

included silica sand, coal slag, copper slag, nickel slag, garnet, staurolite, olivine, crushed glass, specular hematite, and steel grit. Some of the silica sand, coal slag, and copper slag abrasives were treated with a dust suppressant.

Untreated silica sand had the slowest average cleaning rate, while copper slag had the fastest. The abrasives' average consumption ranged from 6 lbs/ft<sup>2</sup> of steel surface cleaned for specular hematite to 25 lbs/ft<sup>2</sup> for steel grit. The abrasives' average cleaning costs ranged from about \$2.60/ft<sup>2</sup> of steel surface cleaned for olivine, to as high as \$3.60/ft<sup>2</sup> for silica sand and crushed glass. This cost range demonstrates that end-users should consider economic factors other than mere price per ton of delivered abrasive. Although silica sand has the lowest price per ton of delivered abrasive, it had the highest cost per square foot of steel surface cleaned. Treated coal slag had the lowest average personal respirable dust concentration, while crushed glass had the highest. Nine of the abrasives did not have detectable levels of quartz. Seven of the 13 abrasives did not have detectable levels of arsenic. Copper slag had the highest average lead concentration.

The NIOSH investigators concluded that silica substitutes may present their own toxicity concerns, although the substitutes examined are not necessarily representative of all substitutes. In spite of those concerns, the investigators conclude that the longstanding NIOSH recommendations to prohibit blasting with materials containing more than 1% crystalline silica is still appropriate and feasible.

### 309

#### EVALUATION OF VIBRATION IN HEAVY CONSTRUCTION EQUIPMENT. N.K.

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Past studies have shown that musculoskeletal diseases affect operators of heavy construction equipment. Some risk factors include whole body vibration (WBV), awkward postural requirements, and psychosocial factors. Although several studies have illustrated an association between operating heavy construction equipment and manifestation of musculoskeletal diseases, only a few studies have quantitatively evaluated the exposures.

It is believed that reducing the exposure to WBV may be an important factor in determining the health, comfort, and efficiency of these operators. High levels of acceleration in the lower frequencies can be deleterious to the lower back. Studies that evaluate the exposure to WBV in field settings are lacking. The objective of this study was to evaluate the vibration at the seat/operator interface (X, Y, and Z axes) and the transmissibility of vibration in the Z axis, from the floor of the cab to the seat, in construction equipment (i.e., excavators, backhoes). Specifically, vibration and transmissibility were evaluated when the equipment were idling (high and low) and digging. Vibration measurements were performed using a tri-axial piezoresistive seat pad accelerometer at the seat and a single-axis piezoresistive accelerometer at the floor of the cab. A Hanning window was applied to the time domain data and then a fast Fourier transform (FFT) was performed to transform the data to the frequency domain. The results indicate that the digging operation had

higher levels of total weighted acceleration than high or low idling. If these were the WBV levels for an 8 hour day, the digging task would exceed the limit of 0.5 m/s<sup>2</sup> recommended by the European Commission. The transmissibility data showed that the seat was amplifying vibration particularly at the lower frequencies. The seats in these equipment demonstrate that they may not be sufficient in protecting operators from long-term effects of vibration exposure.

