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AN ANALYSIS OF LABORATORY SAFETY PRACTICES AMONG AGRICULTURAL EDUCATION TEACHERS IN NORTH CAROLINA. C.L. Ford, F. Walson, North Carolina A&T State University, Greensboro, NC

Safety prevention in agricultural programs has become a major concern when training high school students for careers in agriculture and food science. In North Carolina, little is known about the laboratory safety practices of agricultural teachers when assessing student injuries and laboratory facilities. This study is designed to assess the perceptions of agricultural teachers in North Carolina regarding their laboratory safety practices. More specifically, the investigation is aimed at determining demographic characteristics of teachers, number of major and minor accidents in agricultural programs, instructional time devoted to safety, safety equipment available for students, and safety practices used in laboratories.

The sample population was comprised of 166 agricultural teachers randomly selected from a target population of 310 agricultural teachers in North Carolina. A survey questionnaire was mailed to collect data from the sampling population, which represented 54% of the target population. Seventy-five teachers completed the questionnaire, representing a 45% response rate. Some major findings were: (1) 49 teachers (65%) reported that they had liability insurance; (2) 53 teachers (71%) revealed that they were not certified in first aid and safety; (3) a majority of the agricultural teachers (78%) reported that they had less than 10 minor accidents to occur in the past 5 years; (4) 40 teachers (53%) indicated that they had no major accidents requiring attention from a doctor or nurse to occur in their laboratories during the past 5 years; and (5) 53 teachers (71%) revealed that they devoted less than 11% of their instructional time to teaching safety. In conclusion, there is a need for in-service safety workshops for agricultural teachers in North Carolina and additional curriculum materials to promote safety practices in the workplace.

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NICOTINE AS A FUMIGANT: EXPOSURES AMONG RESEARCH GREENHOUSE EMPLOYEES. A.M. Krake, NIOSH, Cincinnati, OH

An exposure assessment study was conducted by NIOSH investigators in response to a request from the manager of a university occupational health and safety program. The request concerned potential exposures of greenhouse employees and researchers to the insecticide nicotine during fumigation activities and maintenance of research plants. There were no reported health problems; however, there were concerns that employees may be reentering the greenhouse before nicotine air concentrations have decreased to a safe level.

A newly developed NIOSH sampling and analytical method for nicotine in environmental tobacco smoke was used to collect and analyze personal breathing zone (PBZ) and area air samples inside the greenhouse. It was hypothesized that during fumigation, nicotine may be present both as a vapor and bound or absorbed onto particulates generated during the fumigation process. Particle counts were measured over the same time periods as the nicotine concentrations to evaluate the correlation between them and assess the possibility of using the faster and more easily obtained particle count data to estimate nicotine concentration prior to reentry by greenhouse employees. Surface wipe samples were collected on commonly used greenhouse surfaces before and after the fumigation and analyzed for nicotine content.

PBZ samples collected for greenhouse employees ranged from nondetectable to 0.15 $mg/m^3$ and indicated that none of the employees were exposed to nicotine concentrations exceeding applicable occupational exposure limits (0.5 $mg/m^3$). Area air samples collected for nicotine in two greenhouse sections before, during, and after a 13-hour fumigation process indicated that nicotine concentrations peaked at 3.3 $mg/m^3$ within 10 minutes of the start of fumigation but fell within 40 minutes and were less then 0.5 $mg/m^3$ within 1 hour after fumigation began. Nicotine concentrations collected in a connecting hallway remained low (0.0017-0.16 $mg/m^3$) throughout the fumigation. The wipe samples results showed that some residual nicotine levels were almost 60 times higher after the fumigation.

Because nicotine is readily absorbed through the skin, employees may be exposed to nicotine when they touch greenhouse surfaces and use equipment. Particle count data were not useful predictors of nicotine concentrations and therefore could not be used to determine when it is safe to reenter the greenhouse.

