University of Iowa
Iowa City, IA

As distinct from Scott Schneider's hierarchy of interventions [1995], we can also look at interventions in terms of who implements them.

In a meeting six or seven years ago, Scott Schneider, Billy Gibbons, Steve Hecker, and others in this room came up with these five levels of intervention implementation:

1. Workers can develop ergonomic interventions and implement them. This is a very important intervention level. As Billy Gibbons demonstrated, there are many homemade ergonomic interventions out there—very wise and clever methods of making work easier and, in many cases, more efficient.

2. Local Unions develop ergonomic interventions through training and education. This is a great "road" for facilitating awareness of health and safety issues and ergonomic intervention.

3. Contractors, subcontractors, or employers have responsibility. Streimer Sheet Metal in Portland, Oregon, is a great example of a contractor that has been actively implementing ergonomic interventions for years.

4. Owners share responsibility. For example, Intel Corporation has established a health and safety culture, and they demand this from their subcontractors.

5. Manufacturers of equipment and tools also have a role in designing ergonomic products and can facilitate the implementation process.

What about the effectiveness of these interventions? Many interventions are an obvious benefit, and we do not have to study or spend $50,000 to determine if they are effective. However, there is also a need to determine effectiveness. For example, what is an ergonomic chair, an ergonomic keyboard, or an ergonomic wrist rest? How do they get that name? From marketing? You cannot buy a chair anymore that is not an ergonomically designed chair. You perhaps can't buy a hand tool or a car that is not ergonomically designed. We are working with tool manufacturers now to determine the ergonomic effectiveness of tools that are ergonomically designed. We are currently conducting research studies in our labs and in the field to evaluate new designs in hand tools.

Bricklaying is one of the oldest trades on earth. We are investigating the effectiveness of lightweight block vs. heavyweight block on the muscle activity in the low back and arms. It seems like common sense that if it has the same structural qualities, a lightweight block will be easier to lay than a heavyweight block, especially for masons, but certainly for the laborers who keep these people stocked up with these blocks. But perhaps it is not better ergonomically. Perhaps if a masonry block is lighter in weight, the worker will have to move more blocks, so repetition goes up.

As you can see in Figure 3-3.1, we attach electrodes to the body to measure the muscle activity in the back and forearms. We are looking at other trades and working with tool manufacturers.

We just completed data collection on different designs of tin snips. Rather than say that these are ergonomically designed, we are looking at changes in grip force, and how the tool is used, and whether there are more or fewer deviations of the wrist, and whether or not it is more comfortable. We are working with Midwest Tool to determine the effectiveness of ergonomically designed hand tools for the construction trades.

Figure 3-3.1. Measuring muscle activity

We are investigating the muscle activity of the finger flexors, finger extensors, and shoulders during tin snips use. We recruit workers to cut sheet metal with different types of tin snips, both at waist level and at shoulder level. We take measurements of muscle activity when a worker is using the old and the new tool, and then again using the old tool and the new. This type of research allows us to quantify the effectiveness of the ergonomic intervention.

It is important that we do not blindly accept the manufacturers' claims that these tools are ergonomically designed. We should continue to do evaluation studies. The NIOSH has a book called Guide to Evaluating the Effectiveness of Strategies for Preventing Work Injuries—How to Show Whether a Safety Intervention Really Works [2001]. It is important that this type of research is conducted.

Questions from Presentation 3-3

Question for John Rosecrance: Are there any results of your studies?

Answer: I have the results on the tin snips—the ones we were looking at most critically. They are bent at 90 degrees and there's less muscle force used. We thought the workers would use them upright. They chose to use them upside down, even at shoulder height. What we found is that there's less EMG [electromyogram] or muscle force in the low position, but more in the upper position. But, they prefer those in terms of how they rated them to others, although more force in the finger flexors was required.

Question for John Rosecrance: Are the results of the block study available?

Answer: We just finished data collection two weeks ago, so they're not ready yet.

Comment (Peter Vi): A comment about the lightweight blocks: I've asked a lot of architects whether they would prefer to use a lightweight block, and they say that it takes too much paint, so the cost would go up. The material is too porous, so the texture is not as nice as the heavier blocks. The cost is very high, so the owner doesn't want to use them. Those blocks aren't used too much, and there is a lot of negativity about them.

Comment (John Rosecrance): That may be different in different parts of the country. In Michigan, architects prefer light-weight blocks, and they find them cheaper, although they are more porous. They typically use a standard block for the foundation and the lightweight blocks when they build up, because they don't have the problems with water. But, they are finding they can lay the lightweight blocks much faster, so they're building into their bids those offsets in price. They think it washes out—there is no cost savings either way—but they think it may be easier on the laborers who have to handle the blocks.

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SESSION 4:
BREAKOUT SESSIONS
TRADE OF CONDUCT SESSIONS

[Please note: The following presentation summaries are transcriptions from the 2-day meeting. These transcriptions have been edited and reworded for clarity of meaning. The presentations, including questions and answers, are included in the proceedings as documentation of the meeting. The content, however, might not reflect current NIOSH policy or endorsement.]

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SESSION 4: INTRODUCTION TO BREAKOUT SESSIONS 4-0

Breakout sessions were organized for each of the three construction trades and specialties invited to the meeting. Contractors and tradespeople were assigned to their respective trade or specialty. Other stakeholders were assigned to a session according to their knowledge or interest in one of the trades.

During this time, participants addressed the 5 issues described below:

1. Review the activities (jobs) and basic tasks fundamental to each trade and specialty as described by Everett [1997].
2. Review the hazard or risk rank assigned to an activity.
3. Describe the context in which a hazard exists for each task.
4. Describe the currently available interventions and those that have previously been used to reduce risks of developing a soft tissue injury.
5. Identify potentially valuable interventions that need to be evaluated, and high hazard tasks for which no intervention currently exists.

Review the Activities and Basic Tasks That Are Fundamental to Each Trade and Specialty

A NIOSH contract report [Everett 1997] identified 65 construction activities performed by 15 construction trades in southwestern Michigan. Activities were defined as "all the field work which results in a recognizable, completed unit of work with spatial limits and/or dimensions." Examples include *build the 8-inch concrete block south foundation wall*, or *erect structural steel at the 3rd floor.* Construction union representatives surveyed by Everett estimated that each of the activities they described represented 10% or more of the man-hours logged by their members.

The report further identified the basic tasks involved in each activity. Basic tasks were defined as the "fundamental building blocks of construction field work, each representing one in a series of steps that comprise an activity." The following 12 basic tasks were identified: connect, cover, cut, dig, finish, inspect, measure, place, plan, position, spray, and spread. The basic tasks were further elaborated upon for each activity.

Stakeholders participating in the breakout session were invited to modify the activity and basic task list, if a majority of people in the session supported the action.

Review the Hazard or Risk Rank Assigned to an Activity

Everett observed and evaluated the basic tasks for 65 activities performed by 15 construction trades in southeastern Michigan. For each task, Everett rated the intensity of the job-related physical risk factor as: (1) not present or insignificant, (2) moderate, or (3) high. The seven physical risk factors were: repetitive motions, static positions, forceful exertions, localized contact stresses, awkward postures, low temperature, and vibration.

In an effort to streamline the breakout session discussions, the average score of all the risk factors assigned by Everett for a basic task was used as a measure of the risk for the development of a WMSD for that task. Tasks that scored in the upper third were ranked as high risk, the middle third as moderate risk, and the lower third as no risk or low risk. This risk assignment technique was used to facilitate discussion within the breakout sessions, rather than as an absolute measure of comparative risk among the *tasks* within a trade, or between the trades.

Participants were asked to determine whether they believed the average WMSD risk rankings assigned to a basic task were reasonable. If a majority of the group objected to a risk designation, they could downgrade or upgrade the ranking.

Describe the Context in Which a Hazard Exists for Each Basic Task

Participants were asked to consider the basic task and address the following questions: (1) What areas of the body are at risk for WMSDs? (2) What are the risk factors? (3) What is the source of each risk factor? (4) What variable task conditions can affect the presence or intensity of the risk factor? (Examples of task conditions are described below.)

Examples of Task Conditions

Tools or Equipment

Proper tool or equipment not provided; tool or equipment use presents risk factors; no lifting equipment present, malfunction

Site Conditions

Debris on the ground; mud; uneven surfaces; no overhead access; poor lighting; visual obstructions; housekeeping; material storage; noise

Weather or Temperature

Hot; cold; humidity; rain

Planning and Communication

Proper equipment or material not available on time; other trades or equipment in the way; tasks performed out of order; no available electric power (for tools); change in plans

Work Organization

Overtime; lack of ability to perform job in any order; shortage of time; size of company; lack of control over job site

(Note: This information was displayed as a poster in each breakout session.)

Risk factors assigned by participants to a given task were generally compatible with those described in the literature (i.e., forceful exertion for lifting and carrying materials, awkward and static posture for working overhead, repetition for using a manual tool, contact stress for kneeling on the concrete, and vibration for using a rotary drill). Often, however, not all areas of the body or all of the risk factors potentially related to a task were described. NIOSH researchers believed that this part of the breakout session was essential for beginning the discussion, but risk factor identification was not the focus of the meeting. This discussion was limited by design, to allow more time for the next effort—identifying current and future methods to reduce or eliminate WMSD risk factors.

