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

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] Move material to and within jobsite [4] Detail work and field design [4]	Cut and remove duct sections [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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