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ASSESSMENT OF HIGH HAZARD-LOW FREQUENCY ACTIVITIES CONDUCTED ON IOWA FARM OPERATIONS. M.L. Jones, S. Reynolds, C. Zwerling. Institute for Rural and Environmental Health, University of Iowa, Iowa City, IA; W. Popendorf, Utah State University, Logan, UT

The agricultural sector of the United States has seen little change in injury and fatality rates over the last decade, and has been ranked as one of the most dangerous industries in the United States. As part of a multiyear medical and environmental surveillance project (Iowa Farm Family Health and Hazard Surveillance Project) in the state of Iowa, 12 high hazard-low frequency (HH-LF) on-farm activities were identified and evaluated for further in-depth study using an iterative Delphi process. The evaluation process ranked HH-LF activities according to the following criteria: frequency of hazard, severity of hazard, technical feasibility, economic feasibility, and research value. Two of the 12 HH-LF on-farm activities were chosen for further study: grain storage bin clean-out activities and power washing hog confinement buildings. The focus of the studies was on noise, dust, bioaerosols, and toxic gas exposures. The monitoring protocol for the grain storage bin clean-out activities included monitoring for noise; personal and area total particulate and endotoxin; area total bioaerosols; area mycotoxin; and quasi-personal exposure assessment of carbon monoxide, carbon dioxide, temperature, and relative humidity. The monitoring protocol for the power washing of hog confinement buildings included assessing noise; personal and area total particulate and endotoxin; area total bioaerosols; area inhalable dust; area respirable dust; area toxic gases (ammonia, carbon monoxide, hydrogen sulfide, and %LEL-methane); and quasi-personal monitoring of carbon monoxide, carbon dioxide, temperature, and relative humidity. The results from this investigation clearly show that both activities present farm operators with elevated exposures to noise, dust, bioaerosols, and toxic gases. The results from the assessment of these two different HH-LF on-farm activities will be presented and discussed, along with the contents of the monitoring protocols. Further, applicable control measures to reduce noise, dust, bioaerosols, and toxic gas exposures will be presented.

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EFFECT OF IN SITU COMPOSTING ON MALODOROUS GASES IN SWINE CONFINEMENT BUILDINGS. J. A. Kangas, K. Louhelainen, Kuopio Regional Institute of Occupational health, Kuopio, Finland; P. Viilos, A. Veijanen, University of Jyväskylä, Jyväskylä, Finland

Malodorous compounds emitted from swine manure are an important occupational and environmental factor. Ammonia and sulfur gases are the most occupationally harmful of the gases normally found in swine confinement buildings. More than 70 other malodorous compounds have been identified in swine manure. Among these are volatile fatty acids, phenols, and indoles are identified as the most malodorous compounds.

In this project seven swine farms were studied to find out the influence of the in situ composting system to the concentration and occurrence of malodorous compounds compared with those with a slatted floor pit-system. Sawdust was used as a composting material in these swine confinement buildings. The measurements of ambient level of malodorous gases were done in the farms before the change of the system. Afterwards the conditions in swine confinement buildings with in situ composting system were followed for 2 years. Ammonia was measured using diffusion tubes. Malodorous sulfur compounds were analyzed using laminated bags and portable gas chromatograph with FP-detector. Other odor-causing compounds were analyzed by gas chromatography/mass spectrometry system with simultaneous sniffing.

The most intensive and unpleasant odors were caused by p-cresol, carboxylic acids (C2-C7), and some ketones like 3-hydroxy-2-butanone, 2,3-butanedione, and 2-butanone. In swine confinement buildings where the composting system was functioning properly the concentration of sulfur compounds and especially carboxylic acids, ketones, and p-cresol was decreased effectively. The use of sawdust as composting material caused elevated concentrations of terpenes in ambient air.

Ammonia remained at a same level in both types of swine confinement buildings. Concentrations of odorous compounds did not exceed threshold limit values but several compounds exceeded the respective threshold odor concentrations.

