

BREAKOUT SESSION 4-3 MECHANICAL SHEET METAL TRADE AND SPECIALTY

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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 tasks¹

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 Periodic rest breaks	Possible conflict with labor contracts
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 Lower and raise hood with your hand	Intervention commercially available Purchase of auto-darkening replacement lenses or hood with lenses Battery or solar powered, especially for tacking and spot welding
Prolonged standing	Micro-breaks Job rotation Sit-stand stools	
Moving equipment	Welding cart with ramp-gate to eliminate lifting gas cylinders Appropriate casters/wheels	Intervention commercially available and can be fabricated in the shop
Work on floor	Knee (joint) support Knee pads, shoe inserts, or mat/cushions Welding tables, benches, etc.	Intervention commercially available Straps to calf to limit knee bending (flexion) 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). Intervention commercially available Can also sit on stool or sit-stand device Problem: contact stresses from leaning against or resting arm-elbow on table
Poor access to work area	Improved planning and communication among trades	Planning to minimize ground-level work
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)	
Work above existing equipment	Lever for moving equipment (i.e., Johnson bar)	Bar can kick-out
	Use appropriate number of personnel to move equipment, etc.	
	Platforms built above existing equipment, etc. to stand on	Need anchor points for fall protection

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

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