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^2 of steel surface cleaned for specular hematite to 25 lbs/ft^2 for steel grit. The abrasives' average cleaning costs ranged from about \$2.60/ft^2 of steel surface cleaned for olivine, to as high as \$3.60/ft^2 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.

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EVALUATION OF VIBRATION IN HEAVY CONSTRUCTION EQUIPMENT. N.K. Kittusamy, Marshall University, Huntington, WV; B. Buchholz, University of Massachusetts Lowell, MA

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^2 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.

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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.

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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. Foreman 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.

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COMPONENT ANALYSES OF GRAIN DUSTS THAT CONTRIBUTE TO OCCUPATIONAL LUNG INJURY. A. Marinez, 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 amebocyte 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

cytokines interleukin-1/6 and TNF-alpha as measured by immunoassay. These studies suggest the presence of other toxic components in grain dusts, possibly related to levels of metals and silica. We have designed a multiple linear regression model to evaluate the strengths of associations between individual components of the dusts and the severity of inflammatory responses in AM cells. Concern over current permissible exposure limits of organic dusts may be partially resolved by identification of their major toxic components, rather than by monitoring total respirable dust mass.

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COMPONENT ANALYSES OF GRAIN DUSTS THAT CONTRIBUTE TO OCCUPATIONAL LUNG INJURY. A. Martinez, G. Cosma, Colorado State University, Fort Collins, CO; D. Lewis, G. Kullman, NIOSH, Morgantown, WV; H. Gardner, U.S. Army Center for Environmental Health 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 amebocyte lysate assay, 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, (2) synthesis of cytokines interleukin-1/6 and TNF-alpha as measured by immunoassay. These studies suggest the presence of other toxic components in grain dusts, possibly related to levels of metals and silica. We have designed a multiple linear regression model to evaluate the strengths of associations between individual components of the dusts and the severity of inflammatory responses in AM cells. Concern over current permissible exposure limits of organic dusts may be partially resolved by identification of their major toxic components, so that exposure limits can be determined by screening of these individual agents, rather than by monitoring total respirable dust mass.

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RESIDUAL PESTICIDES IN HOUSING AND BEDDING AT MIGRANT LABOR CAMPS IN NORTHWESTERN OHIO. T.M. Bliss, L. Kincl, E. Auyang, J. Baker, L. Dye, P. Everitt, J. Mangharam, E. Paternak, C. Rice, University of Cincinnati, Cincinnati, OH

Few data are available regarding residual home pesticide exposure of migrant farm workers and possible health effects. Field conditions often provide no opportunity for washing skin or clothing to minimize pesticide contamination. Contamination of living spaces, including surface dust and bedding, may prolong exposure if pesticides are "carried home" The purpose of this investigation was to evaluate potential exposure of migrant workers to residual pesticides that may be carried from the field into labor camp housing, document hygiene practices, and conduct postural sway measurements.

Loose house dust samples were collected on paper filters using a handheld vacuum from bedding and mattresses, and on furniture and floor spaces. Samples were fractionated and weighed. The fraction considered to be most likely to contribute to residual contamination were those passing through a 250-micron sieve. The average amount collected was 1.8 g/m^2 (± 0.9, n=13). Samples are also being analyzed for lead, arsenic, copper, zinc, and organic pesticides including azinphos-methyl, carbaryl, diazinon, endosulfan, lindane, malathion, methomyl, methoxychlor, and methyl parathion.

Interviews were conducted with 32 migrant workers and family members to evaluate conditions that would contribute to potential pesticide exposure, such as personal hygiene facilities and practices, laundry facilities and practices, and use of protective equipment. Seventy-eight percent of the respondents had received safety training about pesticides. A dust mask was the only personal protective device reportedly used when handling pesticides by 100% of the respondents. One-hundred percent of the respondents also indicated that they showered daily and washed their hands after work in the field; however, only 59% indicated they washed bedding at least weekly.