Describe Currently Available and Utilized Interventions to Reduce Risks of Developing a Soft Tissue Injury

Many of the participants attending the meeting have used new technology and work organization techniques to prevent WMSDs. Commercially available tools and equipment have been used to reduce workers' exposures to WMSD risk factors during the most physically demanding tasks, such as manual material handling (MMH) and overhead lifting, lifting and positioning mechanical and electrical systems, and pulling electrical cable and wire. Cordless screwdrivers and screw guns have replaced manual screwdrivers for many applications, especially in the electrical sector. The continually changing construction work site presents special problems for unloading, storing, and staging materials, but participants recognized the potential benefits of overcoming these obstacles for reducing WMSD risk. In all sessions, improved site planning and contractor-to-contractor communications were frequently discussed as an important condition that could affect risk.

Identify Potentially Useful Interventions That Need to Be Developed

Participants in each of the breakout sessions also identified tasks involving exposures to WMSD risk factors for which an intervention was not currently available or a more effective intervention was desirable. Participants in the Pipe Trades Session prioritized tasks from the highest to lowest in need of intervention development. Interventions not currently available, which participants believed would be beneficial, included tool stands for overhead work and improved design of power and manual hand tools.

Results

The following three sections summarize the conclusions of the electrical, pipe, and sheet metal breakout sessions. Each section covers: (1) the activities and tasks for the trade, along with information regarding which tasks were added or modified by participants; (2) the average risk level for each task, derived from Everett [1997] and accepted or modified by participants; and, (3) a section for each task describing the risk factors, possible interventions, and comments from the participants.

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Billy Gibbons (Doyle & Gibbons, Inc.) and Leslie MacDonald (NIOSH)

Everett [1997] described 3 electrical construction activities that consume 10% or more of the total work for the trade in southwestern Michigan. These activities were install conduit, install wiring, and install lighting systems and fixtures. Breakout session participants added 3 more activities—install residential wiring, install underground service, and install switchgears.

Table E-1 identifies the basic tasks associated with these activities. Participants also noted that wire and cable are not only housed in conduit piping, but also in other types of channels and, therefore, suggested that *attach conduit to wall or ceiling* be changed to *attach raceway to wall or ceiling*. Time constraints prevented a full discussion of the additions to the list.

After discussion, a majority of electrical breakout session participants suggested modifying the risk scores assigned to several tasks (Table E-2).

Tasks

Attach Raceway to Wall or Ceiling

Raceways are open or enclosed systems used to hold electrical wires or cables, and include traditional conduit and trays. They are attached to ceilings and walls with fasteners, such as anchors, screws, and all-thread rod. Most potential WMSD risk factors identified by meeting participants for this task were related to operating power tools, such as the rotary hammer, powder-actuated tools, and manual tools that tighten fittings. The body regions identified at greatest risk were the upper extremities, due to force (physical exertion and tool rotation and impact), vibration, and repetition. Conditions or circumstances reported to increase the WMSD risks were overhead work, floor level work, work from ladders, and work with large or heavy materials.

Currently available interventions reported to have been used by some contractors and tradespeople to address WMSD risk factors for *attach raceway to wall or ceiling* are shown in Table E-3. In addition to interventions described in the table, participants believed a stand should be developed and evaluated, which could support the weight of power tools used overhead in the installation of raceways (among other tasks).

Lift and Carry Materials and Equipment

Materials and tools used for electrical construction must be unloaded, stored until needed, and transported to the location where they will be used. Many factors determine whether the material handling will be done manually or mechanically.

Potential WMSD risk factors reported by meeting participants for this task were related to lifting, carrying, and pushing-pulling materials, equipment, and tools around the construction site. The body

Table E-1. Electrical trades activities and tasks [1]

Activities [2]	Tasks [3]
Install conduit	Formulate work sequence Carry materials to work location Measure and layout Bend, align, position conduit Attach conduit to wall/ceiling Connect conduit to junction box Inspect work
Install wiring	Formulate work sequence Carry materials to work location Pull wires Strip end of wire Bend wire to proper location Connect wires Inspect work
Install lighting system and/or fixtures	Formulate work sequence Carry materials to work location Position fixture Connect fixture to wall/ceiling Inspect work
Install residential wiring [4]	Connect wires [4] Strip end of wire [4] Bend wire to proper location [4]
Install underground service [4]	
Install switch gears [4]	

[1] Unless otherwise described, activities and basic tasks are taken from Everett [1997]
[2] Activities are specified units of work that are completed on a construction site
[3] Tasks are the "fundamental building blocks of construction field work, each representing one in a series of steps which comprise an activity "
[4] Not included in Everett and added by stakeholders participating in the breakout session

Table E-2 Average work-related musculoskeletal disorder risk for electrical trade tasks [1]

Average Risk [1]	Tasks
High	Pull cable/wires
	Attach conduit to wall or ceiling
	Position fixture
	Bend, align, position conduit [2]
	Connect wires [2]
	Carry materials to work location [2]
Moderate	Strip end of wire
	Connect fixture to ceiling or wall [3]
None-Low	Connect conduit to junction box
	Bend wire to proper location
	Inspect work
	Measure and layout

[1] Seven separately scored risk factors for each task described by Everett [1997] were averaged, and each one-third was assigned a High, Moderate, or Low rating
[2] Upgraded to High risk from Moderate risk category by breakout session participants
[3] Downgraded to Moderate risk from High risk category by breakout session participants

regions reported to be at greatest risk for WMSD were the back and shoulders, due to force (weight of objects), awkward postures (bending and twisting), and contact stress (materials pressing against the body). Conditions or circumstances reported to increase or decrease the actual WMSD risks include the following: the condition of the floors, walkways, and ground surfaces (e.g., mud, rebar mat, uneven surfaces); the location and means of storing materials (e.g., on the ground, racks, or pallets); the availability and maintenance of material handling equipment; and the degree of site planning and communication among contractors (e.g., repeated handling of materials or materials and equipment obstructing the work of other trades on the site).

Currently available interventions reported to have been used by some contractors and tradespeople to address WMSD risk factors for *attach raceway to wall or ceiling* are shown in Table E-3. In addition to interventions described in the table, participants believed a stand should be developed and evaluated, which could support the weight of power tools used overhead in the installation of raceways (among other tasks).

Lift and Carry Materials and Equipment

Materials and tools used for electrical construction must be unloaded, stored until needed, and transported to the location where they will be used. Many factors determine whether the material handling will be done manually or mechanically.

Potential WMSD risk factors reported by meeting participants for this task were related to lifting, carrying, and pushing-pulling materials, equipment, and tools around the construction site. The body regions reported to be at greatest risk for WMSD were the back and shoulders, due to force (weight of objects), awkward postures (bending and twisting), and contact stress (materials pressing against the body). Conditions or circumstances reported to increase or decrease the actual WMSD risks include the following: the condition of the floors, walkways, and ground surfaces (e.g., mud, rebar mat, uneven surfaces); the location and means of storing materials (e.g., on the ground, racks, or pallets); the availability and maintenance of material handling equipment; and the degree of site planning and communication among contractors (e.g., repeated handling of materials or materials and equipment obstructing the work of other trades on the site).

Currently available interventions reported to have been used by some contractors and tradespeople to address WMSD risk factors for *lift and carry materials and equipment* are shown in Table E-4.

Cut, Bend, Align, Position Conduit

Conduit must be cut, bent, aligned and positioned at the ceiling or wall before it can be fastened. Hand tools are used to cut and bend smaller diameter conduit, and power tools are typically used to cut and bend larger conduit.

Potential WMSD risk factors reported by meeting participants for “cut, bend, align, and position conduit” were related to using tools to cut and bend the conduit, including an electric or cordless reciprocating

Table E-3 Attach raceway to ceiling or wall (currently available interventions)

Problem	Intervention	Comment
Drill bit lock or bind	Use clutch power drill	Such as rotary-hammers that are manufactured with clutch; Consider lighter tool
	Sharp bits	
Work overhead	Powered lift or scaffold for raised work	
	Appropriate tool (i.e., in-line vs. pistol grip)	
	Fixture to hold large conduit in place during installation (Not a jig.)	
	Bracket (i.e., "L") attached to the outside of the lift to hold raceway	Attachment needed that does not compromise lift integrity (i.e., counterbalance to maintain stability)
	Neck pillow	
Tool vibration	Anti-vibration gloves[1]	
Manual tool use	Cordless power tools	
General	Training	Proper tool use, body mechanics, etc.

[1] Only gloves that have passed the ISO 10819 test procedures should be considered anti-vibration gloves In addition, anti-vibration gloves should be matched to the dynamic properties of the vibrating tool and should not increase or introduce new risk factors for WMSDs, such as requiring higher grip forces [Mansfield 2005]

Table E-4. Lift or carry materials and equipment (currently available interventions)

Problems	Intervention	Comment
Lifting materials	Materials packaged with handles	Such as 2 x 4 lay-in fixtures
	Weight restriction for lifting	
	Palletize materials	Easier to move with a pallet jack
	Training	Body mechanics, back training, commitment to regular (i.e., annual) training, etc.[1]
Push and pull rolling stock (i.e., gang box, pipe)	Access for material handling equipment	
	Steps, ramps, plates on job site	
	Prior planning of materials to be moved	Pre-walk route to check for problems
	Training	
Carry materials and equipment	Versatile MMH equipment	Provide or rent reach forks—fork extensions, air cushion for heavy objects (i.e., transformer); smaller lift truck (i.e., sky track) for inside building, etc.
	Materials packaged with handles	Such as 2 x 4 lay-in fixtures
	Carrying assists provided	Such as shoulder pad, sling with handles, cargo net for light boxes
Mechanical devices will not reach work area	Access for material handling equipment	
	Prior planning of materials to be moved	Pre-walk route to check for problems

(continued)

[1]The effectiveness of stretching exercises in preventing injuries from work has been proven. For more information on this topic, see Hess et al., 2003.

