

SESSION 4: BREAKOUT SESSION 4-1 ELECTRICAL TRADES AND SPECIALTY

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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

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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 Sharp bits	Such as rotary-hammers that are manufactured with clutch; Consider lighter tool
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 Neck pillow	Attachment needed that does not compromise lift integrity (i.e., counterbalance to maintain stability)
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)

¹The 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	

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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

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

**Jim Albers
Cherie Estill
Leslie MacDonald**

Pipe Trades Training Center, San Jose, California

February 25–26, 2002

DEPARTMENT OF HEALTH AND HUMAN SERVICES (DHHS)
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DHHS (NIOSH) Publication No. 2006-119

April 2006