Postural sway testing, which quantitatively measures the movement pattern of the body's center of pressure over a sway area (SA), was also conducted. Any subtle changes in a person's ability to maintain upright balance can be used to indirectly assess the status of the person's neurological system. Ten subjects performed eight sway tests that included two trials of the following tests: (1) eyes open (EO), (2) eyes closed (EC), (3) eyes open on foam (FO), and (4) eyes closed on foam (FC). Results show an increase in SA by 58% for EO, 11% for EC, 106% for FO, and 60% for FC compared with potentially unexposed population.

Educational programs are recommended to inform farm workers of the findings to help assure that hygiene measures are practiced to minimize residual exposures.

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AN INVESTIGATION OF A SULFIDE HAZARD IN THE PRODUCTION OF YELLOW MUSTARD CONDIMENT. R.J. Rando, H.G. Poovey, Tulane University, New Orleans, LA

Yellow mustard condiment is prepared from white mustard seed (sinapis alba L.), water, vinegar, salt, and various spices. White mustard oil contains sinalbinCa glucoside of p-hydroxybenzylisothiocyanate (PHBI). Upon crushing and wetting of the seed, sinalbin is enzymatically hydrolyzed releasing free PHBI. Under the acid conditions of the mustard preparation, PHBI rapidly hydrolyzes and releases COS, which itself slowly hydrolyzes in this acidic environment to H_2S. This series of chemical reactions may result in the accumulation of hazardous levels of these toxic sulfide gases inside industrial mustard vats. In the laboratory, a 2-L batch of yellow mustard was prepared in a closed reaction vessel using a commercial recipe. Over the course of 72 hours, the head space above the mustard was sampled for COS and H_2S. A rapid accumulation of COS and H_2S was noted over the first 12 hours, after which the head space concentrations continued to rise at a moderate rate, ultimately reaching 3486 ppm COS and 188 ppm H_2S after 72 hours. To confirm these results, sampling of a commercial mustard vat (15 ft x 10 ft diam.) containing 10 inches of yellow mustard residue showed COS and H_2S concentrations up to 794 ppm and 48 ppm in the head space, respectively. These data clearly indicate the potential for a serious toxic hazard from the accumulation of sulfides generated from chemical reactions in freshly prepared yellow mustard. Response to this newly recognized hazard, including ventilation controls and proper confined space entry procedures, will be essential in preventing potential injury to workers in this industry.

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PUBLIC/PRIVATE PARTNERING: A NEW PARADIGM FOR MANAGING PUBLIC AND PRIVATE SECTOR INTERRELATIONSHIPS. G.W. Drumm, Unifrax Corp., Amherst, NY; S. Brown, U.S. EPA, Washington, DC

Historically, evaluation and management of potential health risks to workers, community, and environment involved confrontation between private sector interests and public sector policy. With recognition of common interests and commitment to cooperation instead of confrontation, the limitations of adversarial relationships may be overcome. In some cases, public/private partnerships have been demonstrated to be an effective means of producing cost-effective, mutually desirable achievement.

Initiatives undertaken by the Refractory Ceramic Fiber Coalition (RCFC), a trade organization comprising the three largest manufacturers of refractory ceramic fiber (RCF) in North America, the United States Environmental Protection Agency (EPA), the National Institute for Occupational Safety and Health (NIOSH), and Occupational Safety and Health Administration (OSHA) provide noteworthy examples of public/private partnering. Each entity, collectively or independently, has pursued an ongoing evaluation of the potential health effects believed to be associated with RCF exposure.

The results of industry-sponsored health effects research led to implementation of the RCFC Product Stewardship Program, which has received support and encouragement from EPA, NIOSH, and OSHA. RCFC and EPA developed a consent agreement that has been invaluable for identifying and evaluating occupational exposures. RCFC and NIOSH have explored opportunities for joint efforts involving evaluation of workplace controls, technical data exchange, and development of communication documents. RCFC and OSHA separately evaluated establishment of a permissible exposure limit and periodically review current

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