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RESPIRABLE DUST AND CRYSTALLINE SILICA (QUARTZ) EXPOSURE RESULTING FROM POTATO HARVESTING OPERATIONS. L.J. Berberet, R. Buchan, M. Beard, Colorado State University, Fort Collins, CO; G. Kullman, NIOSH, Morgantown, WV

Occupational exposure to silica dust has historically been known to cause chronic respiratory conditions. Workers and workplaces within agricultural industries remain removed from the attention of occupational health and safety. To date, the identification and degree of exposure of respirable dust, crystalline silica, and endotoxin exposure throughout the potato harvesting process has been uncharacterized. A description of the potential occupational risks in this setting was therefore warranted. The agricultural practices specific to potato harvest, the geographic region, and the soil of the San Luis Valley, are believed to contribute to an occupational risk. The purpose of this research was to identify the components of dust during the fall potato harvest in the San Luis Valley of Southern Colorado. The testing sites were located within three counties of this valley, including seven farming locations. The farm sites were chosen based upon their location, variable soil types, and owner interest. The following parameters were measured: respirable dust, and respirable silica by the 10 mm cyclone; bacterial endotoxin (EU/$m^3$) by the Limulus amoebocyte lysate test; and scanning electron microscopy for particle identification purposes. All exposures were based on an 8-hour time-weighted average. Exposure impact included the following variables: location of the farming site, soil type (sand, rock, loam), individual job description, weather conditions (wind, rain, wet or dry soil during harvesting operations), humidity, and temperature. Results of air monitoring, and the identification, classification, and quantification of agricultural worker exposure to these risks have been reported with a maximum respirable silica (quartz) of 0.105 mg/$m^3$ identified, slightly exceeding the ACGIH TLV of 0.10 mg/$m^3$. This information will allow employers to recognize where silica dust is generated and allow for planning and control implementation to adequately protect workers.

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POLLUTION PREVENTION TO REDUCE WORKER EXPOSURE: ALTERNATIVES TO CHLORINATED CLEANING SOLVENTS. M.J. Ellenbecker, K.B. Thomas, Toxics Use Reduction Institute, University of Massachusetts Lowell, MA

An important source of worker exposure to solvents is parts cleaning. Such exposures typically are reduced by a combination of engineering controls, administrative controls, and personal protective equipment. Recent pollution prevention research, however, has suggested that a far more satisfactory approach, substitution, may be appropriate in many applications including parts cleaning. This paper discusses the results of a specific substitution research project, and the general conclusions that can be drawn about the use of this methodology by industrial hygienists.

This research program investigated the feasibility of nonsolvent alternatives for cleaning metal surfaces at two parts manufacturers and an electroplating job shop. The facilities all used vapor-phase degreasers employing trichloroethylene, 1,1,1-trichloroethane, methylene chloride, and CFC-113. At each facility a complete pollution prevention options assessment was performed, consisting first of options identification followed by technical, financial, and occupational/environmental health and safety (H&S) analyses. Options considered included various aqueous cleaning alternatives such as pressure spray washers, ultrasonic systems and immersion tanks, abrasive blasting, and $CO_2$ blasting.

Each technical evaluation identified viable nonsolvent alternatives, all of which reduced worker/environmental exposures. The financial analysis results were mixed. There was clear financial benefit to the parts manufacturers; the annualized costs of the new processes were less than the degreasers. Here, the nonsolvent substitution clearly is preferable, since it eliminates worker exposure while saving money. The job shop cleans a variety of substrates and soils, so that several cleaning systems were required to replace the degreaser. The financial analysis indicated that the new systems would be somewhat more expensive, so that there was no financial incentive to make the substitution.

The research reported here offers lessons that can be extended beyond these three companies. These lessons, including the benefits of the pollution prevention approach to industrial hygiene, are discussed fully in the complete presentation.