### 310

#### EVALUATION OF DRYWALL HANGING TASKS USING A QUESTIONNAIRE. C.S. Pan, S. Chiou, H. Hsiao, NIOSH, Morgantown, WV

Constant handling of massive and bulky drywall sheets creates hazards among drywall installers. Among handling activities, hanging/lifting/carrying were found to be the most hazardous tasks, in a focus group-based study. The objective of this study was to identify the most hazardous activities associated with drywall hanging tasks. A questionnaire was used for the survey. In the questionnaire, three hanging tasks were included: (1) hanging drywall on the ceiling; (2) hanging drywall on the wall (upper half); and (3) hanging drywall on the wall (lower half). Each of the three tasks was broken into 15-17 constituent activities. Workers were asked to rate the physical stress, fall potential, and risk of being struck by/against an object for these activities, using a seven-point scale (1=hardly at all to 7=a great deal). Sixty carpenters (mean age: 43.7 ± 9.6 years) with drywall hanging experience (mean experience: 14.1 ± 8.7 years) from the Carpenters' Union located in Charleston, W.V., participated in this study. All the participants completed the survey. Workers rated hanging drywall on the ceiling as the most hazardous task with the mean ratings of 3.65 for physical stress, 3.05 for fall potential, and 3.06 for risk of being struck by/against an object. Among all activities associated with hanging drywall on the ceiling, lifting/carrying/holding drywall in an overhead position was perceived as most stressful (physical stress=5.6), followed by lifting drywall to scaffolding (physical stress=5.3) and carrying drywall to be cut at ground level (physical stress=4.6). The activity of ascending scaffold/stilts before hanging drywall on the ceiling was perceived as having the greatest fall potential (mean=4.6). In addition, lifting drywall to scaffolding was perceived as having the greatest risk of being struck by/against an object. Results from this study provide detailed information to understand hazardous tasks/activities related to drywall hanging as viewed from the workers' perspectives.

### 311

#### SOFT TISSUE INJURY PREVENTION IN CONSTRUCTION: TRAINING FOREMEN TO IDENTIFY ERGONOMIC RISKS THROUGH WORK SITE OBSERVATION. S. Hecker, B. Gibbons, Labor Education and Research Center, University of Oregon, Eugene, OR

A soft tissue injury prevention policy (STIP) was developed with a large general contractor to address high incidence of musculoskeletal disorders in construction workers. The policy targets manual materials handling, work heights, body mechanics, and conditioning through a daily stretching regimen. An accompanying survey worksheet with instructions

was developed to implement the policy. Implementation was attempted on a large fast-track construction site by targeting foremen from various trades and subcontractors who were designated as safety group leaders. Training on ergonomic risk factors, specifics of the policy, and use of the worksheet was provided at weekly safety group leader meetings. Foremen were instructed to observe and record ergonomic risks during weekly safety walk-throughs already required of them. An ergonomist also performed weekly audits in selected areas of the site. Effects of training and policy implementation were assessed through a telephone survey of foremen, interviews with the site superintendent, and comparison of ergonomist and foremen audit findings. In interviews 70% of foremen were able to identify at least one ergonomic risk factor, and 46% identified risks in specific tasks of their trade because of the intervention. Only 12% carried out the ergonomic audit and 4% used the survey form. Low participation in safety walk-throughs resulted from lack of time, resistance of supervisor, and poor communication. Low participation in ergonomic audits resulted from training deficiencies, resistance to paperwork, and perceived lack of relevance. Awareness of musculoskeletal injury risk was high, but such risks were not seen as the major hazards on the site. Where specific interventions took place on ergonomically hazardous tasks, crews had greater awareness of risks and countermeasures. Recommendations include establishing accountability with subcontractors in the bid process and with foremen and superintendents at outset of project, more systematic training, and clearer demonstration of task-specific ergonomic solutions.

### 312

#### COMPONENT ANALYSES OF GRAIN DUSTS THAT CONTRIBUTE TO OCCUPATIONAL LUNG INJURY. A. Martinez, G. Cosma, Colorado State University, Fort Collins, CO; G. Kullman, D. Lewis, NIOSH, Morgantown, WV; H. Gardner, U.S. Army Center for Environmental Research

We have developed a lung cell model to explore the pathways of oxidative injury in lung alveolar macrophage (AM) cells exposed to respirable grain dusts. There is a twofold purpose for performing these studies: (1) identify major toxic components of grain dusts and (2) define underlying pathways of inflammatory lung injury. Airborne, respirable wheat and corn dusts were collected at 10 grain elevators in southeastern and northeastern Colorado during harvest. High-flow air pumps, set at 1.7 L/min, were used with 10 cm cyclones to collect dust samples. Samples were analyzed for levels of bacterial endotoxin via chromogenic limulus amoebocyte lysate, crystalline silica via X-ray diffraction, and 20 metals via inductively coupled plasma/mass spectrometry. Surprisingly, aluminum levels were found to exceed the part per thousand level, while iron was the second most common metal detected in grain dusts. As expected, endotoxin levels varied with site and grain; however, we have found imperfect correlations between levels of endotoxin contamination in dusts and the severity of the following inflammatory responses in dust-exposed AM cells: (1) production of hydrogen peroxide and (2) synthesis of

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