Table E-4 *(continued).* **Lift or carry materials and equipment (currently available interventions)**

Problems	Intervention	Comment
Inadequate planning and coordination	(1) Identification of responsibility for material set-up and access maintenance; (2) Availability of MMH equipment when needed; (3) Coordination with general contractor (GC) and trades; (4) Schedule and coordinate use of fork trucks, cranes, etc. with trades and GC	
Poor maintenance of material handling equipment		
Materials stored too low (e.g., on the floor and other standing surfaces)	Keep materials off the floors (e.g., use pipe racks, pallets, etc.)	Can also improve site housekeeping
	Material caddies on scissor lifts	Avoids bending to floor of lift (often made on job, but commercially available)
Materials are stored too high	Versatile MMH equipment	Provide or rent reach fork—extensions, air cushion for heavy objects (i.e., large transformer); smaller lift truck (i.e., sky track) for inside building
	Attachments to lifts to raise materials	Need for manufacturers to develop, rather than made on job
Inexperience, i.e., crew always changing	Participatory ergonomics program	Involve crew in MMH issues
	Training	Body mechanics, back training, commitment to regular (i.e., annual) training, etc.[1]
Job assignment	Weight restriction for lifting	
Poor work surfaces on site	Steps, ramps, plates on job site	

[1]The effectiveness of stretching exercises in preventing injuries from work has been proven. For more information on this topic, see Hess et al., 2003.

saw (a.k.a., saw-zall) or hacksaw and a manual bender. The participants identified the body regions at greatest risk of injury as: (1) the upper extremities (e.g., hands, wrists, elbows, shoulders) due to vibration (power cutting) and contact stress (manual bending) and (2) feet due to forceful exertions and awkward postures (cutting and bending). Conditions or circumstances reported by participants to increase or decrease the actual WMSD risks included the working height, tool design, site planning, and communication among contractors.

Currently available interventions reported to have been used by some contractors and tradespeople to address WMSD risk factors for *cut, bend, align, and position conduit* are shown in Table E-5.

In addition to the currently available interventions, participants discussed the desirability of developing a battery–powered portable conduit bender for smaller diameter conduit.

Position Fixture

Commercial and industrial construction often involves installing heavy and awkward lighting fixtures on the ceiling.

Potential WMSD risk factors for *position fixture* were reported by meeting participants to be associated with holding the fixture above the shoulders. The body regions identified at greatest risk of fatigue and injury were the shoulders, arms, and neck, due to forceful exertions and sustained non-neutral postures. Conditions or circumstances reported to increase or decrease the actual WMSD risks include: working on a ladder (e.g., climbing ladder, carrying fixture, and bracing knees against ladder rungs) and housekeeping (e.g., poor placement of ladder, scaffold, or lift device can result in extended reaches, etc.).

Currently available interventions reported to have been used by some contractors and tradespeople to address WMSD risk factors for *position fixture* are shown in Table E-6.

Pull Conductors (Cable and Wire)

Many different types and sizes of electrical conductors are used in construction, depending on the required service, according to meeting participants. The types of conductors and raceways used and the placement location determine the actual risk factors and the types of interventions available.

Potential WMSD risk factors associated with pulling conductors (e.g., by hand, pliers, or rope) and lifting (e.g., cable, spools) were reported to include: forceful exertions, non-neutral postures, repetition, and contact stress. The affected body areas identified to be at risk include: the back, upper extremities (e.g., shoulders, elbows, hands, and wrists), and lower extremities. Circumstances or conditions reported to affect the actual WMSD risk include: the type and diameter of the conductor, site conditions (e.g. housekeeping, open or cramped spaces), number of bends in a pull, and the type of work platform (e.g., ladder vs. lift).

Currently available interventions reported to have been used by some contractors and tradespeople to address WMSD risk factors for *pull conductors* (cable and wire) are shown in Table E-7.

Table E-5. Cut, bend, align, and position conduit (currently available interventions)

Problem	Intervention	Comment
Bend large diameter conduit	Electric or hydraulic bender	
Make offset bend for smaller diameter conduit	Evans' bender	Portable and allows for waist high work (must overcome craft pride and macho disincentives to use)
	Box offset bending machine (i.e., bend conduit to enter an electrical box or pass above/below object)	Stamps out a perfect box offset
Repeated bending at job site	Job rotation	
	Prefabrication. Bend conduit in shop, using mechanical device	Such as telephone stud-up of walls
	Factory bends where appropriate (i.e., longer, straighter runs)	May result in more cutting
Improper tool use	Training	Teach manual bending especially (will also decrease re-work)
Inexperience	Mentoring inexperienced workers	Pair apprentice with journey-status electrician
Contact stresses (knees and elbows)	Knee and elbow pads and camping mats.	
Lifting conduit from floor	Storing conduit on pipe stands	Decreases need to bend
	Job planning	
Working at floor level	Portable work tables with jig to hold bender	Work at waist height to decrease bending
	Job planning	
Poor body mechanics	Training	

Table E-6. Position fixture (currently available interventions)

Problem	Intervention	Comment
Manually hold and position fixtures	Mechanical devices to position fixtures (i.e., drywall, duct, or fixture jacks) Two-worker teams	Place plank between jacks for continuous rows (not of T-bar or drop-in) Possible on scissor lifts, and can increase productivity
Ladder instability	Rolling scaffold or lift (e.g., scissor, vertical), instead of ladder	Follow safety rules (e.g., wheel locks, weights, etc.)
Ladder use	Training	Position correctly, and do not walk ladder
Poor housekeeping	Floor kept clear by general contractor Improved job site communication	
Fixture features (i.e., weight, dimensions, etc.)	Better designs for fixtures	Fixtures not chosen by contractor Six major manufacturers Small drop-in is easy to handle Pre-assembled are heavy Parabolic easier to hold than prismatic Thin-line and electronic ballast are lighter
Bending to pick-up fixtures stored closer to floor	Fixtures shipped job-packed or elevator packed	Fixtures stand on end with minimal packing

Table E-7. Pull conductors for cable and wire (currently available interventions)

Problem	Intervention	Comment
Manual pulling	Cable and wire pulls: commercially available cable and wire feeding and pulling equipment	Building owner could promote/require use of equipment and insure building design compatible with equipment
	Wire pulls: special hand tools, such as friction pliers and fish tape puller	May need to be evaluated for effectiveness
	Oversized conduit/raceway to facilitate wire pulling	Material costs may increase
	Cable pull: gravity-fed cable (i.e., raise on platform)	
Working on ladder	Person-lifts	
Frequency and type of bends in pull	Reduce number of bends in pull	
	Teflon™ coated wire to reduce friction	
	Shivs and pulleys for larger cable	
Work gloves	Correctly sized and type glove for job	
Lifting	Mechanical lifting devices	
	Proper body mechanics and flex and stretch programs[1]	
Force, posture, and repetition	Job rotation	
General	Ergonomic awareness training and participatory ergonomics programs	
	Group employee incentives and reward program for safe practices	

[1] The effectiveness of stretching exercises in preventing injuries from work has not been proven
For more information on this topic, see Hess et al., 2003

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BREAKOUT SESSION 4–2
PIPE TRADES AND SPECIALTY

Tony Barsotti (Hoffman Construction) and Jim Albers (NIOSH)

Everett [1997] described three plumbing and piping construction activities that consume 10% or more of the total work for the trade in southwestern Michigan. These activities were: *install pipe hangers*, *install piping systems*, and *install fixtures*. In the pipe trades breakout session, three installation activities and three tasks related to piping systems installation were added (Table P-1). The three activities added were: *install equipment*, *install deck inserts (i.e., site prep)*, and *plan reading and detailing*. One additional task, *site cleanup*, could also be considered a required task for most other activities related to the pipe, electrical, and sheet metal trades. Time constraints prevented a full discussion of the additions.

After a discussion, a majority of pipe trades breakout session participants suggested modifying the risk scores assigned to several tasks (Table P-2).

Tasks

Drill Holes and Screw or Shoot Fasteners Into Ceiling

Non-residential piping systems are usually placed near the ceiling and supported by hangers. Hanging systems are often fastened directly to the building structure (e.g., concrete or metal ceiling), and installed by using a rotary hammer drill or a power-actuated tool (PAT). A rotary hammer drill is used to drill a mounting hole in concrete for the fasteners, and a PAT shoots a fastener (e.g., pin or bolt) into concrete or metal. A hammer, hand wrench or a screw gun is used to set or tighten the threaded connection for the hanging system.

