

sorbent utilization with low total thickness and pressure drop. The polishing filter portion of the composite bed is composed of small, well-dispersed sorbent particles (10–250 µm) sintered in a layer several millimeters thick of micron diameter fibers. The outlet gas from the packed bed immediately encounters the high contacting efficiency polisher which reduces normal inefficiencies associated with the mass transfer zone/critical bed depth. Overall 5-log breakthrough time is greatly increased as compared to a conventional packed bed.

Test data using a hexane challenge, and other simulants, have shown this arrangement capable of 5-log protection for 85 minutes (200 ppm hexane, 24.2 cm/s face velocity) at only 1.3" H<sub>2</sub>O pressure drop and 1.3 cm total bed thickness. Two CPE composite bed types have been evaluated, regenerable and single use/throwaway systems. Regenerable composite beds utilize micron diameter nickel fibers in the polishing layer and high-temperature sealant for regeneration via TSA, PSA, and PTSA. 5-log protection was observed after six regeneration cycles via TSA. Single-use/throwaway composite beds incorporate polymer fiber polishing filters into current COTS units. This approach yields high logs of removal and increased bed utilization by addition of a thin polisher to the back of an existing COTS unit.

## Podium Session 127: Ergonomics in Construction and Heavy Industry

Papers 205–212

### 205

**BIOMECHANICAL EVALUATIONS OF FOOT PLACEMENT FOR CONSTRUCTION WORKERS ON STILTS.** C. Pan, S. Chiou, T. Kau, D. Ammons, D. Cantis, NIOSH, Morgantown, WV.

Stilts are elevated tools that are frequently used by construction workers to raise workers 18 to 40 inches above the ground. Previous studies indicated that construction workers perceive risk of injury when working on stilts. However, no in-depth biomechanical analyses have been conducted. The objective of this laboratory study was to evaluate joint loadings on lower extremities and potential loss of balance associated with the use of stilts in various foot placements. Twenty construction workers (mean age = 36 ± 7 years) with at least 12 months (mean experience = 10 ± 7 years) of experience in the use of stilts participated in this study. A PEAK™ motion system and two Kistler™ force platforms were used to collect data on both kinetic and kinematic measures. Subjects were tested under six foot-placement conditions. These six experimental conditions were statically tested under all combinations of three levels of elevation: 0" (no stilts), 24" stilt height, and 40" stilt height. SAS mixed procedure was used to evaluate the effect of different experimental conditions. The results of univariate analysis and principal component analysis

demonstrated that stilt height, foot placement direction, and foot placement width all had significant effects on whole body postural stability, as well as on joint loadings for lower extremities. This study found that the higher the stilts were elevated, the greater the postural instability and joint loadings. A foot position in which one foot was placed forward of the other foot produced greater postural instability and joint loadings than a position with two feet parallel and directly beneath the body. This study also found that placing the feet parallel and directly beneath the body, with the feet positioned either one shoulder width apart or 1½ shoulder width apart, caused less postural instability and joint loadings than at half shoulder width.

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**ERGONOMIC ASSESSMENT OF TANK TRUCK DRIVERS.** C. Chang, Exxon Mobil Corporation, Annandale, NJ.

One of the major tasks that a tank truck driver does during a delivery is removing the product and vapor recovery hoses from a storage area prior to off-loading petroleum products at gas stations and returning them back to the storage area. In general, a hose box was used to store the hoses for some trucks while a hose tray was used for others. Back and shoulder strains were reported, allegedly caused by pulling/pushing the hoses out of/into the hose box before/after off-loading the products. Using the Ergonomic Job Measurement System, a tool developed by Applied Ergonomics Technology Inc., two assessments were conducted to evaluate/compare the potential relative ergonomic risks of tank truck drivers handling the hoses stored in the hose box versus the hose tray. The assessment evaluated various elements of three major task categories, i.e., repetitive motion/awkward postures (Part I), lifting (Part II), and the ratio (%) of employee complaints (Part III). A score or ranking was assigned to each element and the sum of all elements (total score) was used to identify the risk ranking of the task with the following scale: high risk = 85 or more; moderate risk = 45–84; low risk = 0–44. The assessment resulted in a total score of 76 for handling hoses stored in the hose box, versus a total score of 53 for the hose tray, i.e., upper moderate risk and Lower Moderate Risk. This finding resulted in all tank trucks manufactured thereafter to be equipped with a hose tray as a standard design.

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**EVALUATION OF CAB DESIGN IN EARTHMOVING CONSTRUCTION EQUIPMENT.** M. Viswanathan, M. Jorgensen, Wichita State University, Wichita, KS; N. Kittusamy, NIOSH–SRL, Spokane, WA.