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EVALUATION OF CONTROLS USED TO REDUCE WELDING FUME EXPOSURES. M. Wallace, NIOSH, Cincinnati, OH

This report summarizes the data collected during a major control technology study of welding operations conducted at seven field sites. The purpose of the study was to evaluate the effectiveness of various engineering control measures in reducing welding fume exposures. Welding parameters varied at each location; however, all used arc welding techniques. Types of arc welding evaluated included shielded metal (stick or SMAW), gas metal (GMAW or MIG), flux cored (FCAW), and gas tungsten (GTAW or TIG). Metals welded included aluminum, mild steel, galvanized steel, and stainless steel. Five studies were conducted at industrial sites, while two studies were conducted at a union training center for welders and at a vocational school. The majority of evaluated control measures were classified as ventilation units, including portable and fixed local exhaust hoods, canopy hoods, and fume extraction welding guns. At one industrial site, rather than using ventilated measures, fume levels were controlled by modifying the process that involved using pulsed arc welding techniques in place of conventional GMAW techniques. During each field study, industrial hygiene air samples were collected to determine total welding fume concentrations and levels of airborne metals. The NIOSH analytical methods for total particulates (0500) and elements (7300) were followed. Additional information on total welding fume exposures was collected using real-time aerosol instrumentation. Results indicated that the ventilated controls ranged from being completely ineffective (a canopy hood system) to very effective, reducing workers' fume exposures by up to 83% (a fume extraction gun system). The process modification control method resulted in a 24% reduction in welding fume exposures. Overall, however, even with controls, exposure levels for total welding fume and metals such as hexavalent chromium, arsenic, and manganese occasionally still exceeded limits set by the ACGIH, NIOSH, and OSHA.

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THE DEVELOPMENT OF CONTROLS AND INK SUBSTITUTES FOR REDUCING WORKPLACE CONCENTRATIONS OF ORGANIC SOLVENT VAPORS IN A VINYL SHOWER CURTAIN PRINTING PLANT. H.V. Piltingsrud, A. Zimmer, NIOSH, Cincinnati, OH; A. Rourke, Ohio Bureau of Workers Compensation, Dayton, OH

During the summer of 1994 there were complaints of noxious odors reported by football players at a practice field located in Cincinnati. During Ohio Environmental Protection Agency (OEPA) investigations of industries surrounding the field, they inspected a printing facility located approximately one-quarter mile from the practice field. The facility produces vinyl shower curtains having screen-printed designs on them. Printing is carried out by means of movable screen printing units, having polyester screens approximately 6 × 6 feet. The printing units move over tables approximately 7 feet wide by 150 feet long. Four printing tables are located side-by-side in a room approximately 50 × 200 × 12 feet high. The OEPA found that they were not the source of the odor in question; however, they were in regulatory noncompliance for uncontrolled volatile organic compound (VOC) discharges to the environs resulting from their use of organic solvents in their printing process. The company was then required to install an air incinerator at the facility to treat discharged air. The cost of such equipment was very high, and the capacity of the incinerator they installed resulted in a reduction in the flow of discharged air to approximately one-third of previous levels, increasing solvent vapor concentrations within the workplace atmosphere to levels exceeding NIOSH, OSHA, and ACGIH acceptable concentration levels for worker exposure. Consequently, workers were required to wear organic vapor cartridge respirators nearly full time. The printing company requested NIOSH assistance in finding methods to reduce solvent vapor exposures. NIOSH studies included the identification of the sources and relative magnitude of solvent emissions from the printing process, the design of controls for solvent emissions from the printing process, and the development of substitute inks using nonphotochemically reactive (as defined by the OEPA) solvents. Controls included the enclosure of the movable printer units to suppress evaporation of solvents from the printing screen. The NIOSH-developed ink used lower evaporation-rate solvents, having TLV values >100 ppm. Their nonphotochemically reactive status allowed OEPA removal of the requirement for the incineration of discharged air. This allowed substantial increases in dilution ventilation, enabling a reduction in worker exposures to less than one-third TLV additive levels, and a consequential removal of requirements for respirator usage. The solution was the result of a comprehensive review of all facets of the problem, including OEPA regulations. It also

**Abstracts**

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