The potential WMSD risk factors reported by meeting participants for *drill holes and screw* or *shoot fasteners into ceiling* were related to operating power tools overhead, such as the rotary hammer, PAT, and manual tools to tighten fittings. The body regions identified to be at greatest risk were the back and upper extremities, due to: force (physical exertion and tool rotation and impact), sustained non-neutral postures, vibration, and repetition. Conditions or circumstances that can increase the WMSD risks were: working overhead, tool torque and recoil, drilling into reinforced concrete, and the job characteristics (e.g., number and size of holes, frequency, and duration of drilling).

Currently available interventions reported to have been used by some contractors and trades people to address WMSD risk factors for *drill holes and screw/shoot fasteners into ceiling* are shown in Table P-3. Participants believed that tool users could benefit from improved tool design, including lower vibration levels, and that interventions were needed to support tools while they were being used overhead (e.g., drill stand).

Table P-1. Pipe trades activities and tasks [1]

Activity [2]	Basic Tasks [3]
Install pipe hangers	Formulate work sequence
	Carry materials to work location
	Measure and layout
	Drill holes
	Place hanger/fitting
	Screw/shoot into wall/ceiling
	Inspect work
Install domestic water pipes, sanitary sewers, gas pipes, etc.	Formulate work sequence
	Carry materials to work location
	Measure lengths of pipe
	Cut pipe
	Check for burrs
	Remove burrs, grind ends
	Move pipe to correct location
	Weld, solder, braze, screw, bolt
	Inspect work
	Position pipe [4]
	Test piping [4]
	Site clean-up [4]
Install fixtures	Formulate work sequence
	Carry materials to work location
	Measure and layout
	Drill holes
	Position fixture
	Attach fixture to wall/floor
	Inspect work
Install equipment [4]	
Install deck inserts (i.e., site prep) [4]	
Plan reading and detailing [4]	

1 Unless otherwise described, activities and basic tasks are taken from Everett [1997]
2 Activities are specified units of work that are completed on a construction site
3 Tasks are the "fundamental building blocks of construction field work, each representing one in a series of steps which comprise an activity"
4 Not included in Everett and added by stakeholders participating in the breakout session

Table P-2. Average work-related musculoskeletal disorder risk for pipe trade tasks [1]

Average Risk	Tasks
High	Place hanger/fitting
	Drill holes
	Screw/shoot into wall/ceiling
	Remove burrs, grind ends
	Join pipe [2]
	Lift and carry materials to work location[3]
Moderate	Attach fixture to wall/floor[4]
	Position fixture[4]
	Cut pipe
None-Low	Measure and layout
	Measure lengths of pipe
	Inspect work
	Formulate work sequence

1 Everett [1997]

2 Participants substituted join pipe for weld, solder, braze, screw, and bolt, and the task risk was upgraded to High-risk from the Moderate-risk category

3 Participants renamed Everett's task lift and carry to carry materials to work location, and the task risk was upgraded from the Moderate-risk to High-risk category. This basic task includes unloading equipment and material from trucks to intermediate staging areas, and to point of use areas.

4 Participants downgraded risk from the High-risk to Moderate-risk category

Table P-3. Drill holes and screw or shoot fasteners into ceiling (currently available interventions)

Problem	Intervention	Comment
Operate tool (general)	Improved ergonomic design features	Develop intervention
	Tool does the work, not tradesperson	Disseminate intervention
	Remote actuating device (i.e., foot pedal)	Evaluate intervention Prevent trigger finger
Tool torque/vibration	Clutch-driven tool to control torque	Disseminate intervention
	Second grip to control torque	
	Tool designed to dampen vibration	Develop and/or disseminate intervention
	Vibration dampening-glove[1]	
Tool recoil	Tool designed to dampen recoil	Develop and/or disseminate intervention
Drill bit sharpness	Tool and bit maintenance program	Disseminate intervention
Drilling above shoulders	Engineered or designed hanger system (i.e., embedded concrete systems, etc. into structure)	Develop and disseminate intervention
	Drill stand (i.e., inverted drill press, mining roof bolt drill, etc.)	Develop intervention
	Drill bit extension—purchase or fabricate	Disseminate intervention
	Suspension and balance system for tool	
	Belt holder for tool (i.e., flag holder)	Develop intervention
	Neck pillow	Evaluate intervention
	Mechanical lift preferred to ladders; ladder platform better than ladder	Disseminate intervention
Standing on concrete	Anti-fatigue mats or shoe inserts	Disseminate intervention Work site use may require culture change
General	Job rotation when possible	Disseminate intervention
	Micro-breaks	Disseminate intervention
	Physical conditioning (i.e., stretch and flex)[2]	Disseminate intervention
	Assignments made according to physical capabilities	
	Alert to current information on tool development (i.e., speak with tool reps)	Disseminate intervention
	Pre-job hazard analysis and management communication regarding safety	Disseminate intervention

1 Only gloves that have passed the ISO 10819 test procedures should be considered anti-vibration gloves. In addition, anti-vibration gloves should be matched to the dynamic properties of the vibrating tool and should not increase or introduce new risk factors for WMSDs, such as requiring higher grip forces [Mansfield 2005]

2 The effectiveness of stretching exercises in preventing injuries from work has not been proven. For more information on this topic, see Hess et al., 2003

Place and Install Hangers for Mechanical Hanging Systems for Small Bore Pipe (≤ 6-Inch Diameter)

Mechanical systems are supported by hangers attached to the building structure, with or without modifying the structure. Drilling or shooting studs into concrete or metal ceilings modifies the structure, while attaching a beam clamp to a steel girder does not modify the structure. In either case, the trade person must assemble the hanging system and fasten it to the building structure using power and/or hand tools.

Potential WMSD risk factors reported by meeting participants for place and install hangers for mechanical hanging systems were related to fabricating and assembling hanging systems, including power tools and hand tools held above shoulder level. The body regions identified by participants to be at greatest risk were the upper extremities and shoulders, due to: forceful exertions, tool reaction forces (rotational and impact), sustained non-neutral postures, repetition, and hand-arm vibration. Conditions or circumstances reported by participants to increase the WMSD risks were: working overhead, working on the floor (e.g., bent forward or kneeling), tool torque and recoil (e.g., PAT), and the job characteristics (e.g., number of hangers, fasteners, etc.).

Currently available interventions reported to have been used by some contractors and tradespeople to address WMSD risk factors for *place and install hangers for mechanical hanging systems for small bore pipe* are shown in Table P-4. Participants believed that hanging systems could be better engineered into the building structure (e.g., embedded concrete inserts).

Lift and Carry Materials and Equipment

Materials and tools used to install piping systems must be unloaded, stored until needed, and transported to the location where they will be used. Many factors determine whether the material handling will be done manually or mechanically, and how often something must be handled.

Potential WMSD risk factors reported by meeting participants for this task were related to lifting, carrying, and pushing-pulling the following items throughout the construction site: materials, equipment, and tools. The body regions identified by participants to be at greatest risk were the back and shoulders, due to: force (weight of objects), awkward postures (bending and twisting), and contact stress (materials pressing against the body). Conditions or circumstances reported by participants to increase or decrease the actual WMSD risks included the following: inside vs. outside work; the condition of the floors, walkways, and ground surfaces (e.g., mud, rebar mat, uneven surfaces); the location and way materials are stored (e.g., on the ground, racks, or pallets); hand-to-object coupling (e.g., use of one or two hands, and full-hand or partial-hand grip); work on multiple floors or levels; weather conditions; the availability and maintenance of material handling equipment; and, the degree of site planning and communication among contractors (e.g., repeated handling of materials, or materials stored in the way of other trades).

Currently available interventions reported to have been used by some contractors and tradespeople to address WMSD risk factors for *lift and carry materials and equipment* are shown in Table P-5.

Table P-4. Place and install hangers for mechanical systems (currently available interventions)

Problem	Intervention	Comment
Place or install hangers	Hangers engineered into building structure (i.e., embedded concrete)	Disseminate intervention
	Lighter materials to reduce weight	
	Micro-breaks when doing hand-intensive tasks	
	Physical conditioning (i.e., stretch and flex)[1]	
Cut metal	Tool selection based on ergonomic design features (i.e., low vibration)	Develop and disseminate intervention
Screw nuts to thread	Split nuts for all threads	Disseminate intervention
	Open-end ratchet to thread hangers	Disseminate intervention
Use manual hand tools	Tool selection based on appropriate design features for activity	Disseminate intervention
	Micro-breaks for hand-intensive tasks	
Work overhead	Stable work platform (i.e., scissors or vertical lift)	Disseminate intervention
	Extension poles and remote triggering available from Hilti & other vendors	Disseminate intervention
Multi-employer site	Communication and planning of tasks with other contractors	Disseminate intervention

[1] The effectiveness of stretching exercises in preventing injuries from work has not been proven. For more information on this topic, see Hess et al., 2003.