Awkward postures while operating construction equipment are due to improper cab design and work procedures. If not addressed, awkward posture of any body part can result in increased risk of fatigue, pain, or injury. The objective of this study was to use a checklist

for evaluating cab design of construction equipment. This checklist has 31 questions that can be used to evaluate different characteristics of cab design. Eighteen pieces of earthmoving construction equipment were analyzed, including excavators, dozers, and dump trucks. An overall score for each cab was calculated by assigning equal weight to all questions. Results showed that the overall total cab design scores for all equipment ranged from 77 to 97%, the higher the score the better the design. Some design concerns were: (1) the seat did not swivel in the majority of the equipment (94%), (2) the controls in most of the dump trucks were not adjustable, (3) among the various dump trucks, some of the operators felt vibration through the floor, seat, and/or controls of the cab, and (4) noise was a common problem among the dozers. This checklist was useful in identifying several design characteristics of the cab that may need further improvement, which in turn can be useful in reducing awkward postures and improving the working environment.

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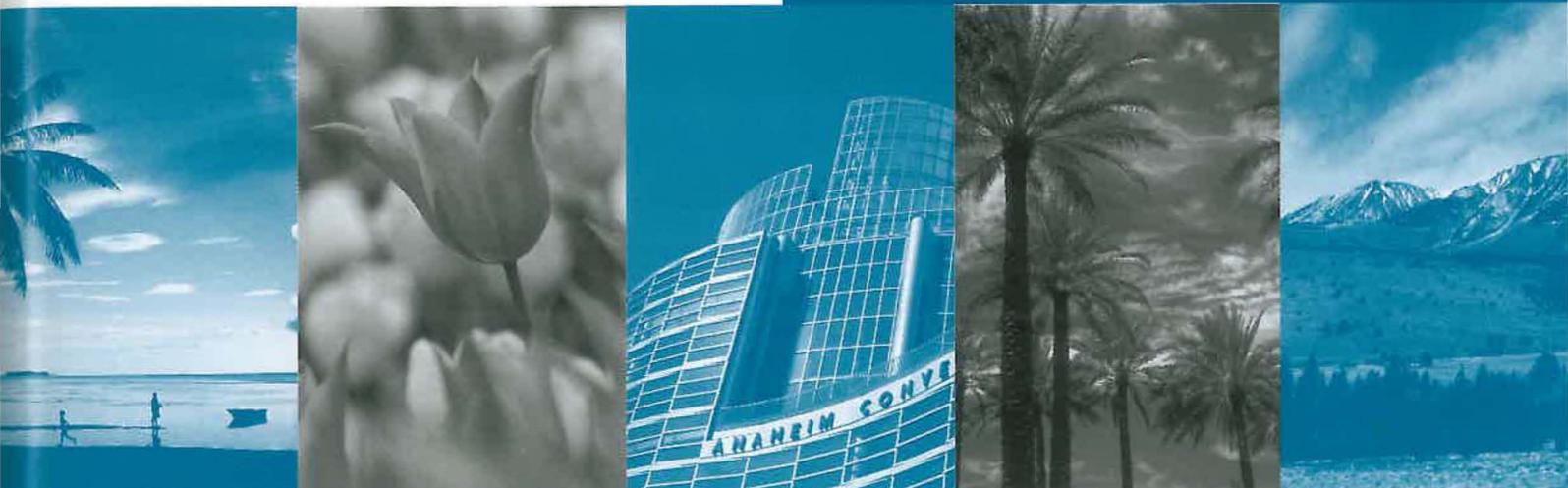
**EFFECT OF WORKPLACE RISK FACTORS ON GAIT TASK PERFORMANCE BY LOW-SEAM MINERS.** A. Bhattacharya, J. Gordon, P. Succop, T. Sobeih, University of Cincinnati, Cincinnati, OH; L. Kincl, University of Oregon, Eugene, OR.

The performance of tasks in mines with low ceilings requires work in restricted postures. Under these conditions the performance of dynamic (gait) tasks in stooping postures will cause potential loss of stability/balance to increase. A study was designed to quantify postural instability of 25 low-seam miners while carrying out mine-related tasks (walking with 20 lbs weight) under exposure to individual and combined risk factors of environmental lighting, surface slipperiness (DCOF range for firm-dry, uneven dry and firm-slippery surfaces: 0.9 to 0.22), and footwear (leather steel-toe boot and rubber steel-toe boot) used. The miners' kinematic and kinetic data, incidence of slip and fall events and perceived exertion (RPE) levels and perceived sense of slip (PSOS) were collected during the experiments. The type of walking surface was significantly ( $p < 0.0001$ ) associated with maximum medial force, maximum braking force, maximum propulsion force, and maximum lateral force with highest response observed for the uneven-dry surface followed by firm-dry and firm slippery surface. This was expected, as the firm-slippery surface does not provide the necessary foot-floor surface friction to allow development of adequate ground reaction forces and moments necessary for safe upright balance. This is supported by the fact that firm-slippery surface produced the highest level of slip (83% of trials produced slips) and fall incidences (8% of trials produced falls). Carrying a weight also significantly affected both RPE and PSOS ( $p < 0.0001$ ) inducing 20.5% greater RPE and 40.6% greater PSOS than not carrying a weight. This increased perceived level of exertion and slips

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