Table P-5. Lift and carry materials and equipment (currently available interventions)

Problem	Intervention	Comment
Lift and carry heavy objects	Material handling equipment (i.e., pipe carriage with offset extended handle, pipe stand with casters, carts, grasshopper, pallet jack, fork truck, cranes, helicopters, etc.)	Problems are work surface and equipment availability. Should not need to go far to get equipment
	Lift/carry devices (i.e., double-hook or single circular slings, fabricated handles, suction and magnetic handles, handy hook, shoulder guard, etc.)	Evaluate and disseminate intervention Improve hand-object coupling and reduce contact stresses
	Roller conveyor systems	Locations where fork truck, etc. cannot operate
	Lift pipe and materials between floors with a crane	Eliminates manual materials handling (MMH) between floors
	Shoulder guard	Evaluate and disseminate intervention
	Best glove for optimal coupling (i.e., glove size, grippers, etc.)	Evaluate and disseminate intervention
	Attention to exposure limits (e.g., NIOSH lifting equation [1994], Dutch construction industry push/pull/carry limits)	Evaluate and disseminate intervention
	Weight of materials and objects by color coding other identification	Object profile influences limits (e.g., size, shape, etc.)
	Coordination and planning of work site activities, (i.e., off-load close to use location, just-in-time delivery)	Disseminate intervention Space limiting factor (i.e., zero lot line jobs). Unloading sometimes done in evening
	Training (i.e., stretch and flex programs)[1]	Evaluate and disseminate intervention
	Housekeeping (i.e., 5 "S" program)	Evaluate and disseminate intervention.
Lift and position	Use ladder hoist roustabout (i.e., tripod stand on wheels)	
	Lift pipe held in a "v" fixture with an attached fittings box	
	Use hoisting equipment for mechanical advantage (chain falls, com-a-longs, forklifts, cranes, etc.)	Disseminate intervention
Storage	Off-ground storage for materials (i.e., pallets, cut-away bins), to eliminate severe forward bending	Disseminate intervention
	Vertical gang/tool box (i.e., cabinet style)	Disseminate intervention Reduce bending
	Bag and tag by use location (i.e., also system use global positioning system [GPS] to locate materials and equipment)	

[1] The effectiveness of stretching exercises in preventing injuries from work has not been proven. For more information on this topic, see Hess et al., 2003

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Phil Lemon (Streimer Sheet Metal Works, Inc.) and Cherie Estill (NIOSH)

Everett [1997] described three mechanical sheet metal construction activities that consume 10% or more of the total work for the trade in southwestern Michigan. These activities were: install duct hangers, install ductwork, and install equipment. In the sheet metal trades breakout session, four additional activities and five tasks were added (Table SM-1). Time constraints prevented a full discussion of the additions.

After a discussion, a majority of sheet metal trades breakout session participants suggested modifying the risk scores assigned to several tasks (Table SM-2).

Tasks

Drill Holes

Sheet metal workers drill holes into building structures (e.g., floors, walls, and ceilings) and sheet metal when installing heating, ventilation, and air-conditioning (HVAC) duct systems and equipment. Rotary hammer drills are used to drill mounting holes in concrete for fasteners to hold hanging systems and equipment. Electric and cordless drills are used to drill holes into sheet metal.

Potential WMSD risk factors reported by meeting participants for *drill holes* were related to operating rotary hammer drills and drills overhead and at floor level. The body regions identified as being at greatest risk were the back, upper extremities, and knees, due to: force (physical exertion and tool rotation and impact), sustained non-neutral postures, repetition, vibration, and contact stress. Conditions or circumstances reported by participants to increase the WMSD risk were: work location (e.g., ceiling, floor), substrate (e.g., reinforced concrete, concrete block, metal), tool reaction forces (e.g., torque), tool design, job characteristics (e.g., number and size of holes, and frequency and duration of drilling), and poor planning and communication.

Currently available interventions reported to have been used by some contractors and tradespeople to address WMSD risk factors for *drill holes* are shown in Table SM-3. Participants believed that more tool users could benefit from improved tool design, including lower vibration levels, and that interventions were needed to support tools while they were being used overhead (e.g., drill stand).

Screw or Shoot Fasteners Into Ceiling

A screw gun or a PAT is often used to fasten hanging systems directly to the building structure (e.g., concrete or metal ceiling). PATs shoot a fastener (e.g., pin or bolt) into concrete or metal. Screws and other fasteners are secured with cordless screw guns and manual tools to tighten screws used for the hanging system.

Potential WMSD risk factors reported by meeting participants for *screw/shoot fasteners into ceiling* were related to using powered and manual tools overhead. The

Table SM-1. Sheet metal trades activities and tasks[1]

Activity [2]	**Tasks** [3]
Install duct hangers	Formulate work sequence
	Carry materials to work location
	Measure and layout
	Drill holes
	Place hanger
	Screw/shoot into ceiling
	Inspect work
Install ductwork	Formulate work sequence
	Carry materials to work location
	Measure and layout
	Position duct section
	Connect ductwork to hanger/ceiling
	Inspect work
Install equipment	Formulate work sequence
	Carry materials to work location
	Measure and layout
	Connect equipment to ceiling/duct
	Inspect work
Assemble duct pieces in field [4]	Install flange/collar and tap-in/spin-in [4]
	Cut and trim duct joints [4]
	Assemble duct sections [4]
	Weld
Demolition [4]	Cut and remove duct sections [4]
Move material to and within jobsite [4]	
Detail work and field design [4]	

1 Unless otherwise described, activities and basic tasks are taken from Everett [1997]
2 Activities are specified units of work that are completed on a construction site
3 Tasks are the "fundamental building blocks of construction field work, each representing one in a series of steps which comprise an activity"
4 Not included in Everett and added by stakeholders during the breakout session

Table SM-2. Average work-related musculoskeletal disorder risk for sheet metal trade tasks[1]

Risk	Tasks
High	Drill holes
	Screw/shoot into ceiling
	Connect duct to hanger/ceiling
	Place hanger
	Position and connect duct pieces together [2]
	Assemble duct pieces in the field [3]
	Cut and trim duct joints [3]
	Weld [3]
	Move heavy equipment (rigging) [3]
	Cut and remove duct sections during demolition [3]
Moderate	Position and connect equipment to ceiling/duct
	Position duct section
	Carry materials to work location
None-Low	Measure and layout
	Inspect work
	Formulate work sequence

[1] Everett [1997]
[2] Added by recommendation of a mechanical contractor before the meeting. Upgraded in session from the Moderate-risk to High-risk category.
[3] Participants upgraded from the Moderate-risk to High-risk category

body regions identified by participants to be at greatest risk were the shoulders and upper extremities, due to: forceful exertions (e.g., hand grip and push forces), PAT reaction force (e.g., recoil), sustained non-neutral postures, and repetition. Conditions or circumstances reported by participants to increase the WMSD risks were: work location (e.g., ceiling), building substrate (e.g., reinforced concrete, concrete block), tool features, site planning and communication among contractors, housekeeping (e.g., cluttered walking and working surfaces), and job characteristics (e.g., number and size of holes, frequency, and duration of drilling).

Currently available interventions reported to have been used by some contractors and tradespeople to address WMSD risk factors for *screw or shoot fasteners into ceiling* are shown in Table SM-4. Participants believed that more tool users could benefit from improved tool design, stands to support overhead tool use, and better-engineered hanging systems in a building structure (e.g., embedded concrete inserts).

Cut and Trim Duct Joints

Tasks involved in assembling ductwork—*cutting, bending, and assembly* usually occur in a sheet metal fabrication shop. It

Table SM-3. Drill holes (currently available interventions)

Problem	Intervention	Comment
Rapid work pace	Job rotation	Possible conflict with labor contracts
	Periodic rest breaks	
Work on floor (e.g., drill holes into floor/deck)	Knee pads Anti-fatigue work mats	Intervention commercially available
Confined work areas	Coordination of hanger installation with other trades to improve access	
Excessive vibration	Purchase and use lower vibration tools	Intervention commercially available: Atlas-Copco, Hilti, etc.
Proper tool not available (i.e., wrong size, weight, etc.)	Program to identify and purchase tools based on performance criteria	Tools must be used as designed
Rotational force (torque)	Side arm on large drill	Intervention commercially available
Poor planning and communication		
Housekeeping		

Table SM-4. Screw or shoot fasteners into ceiling (currently available interventions)

Problem	Intervention	Comment
Operate PAT or rotary-hammer	Embedded concrete inserts to support hangers, i.e., metal channel, screw, wedge (Unistrut™, Anvil, etc.)	Commercially available intervention Inserts are attached to forms and embedded in concrete ceiling Eliminates drilling holes for hangers Expensive and requires more time preparing forms. Could result in competition among trades for insert use.
	Tool stand or inverse drill press to absorb recoil and reduce static postures	Commercially available intervention Reduces impact of recoil and static posture (Hilti manufactures extension for PAT)
	Beam clamps, caddy clips, etc.	Commercially available intervention Easier, quicker, and increases productivity, but requires structural support (e.g., I-beam).
	Tool counterweight	Commercially available intervention Use for tools like rotary hammer. Potential liability if attached to lift device.
	Use minimum number of hangers required	Commercially available intervention Only drill for minimum number of anchors required by code
	Job rotation	Possible conflict with labor contracts
	Pre-task planning	Assure that anchors set in correct location to avoid setting additional anchors

(continued)

is usually necessary, however, to cut and trim duct joints in the field using both powered and manual tools.

Potential WMSD risk factors reported by meeting participants for *cut and trim duct joints* were related to using manual tools (e.g., tin snips) and power tools (e.g., reciprocating saws, grinders, double cuts). The upper extremities were identified by meeting participants to be at greatest risk of injury due to: forceful exertions (e.g., hand grip and push forces), sustained non-neutral postures, vibration, and repetition. Working height (e.g., below knees, above shoulders) was the principle condition or circumstance reported to increase the WMSD risk.

Currently available interventions reported to have been used by some contractors and tradespeople to address WMSD risk factors for *cut and trim duct joints* are shown in Table SM-5. Participants believed that powered and hand tool users could benefit from improved tool design.

Connect Duct to Hanger or Ceiling

Ducts are attached to hangers using powered and manual tools. Most potential WMSD risk factors reported by meeting participants for this task were related to manually holding and positioning ductwork in place and tightening fasteners that support ductwork. The body regions identified by participants to be at greatest risk were the shoulders, back, and upper extremities, due to: forceful exertion, sustained

Table SM-4 *(continued).* **Screw or shoot fasteners into ceiling (currently available interventions)**

Problem	Intervention	Comment
Set threaded rod-type anchor (i.e., thunderbolt) using hammer and wrench to tighten anchor	Use embedded concrete inserts to support hangers, i.e., metal channel, screw, wedge (Unistrut™, Anvil, etc.)	
	Substitution of electric or pneumatic drill to tighten anchors using attachment to set nut and wedge anchor	Commercially available intervention
	Substitution of ratchet with open socket (allows rod to go through socket)	Commercially available intervention
Working overhead	Correct placement of ladder and lift	
	Shin guards to prevent contact stresses when working on ladder	
Multiple issues	Pre-task planning	
	Worker training	
	Communication with other crafts/contractors	

non-neutral postures, repetitive movement, and contact stress. Conditions or circumstances reported to increase the WMSD risks were: working overhead, working in cramped spaces, and working on a ladder.

Currently available interventions reported to have been used by some contractors and tradespeople to address WMSD risk factors for *connect duct to hanger or ceiling* are shown in Table SM-6. In addition to interventions described in the table, participants believed a stand should be developed and evaluated that could support the weight of a power tool, while in use overhead.

Welding

Ductwork, hangers, and other HVAC system components are sometimes joined in the field by welding. Potential WMSD risk

Table SM-5. Cut and trim duct joints (currently available interventions)

Problem	Intervention	Comment
Power tool vibration	Low-vibration tools	Improve design to further reduce vibration
	Anti-vibration wraps on tool handle	Not a substitute for using a low vibration tool. Some materials breakdown quickly and circumference of handle can be too large.
	Scheduled tool preventive maintenance program	
Power tool weight	Appropriate tool (e.g., use a 4.5 inch grinder if it will do the job, rather than a 9 inch diameter grinder).	Weight difference (3 lb vs. 12 lb)
	Tube cutter for small bore stainless steel (4-inch diameter)	
Manual tin-snips usage	Electric snips	Intervention commercially available Not usually provided to each worker on a job site
	Drill adapter to cut circles	Intervention commercially available
	Minimize on-site cutting by prior planning	
Working on floor	Bring the work up to a better height (e.g., work table)	
	Knee pad or small anti-fatigue mat used when kneeling	Intervention commercially available

Table SM-6. Connect duct to hanger or ceiling (currently available interventions)

Problem	Intervention	Comment
Working overhead	Person-lifts, rolling scaffold, etc., rather than ladders	Interventions commercially available (e.g., Baker scaffold)
	Platforms built to give better footing for workers	Example: run planks across Unistrut™ and use anchor points on Unistrut™ to tie-off
Hold duct and tools	Device to lift, position, and hold duct	Interventions commercially available
Screw and/or bolt and fasten straps	Ergonomically designed tools, having different grip orientations	Intervention commercially available (e.g., cordless screw drivers now bend in center)
Manually lift, move, position, and hold duct overhead	Mechanical lifting device	Intervention commercially available Products mentioned were cranes, forklifts, electric chain or tugger
	Encouragement for manufacturers of person-lifts to develop acceptable and safe attachments to hold and position duct in the air	One contractor recounted an unsuccessful attempt to interest a manufacturer in this idea
	Rollers attached to structural support members to move duct sections farther distances (i.e., 100 ft)	
	Handled-magnets or suction cups to position duct on the lift	Intervention commercially available
Lift, position and hold spiral (round) duct at ceiling	Jig (shaped like half-m scissors lift to raise and hold spiral (round) duct	One contractor reported fabricating a jig this way. Jigs are used to hold duct in place when moving. Cannot use lift if total weight exceeds the manufacturers' weight limit. [1]
Lift large duct (manually) and place on mechanical lift	Electrical chain fall or tugger	
Confined or cramped work areas	One-person lift for tight spaces	
	Baker scaffolds	Baker scaffold is smaller and has locking wheels
General	Ensure availability of equipment and materials by prior planning, and that equipment is handled a minimum number of times	
	Stretching programs to warm-up before lifting or working in awkward postures[2]	

[1] The effectiveness of stretching exercises in preventing injuries from work has not been proven. For more information on this topic, see Hess et al., 2003.

[2] Aerial lifts should not be modified without the approval of the manufacturer

Table SM-7. Welding (currently available interventions)

Problem	Intervention	Comment
Hold welding torch, etc. in hands	Job rotation Micro-breaks	
Snapping head/neck forward to lower welding hood	Welding lenses that automatically darken when welding begins	Intervention commercially available Purchase of auto-darkening replacement lenses or hood with lenses Battery or solar powered, especially for tacking and spot welding
	Lower and raise hood with your hand	
Prolonged standing	Micro-breaks	
	Job rotation	
	Sit-stand stools	
Moving equipment	Welding cart with ramp-gate to eliminate lifting gas cylinders	Intervention commercially available and can be fabricated in the shop
	Appropriate casters/wheels	
Work on floor	Knee (joint) support	Intervention commercially available Straps to calf to limit knee bending (flexion)
	Knee pads, shoe inserts, or mat/cushions	Intervention commercially available Different styles are available (i.e., padding just for knee, padding extending from knee to ankle, and inserts for work pants). Portable mat to kneel on (i.e., rubber gardening mat).
	Welding tables, benches, etc.	Intervention commercially available Can also sit on stool or sit-stand device Problem: contact stresses from leaning against or resting arm-elbow on table
	Planning to minimize ground-level work	
Poor access to work area	Improved planning and communication among trades	
Contact stresses to thigh, elbows, shins, etc.	Pad edge of welding table, wear elbow pads and shin guards	

factors reported by meeting participants for “welding” were related to: holding and using the welding torch, snapping the head to raise and lower the welding hood, and prolonged standing or kneeling. The body regions identified by participants as being at greatest risk of injury were the neck, back, upper extremities, and knees due to: sustained non-neutral postures, repetitive movement, and contact stress. Conditions or circumstances reported to increase the WMSD risks were: working overhead, working in cramped spaces at ground level, and working on a ladder.

Currently available interventions reported to have been used by some contractors and tradespeople to address WMSD risk factors for *welding* are shown in Table SM–7.

Move Heavy Equipment and Materials

Heavy equipment and building materials, such as welding equipment and cylinders, ductwork, and air–handling units, must be unloaded and transported to work areas on construction sites. Potential WMSD risk factors reported by meeting participants for this task were related to lifting, pushing, and pulling heavy objects. The body regions reported by participants as being at greatest risk of injury were the back and upper extremities, due to: forceful exertions, awkward and static postures, and contact stress. Conditions or circumstances reported to increase the WMSD risks were: working in confined areas (e.g., above existing equipment) and working on uneven surfaces).

Currently available interventions reported to have been used by some contractors and tradespeople to address WMSD risk factors for *move heavy equipment and materials* are shown in Table SM-8.

Table SM-8. Move heavy equipment and materials (currently available interventions)

Problem	Intervention	Comment
Grip, push, pull and lift equipment and materials	Use mechanical material handling equipment as much as possible.	Intervention commercially available Such as pallet jack, forklift, air bearings, dolly, crane, roll-o-lift, roof cart, sheet rock cart. Select device that can be easily moved on work source (i.e., pneumatic tires)
	Planning—coordinate and sequence moving equipment (i.e., bring air handling unit in with crane before roof built, rather than side of building)	Minimize physical exertion
	Pulley or smaller chainfall attached to joist, or scissor lift, etc. to move large chainfall into place	
	Move and position duct during installation using secured rollers	Use a retrieval tool to prevent hand or glove from getting caught
	Improved coupling on equipment (i.e., fabricate handles or pick points, encourage manufacturers to build with handles)	
	Levers for moving equipment (i.e., Johnson bar)	Bar can kick-out
	Use appropriate number of personnel to move equipment, etc.	
Work above existing equipment	Platforms built above existing equipment, etc. to stand on	Need anchor points for fall protection

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Breakout Report 1: Electrical Trade and Specialty Job Tasks Presenting High Risk for Developing WMDSs

The Electrical Trade and Specialty Breakout Session added the following three jobs to the list of jobs:

- Install underground service
- Install switch gears
- Residential wiring

In addition, the group identified two risk factors for the first two jobs. *Installing underground service* and *installing switch-gears*, which were described to have many high-risk issues.

Participants changed the hazard rank for each of the following tasks:

- *Connect fixture to ceiling or wall* was upgraded from the Moderate-risk to High-risk category.
- *Bend, align, and position conduit* was upgraded from the Moderate-risk to High-risk category.
- *Carry materials to work location* was upgraded from the Moderate-risk to High-risk category.
- *Connect wires* was downgraded from the High-risk to Moderate-risk category.
- *Bend wire to proper location* was downgraded from the Moderate-risk to Low-risk category.

As a result of this hazard ranking, six tasks were in the High-risk category, and two tasks were in the Moderate-risk category (see Table E-2 in Electrical Trade and Specialty, Breakout Sessions).

Exposures, risk factors, affected body parts, and interventions were identified and discussed for the following five high-risk tasks: *attach raceway to wall or ceiling; lift and carry materials and equipment; cut, bend, align, and position conduit; position fixture;* and *pull conductors (cable and wire).*

Interventions

Many different interventions were discussed, including those that participants reported in current use, as well as some that were believed to have a future potential for use. A few examples of each are described below.

Interventions in Use:

- Sling with built-in grips for manual material handling (MMH), especially where larger material handling equipment cannot be used or is impractical.
- Reinforcement by foreman of correct way to use equipment to reduce exposure to biomechanical stressors.
- Improved mentoring of younger workers to increase the learning curve, so that experience (e.g., bending conduit) comes faster.
- Conduit bending equipment that allows the worker to work from a standing position, rather than from kneeling on the ground.

Potential Future Interventions:

- Changes in material packaging (e.g., size, weight, handles) for better handling.
- Packaging designed with attachments (i.e., couplings) to improve material handling of equipment and materials.
- Battery-powered, low-vibration cutting tools provided to reduce hand-arm vibration exposure.
- Development of a portable battery-powered bender for small diameter conduit.

Breakout Report 2: Pipe Trade and Specialty Job Tasks Presenting High Risk for Developing WMDSs

The Pipe Trade and Specialty Breakout Session added the following two jobs to the original list of jobs:

- *Install equipment* (e.g. heating, ventilation, and air conditioning [HVAC] equipment, rooftop units, pumps, chillers, boilers); and
- *Building site preparation* (e.g., planning and organizing work).

Participants added the following task to the original list:

Position pipe, and assigned a Moderate risk to the task.

The following job and task names were modified for brevity, or to better represent the work:

- *Install plumbing or process piping systems* replaced *install domestic water/sanitary/gas pipes* (installing piping systems).
- *Join pipes* replaced *weld, solder, braze, screw, and bolt pipes.*
- *Lift and carry materials* replaced *carry materials to work location.*

Participants changed the hazard rank for each of the following tasks:

- *Join pipes* was upgraded from the Moderate-risk to High-risk category.
- *Lift and carry materials* (including offloading at intermediate staging areas and point of use) was upgraded from the Moderate-risk to High-risk category.
- *Position fixtures* was downgraded from the High-risk to Moderate-risk category.
- *Attach fixtures* was downgraded from the High-risk to Moderate-risk category.

As a result of this task hazard ranking, six-tasks were in the High-risk category, and three tasks were in the Moderate-risk category (see Table P-2).

Interventions

Exposures, risk factors, affected body areas, and interventions were discussed for the following High-risk category tasks: drill holes/drive/shoot fasteners into ceiling; place hanger; lift and carry materials; and join pipe.

Interventions Needing Further Evaluation: Participants also considered whether the interventions discussed should be publicized at this time, or whether further work was necessary, such as evaluating the effectiveness of the intervention. The group decided there were universal recommendations that could apply to many tasks, and not just to the one under discussion.

Participants decided the following interventions needed further evaluation:

- Power tool vibration levels assessed. Results should be disseminated to contractors and tradespeople, so they can select and use tools that produce lower vibration levels.

- Neck pillow used to support the head during overhead work.
- Drill stand to hold rotary drills and other power tools during overhead work.
- Remote actuating devices for power tools, to activate them without use of a finger trigger.
- Guidelines for the weight and profile (e.g., size) of materials, e.g., NIOSH lifting guideline [1994]. If a guideline is recommended, what specifications are needed in terms of height of lift, type of coupling (e.g., cutout for hand grip, handle), etc.
- Material handling system developed in Japan (5 S's), which provides a comprehensive view of how building materials can be more efficiently organized and used on a job site.
- Properly fitting gloves.
- Shoulder guards (carrying materials on the shoulders can limit visibility).

Potential Future Interventions:
Interest was highest for addressing the following interventions:

- Improved construction material handling devices;
- Development of weight and profile guidelines for materials;
- Development of a stand for overhead drilling into concrete; and
- Improved hand tool design.

The following topics also generated lively discussion:

- Upstream engineering and design, particularly with hanger systems for piping and equipment;
- Importance of coordination and planning (e.g., interaction of the foreman and crew, task planning, and coordination with other trades and contractors); and
- Training for workers.

Breakout Report 3: Sheet Metal Trade and Specialty Job Tasks Presenting High Risk for Developing WMDSs

The Sheet Metal Trade and Specialty Breakout Session added the following three jobs to the original list:

- Demolition;
- Move material to and within job site; and,
- Detail work and field design, which can impact other activities that may involve hazards.

Participants added the following tasks to the original list:

- Welding;
- Cut and trim duct joints;
- Moving heavy equipment;
- Cut and remove duct sections; and,
- Assemble duct sections in the field.

As a result of this task hazard ranking, 10 tasks were in the High–risk category, and three tasks were in the Moderate–risk category (see Table SM–2, in Sheet Metal Trade and Specialty, Breakout Sessions).

Interventions

Exposures, risk factors, affected body areas, and/or interventions were discussed for the following tasks: *drill holes; screw or shoot into ceiling; connect duct to hanger or ceiling; place hanger; welding; cut and trim duct joints; moving heavy equipment;* and, *cut and remove duct sections.*

Interventions Discussed:

Tasks 1-4 involve overhead work. Considerable discussion ensued about supporting tools for overhead work. Everyone had heard of such supports, but no one had ever seen one used. It was questioned whether a reverse drill press would work with a roto-hammer, which is an important area to explore.

The discussion concerning interventions included the following concerns:

- Many interventions implemented in the sheet metal fabrication shops have been difficult to implement or maintain on a construction job site, because contractors and tradespeople have less control of their work environment outside the shop.
- The need for job site coordination and planning and stretching programs was universal.
- Participants reported that cordless (battery-operated) tools are reducing some repetitious hand activity.
- Greater attention to upstream design was discussed to eliminate WMSD risk factors (e.g., reduce the need to drill holes for overhead hanger systems).

- Genie™ and other powered person–lifts were reported to have had a positive effect at reducing exposures to biomechanical stressors reported to occur during the installation of duct and equipment at or near the ceiling.

Questions and Comments from Breakout Session 3

Jim Albers: Did you discuss how the innovations implemented in the shop can be transferred to the field, and whether training increases recognition of what needs to be done in the field?

Chris Warren: We do a great job in our shops because it's a controlled environment. If we take these ideas to a job site where there's a cooperative general contractor and owner, it's easy. At a job site where the culture and equipment are not there, it's different. I see the need for more cooperation from the owners, contractors, and unions. It sounds like in Washington and Oregon the union is proactive. They should be more involved in Wisconsin.

Steve Hecker: One area where changes are making their way out to the field is pre-fabbing and doing work at table height. Streimer Sheet Metal has sent worktables that originated in the shop to the site.

Phil Lemons: Kelly True gave the example of a duct assembly system built in the field that is now making its way back into the shop. So, the influence can move both ways. Sometimes the driver for change is quality rather than safety. The field might receive damaged duct from the shop, or duct that is improperly put together or in need of adjustment. That is an added cost. Safety improvements have come out of these concerns. We can't ignore the connection between safety and productivity. There are two drivers—the shop and field, working back and forth.

Tony Barsotti: Words of caution about shop pre-fabrication. It includes specialization. The history of the trades is increased specialization to increase productivity. This results in some people doing the same things longer and longer. Some piping fabrication shops are mini-sweatshops. It might help in the field, but we could just be shifting our exposures. That applies to outsourcing pre-fabrications, as well. Last year, we outsourced some heavy steel pedestals, and a young apprentice was killed in the pre-fabrication shop in material handling. He wasn't fully trained in the rigging.

FINAL SESSION
General Discussion

Cherie Estill: How can the three trades work together? For example, many are working in the same overhead areas. Could they use the same hangers, for instance?

Reinhard Hanselka: Communication is most important.

John Rosecrance: There's a need for communication within the trades too, about interventions. There are also applications from the automobile industry and other industries.

Chris Warren: The larger companies that have the capability to do design-build can get involved with the owner early in the project. Superintendents, engineers, and design-build people can work in the design mode much earlier. You can use Unistrut™ or cable in the concrete form, when it's poured and have the anchors already there, before you drill.

Scott Schneider: The National Institute for Occupational Safety and Health (NIOSH) has been looking at crossover technologies from the mining industry in putting in roof bolts. In addition, as with operators of heavy equipment in mining, there are similarities in construction. The mining industry has done more than we have; we can learn from them.

Kelly True: In some projects I've been involved in, they've established zones for routing the various utilities—electrical, mechanical, sheet metal, and piping trades. Sometimes one gets the right of way, and the rest coordinate around it. For example, on a utility pump, the lines that go to them have a prescribed length which dictates where the others have to route and run their utilities. That requires a lot of coordination up front. On larger base field activities, those who are coordinating the installation get together with the other trades. They look at their shop drawings and coordinate their layouts and routings to make sure they've identified interferences. There's less re-work, and you know where people are going to be. It's streamlined.

Charles Austin: We can see if there can be crossover for training materials, as well (e.g., like SMOHIT's welding chart). I found that other trades have similar hazards. If we're training on similar materials, then we can understand how that craft uses those materials, and what kind of work they do. As an industrial hygienist, I'm trying to learn how the construction crafts work together.

Tony Barsotti: Equipment made by Greenlee (primarily an electrical manufacturer) has spread to other trades, by people just noticing that it would work for them, as well. Material handling equipment developed for one could meet the needs of others. We need to have our needs better understood by manufacturers and vendors: the question of using scissor lifts for material handling—everyone is doing that. The manufacturers claim you can't modify that equipment, but you need to get the material up in the air, as well as the people. It works well for almost everybody, without a perceived hazard in most cases. These needs can be addressed across trades and across different handling equipment.

Peregrin Spielholz: Some general contractors (GCs) in Washington are interested in moving higher up in the process. Safety and Health Assessment and Research for Prevention (SHARP) has arranged meetings with some architects and some of the largest contractors to develop guidelines for integrating ergonomics into the design. Another thing some GCs have discussed, at least on public projects, is to have ergonomics be required as a line item on the contract, so that it's built into the cost of the contract.

Joe York: We overlook coordination of training between the trades. Electricians do many of the same things we [pipe trades] do. A gentleman here teaches the OSHA 10. I have to have my people trained back in Michigan to teach that class. We have training centers around the state, so we could have other trades at our training facilities with our people and/or their people. They already do this at the bigger high-tech plants, like Intel. When Billy Gibbons teaches an ergonomics class, she has people from several trades. Unfortunately, the unions haven't come to that level.

Cherie Estill: This question is for contractors. If there's a new engineering change, what does it take to adopt that solution? How much research do you want to have seen? Do you have to have a study showing that it's less of a physical hazard, or do you have to know that somebody else is actually using it?

Chris Warren: If it works, use it. If the guys like it, use it. If the guy likes the safety glasses he's wearing, he'll wear them. If it's going to be easier on workers, I don't need a study to tell me it's worthwhile.

Cherie Estill: You're willing to give it an on-the-job trial?

Chris Warren: Unless it's very expensive.

Unidentified participant: As safety people, we don't always talk about this, but proactive contractors take on things that are more expensive. However, for most contractors, availability and money are the two biggest issues.

Billy Gibbons: From experience, I know it's a myth to think that if something costs money, it should work. A contractor can have the best equipment, but that doesn't guarantee that people will use it in the field. What's important is relationship: Who's presenting this tool? What's their motive? Are they your friend or foe? For example, take Ironworkers and the automatic rebar tier. Initially, they dismiss the automatic tier. But once you establish a relationship, walk it out to the field, give people time to try it, brainstorm with them, then they say, "Yeah, we could use it for people who are injured and keep them on the job" and other applications.

Scott Schneider: If it's complicated to use, people don't want it. If it takes more than 30 seconds to adjust, so that it's at your height, that's a disincentive. It's also a disincentive if you have to go somewhere to get it. If the change will reduce the skill level, there will be resistance. People don't want to lose their skills or find them de–valued. Changing rebar tying from a hand operation to a mechanical operation is a tough sell. We have to be more careful about how we make that change, and if that change is really needed.

Patty May: In our company, we've rented the equipment before investing in it. We've found that safety often brings up productivity.

Cherie Estill: What do you expect of NIOSH?

Unidentified participant: There's always resistance. You can put out a tool for an injured worker or someone who can't do the job the typical way, and with enough promotion of that tool, more people will be using it—if they see the benefits for themselves. Perhaps NIOSH could partner with contractors to test these tools in the field and evaluate them.

Unidentified participant: Influence the contractors to try these new ideas. Workers don't know you exist. You need a publication to let them know you're there.

Unidentified participant: Lobby the tool manufacturers and look at how to change the packaging of construction materials.

Unidentified participant: Let the contractors know who you are. I thought you were a part of OSHA, and I wasn't interested in talking to you. Contractors associate you with regulatory activities, rather than research.

Laura Boatman: We need a clearinghouse or library where all this great work comes together, that we can easily access.

Billy Gibbons: If they know NIOSH is not OSHA, the next perception is "Be careful of those researchers; they'll suck all your time." There's a perception that we don't operate in real time and are more concerned about our own data collection. NIOSH needs to get better at field application research so the contractors will want us there, rather than being more focused on our classroom or data collection in a lab, so we can make it more applicable.

Chris Warren: I want to thank NIOSH for putting an agenda together and getting some tasks completed. What are we going to do with this stuff now? We've been talking about ergonomics for ten years, but we're still working on it, and in ten years we still will be. Do we get this group back together again, or new people, and recap what we've done and the way forward?

Cherie Estill: I don't know that we have a plan to get this exact group together or these trades, but that would be a good idea.

Unidentified participant: Go to the people. Get a team together, do your homework ahead of time, call some organizations, [and] set up time on the job site where you do nothing but observe. Talk to the workers and observe their work. You can't replicate conditions in a lab.

Zin Cheung: What level is the information targeted to? That's important, whether it's for the worker, or the contractor, or owner. Each project should have a clear target.

Cherie Estill: NIOSH's plan is to publish the conference proceedings with all the interventions. Our larger goal is to identify interventions that are already out there, but need to get out to everybody else. We'll develop two-page "tip sheets" that have the problem, the solution, productivity, and cost issues, and where to buy it, or how to make it. We'll collect them and make a tip sheet publication, and put each tip sheet on the NIOSH Web site. That's the best place we know to disseminate them. For tip sheets that are specific to a trade, we could go through SMACNA or SMOHIT and send one to each contractor.

The second area is ideas that haven't been tried that we could build ourselves and take to sites to try out. We'll do a few each year. If there are specific ideas that you think could be made into a tip sheet, please let me know.

Besides our Web site, there's the CPWR's <www.cpwr.com> and the Electronic Library of Construction Occupational Safety and Health (eLCOSH) <http://www.cdc.gov/niosh/elcosh/index.html>. They're trying to find all the information that exists that's particularly for workers.

Jim Albers: We plan to continue doing field investigations, and we will evaluate several interventions each year that look promising. We have limited resources for dissemination of information, but we can make sure trade associations—like the Associated General Contractors (AGC), SMACNA, and Mechanical Contractors Association (MCA)—get the materials we produce.

Scott Schneider: The Washington State Department of Labor and Industries is developing an ergonomic resource library of interventions. We'll be working with the Washington AGC to do something for the construction industry, maybe working with the eLCOSH. The question for me is not so much what's out there. It's not as if people don't know you can use a cart or a dolly. The question is what are the obstacles. Why isn't this intervention integrated into all of our safety programs? Just as people talk about guardrails on scaffolds, they should talk about making sure they have a level surface so people can use a dolly or cart. People don't know about some of the new equipment, but a lot of it is getting people to think about ergonomics as part of their daily activities.

Zin Cheung: The states have licensing boards. Can information pertinent to certain trades be spread through the licensing system?

Steve Hecker: I agree a lot is out there, and we have to overcome the barriers. There is a lot in Europe that we don't know how to get. NIOSH could take steps there.

Cherie Estill: I want to thank our three facilitators? Steve Hecker, Billy Gibbons, and Tony Barsotti, and the contractors and workers, or former workers, who came. Also, Jim Albers, Leslie MacDonald, and Yongku Kong (NIOSH). Thank you all for coming.

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APPENDIX I

The 65 meeting attendees were drawn from the following organizations and contractors:

Trade Associations: Associated General Contractors; Mechanical Contractor's Associ–ation of Western Washington; Sheet Metal and Air Conditioning Contractors of North America

Electrical Contractors: Cupertino Electric (CA); Dickey Electric (OH); Frank Electric (CA); Helix Electric (CA); Rosendin Electric (CA); SASCO Electric (WA); Valley Electric (WA)

Mechanical Contractors: Cal-Air, Inc. (CA); Encompass Mechanical Services (CA, TX); Kinetics Group, Inc. (CA); Southland Industries (CA); Streimer Sheet Metal (OR); Triad Mechanical (OR); Tweet–Garot Mechanical (WI)

General Contractors: Hoffman Construction (OR); WG Clark Construction (WA)

Joint Labor–Management: Construction Safety Association of Ontario (Canada); IBEW-NECA Joint Apprenticeship Training (CA, OR); Sheet Metal Occupational Health Institute Trust (VA); Laborers' Health and Safety Fund (DC); South Bay Piping Industry Labor Management (CA)
Labor Organizations: California Building Trades Council; International Brotherhood of Electrical Workers; United Association of Plumbers and Pipefitters; Sheet Metal Workers' International Association

Universities: Purdue University (IN); University of California Berkeley (CA); University of California–San Francisco (CA); University of Iowa (IA); University of Massachusetts, (Lowell, MA); University of Oregon-Salem (OR)

Government: British Columbia Workers' Compensation Board (Canada); California OSHA Consultation Program (CA); California Health Evaluation System and Information Services, Department of Health Services (CA); National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention (Cincinnati, OH); Oregon OSHA Program Consultation (OR); Safety and Health Assessment and Research for Prevention (SHARP), Washington State Department of Labor & Industries (WA)

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