plete a computer-based multimedia course at some point during their first week of employment. Attendance sheet and evaluation forms were compared for this exercise. The computer-based multimedia course was well-received by second shift employees, and first shift employees had a preference for the multimedia option.

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DEVELOPING COST-EFFECTIVE CUSTOM INTERACTIVE MULTIMEDIA TRAINING PROGRAMS. D. Wolski, Environmental Resources Management, Inc., Exton, PA

Health and safety training programs have progressed from slides and lectures through straight video presentations and recently into train-the-trainer formats. The recent advent of computers with high speed microprocessors and CD-ROM technology has allowed the creation of another type of format: computer-based interactive multimedia training (IMT). IMT has been demonstrated to be one of the most effective and efficient ways of training workers. Increased retention, flexibility, documentation, and tracking are some of the reasons IMT is being regarded as one of the best ways to train employees. The only way to make IMT more effective is to customize it. Installing company logos, site-specific video footage, corporate-specific operating procedures, messages from facility managers are all ways to send the message a little deeper. The ultimate outcome is a well-trained workforce capable of responding in the most appropriate way to physical and chemical hazards they encounter in their workplaces. It is concluded that customized IMT programs are the best way to get this accomplished.

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GRADUATE EDUCATION VIA DISTANCE LEARNING. R. Soule, Indiana University of Pennsylvania, Indiana, PA

The escalating emergence of the safety/health profession has increased the demand for academically prepared professionals. It has had similar effect on the need for continuing education and graduate studies in the safety sciences. However, manpower surveys have indicated that the rate of supply of new professionals is not keeping pace with the demand. A significant roadblock is the physical distance the typical practicing safety professional has to travel to access formal professional education and training. One potential answer to the problem is making graduate study (and other forms of training and education) available by means of various forms of distance learning. The Safety Sciences Department at Indiana University of Pennsylvania (IUP) offers an ABET-accredited program leading to a Master of Science in safety sciences. In 1996, a commitment was made to make the program available through distance learning, with the first course, Concepts of Risk Assessment, available in the Fall of 1997. The format for "distance delivery" of each course consists of a major component, approximately two-thirds of course content, that is delivered via the Internet. For this component, students can register, participate in "lectures," conduct research, and complete assignments and projects all via the Internet. A second component, approximately one-quarter of the course content, is delivered by way of interactive audio, and in select locations video, teleconferencing. A final component for most courses is a "residency" aspect in which the instructor of record interfaces directly with students at appropriate sites determined by the location of registered students. Although the academic, technological, and administrative problems encountered in development of the courses are substantial, the contribution of the effort to needs of industrial hygienists and other safety professionals is vital to their continuing education.

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CUSTOMER VIEWS ON THE NIOSH MANUAL OF ANALYTICAL METHODS (NMAMTM). M.E. Cassinelli, P.C. Schlecht, National Institute for Occupational Safety and Health, Robert A. Taft Laboratories, Cincinnati, OH

The American Industrial Hygiene Association (AIHA) and the National Institute for Occupational Safety and Health (NIOSH) conducted a survey of over 1700 laboratories participating in the Proficiency Analytical Testing (PAT), the Environmental Lead Proficiency Analytical Testing (ELPAT), and the Asbestos Analyst Registry (AAR) Programs. The survey was designed to obtain customer feedback on the NIOSH Manual of Analytical Methods (NMAMTM) and industrial hygiene methods from other sources. Preliminary results of the survey indicate that laboratories prefer the current format of NIOSH analytical methods. In general, they found the NIOSH format to be direct, concise, and easy to read. The summary page of NIOSH methods was found to provide useful quick information on the subject chemical, its sampling and analysis, and its accuracy with respect to NIOSH criteria. Similarly, laboratories found the Method Finder, a list of chemicals with corresponding method name and number, as well as basic sampling information and analytical techniques, to be very helpful in locating methods. Comments related to a specific method or methods were received where laboratories felt that procedures were sometimes too brief, particularly in the calculations section. Numerous substances were suggested for method development. The most frequently stated dislike was that methods are not always up-to-date, particularly the GC methods where the specified packed analytical columns need to be replaced with capillary columns. The survey responses revealed a need for a central bank of methods so that all the industrial hygiene methods could be found in one place. The vast majority of respondents favor NIOSH publication of methods developed by others provided that NIOSH method validation criteria are met.

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DETERMINATION OF LOW MOLECULAR WEIGHT ALDEHYDES AND KETONES BY HIGH PERFORMANCE LIQUID CHROMATOGRAPHY. K. Wiesenthal, S. Que Hee, University of California, Los Angeles, CA

Human activities contribute to the production of low molecular weight aldehydes and ketones in air and water. They are released in to air as byproducts of combustion processes and industrial uses. Aldehydes and ketones are formed as byproducts of ozone reaction during water treatment processes. They are irritants; formaldehyde, acetaldhyde, and crotonaldehyde are carcinogens. While there is a gas chromatography method, there is no high performance liquid chromatography (HPLC) method for these derivatives. This was the aim of the present study. O-(2,3,4,5,6-pentafluorobenyl)-hydroxylamine hydrochloride (PFBHA) is a derivatizing agent for the carbonyl compound to produce oxime derivatives. The oximes were extracted with hexane, the solvent evaporated, and then dissolved in acetronitrile. Eleven different oxime derivatives were mixed in a cocktail. They were resolved on a 25-cm length Bio-Sil ODS-5S reverse phase of film thickness 5 µm column, with the following conditions: mobile phase 57% acetonitrile and 43% water; temperature 39 degrees C; flow rate 0.8 mL/min; UV detector wavelength 22 nm. These conditions allowed baseline resolution of 11 oximes. The run time was 113 minutes. The detection limit for most derivatives was 1 mg/L. The linear region for most derivatives was 1 mg/L to 36 mg/L. HPLC can be used to complement the standard GC method for quality control and quality assurance. It is inexpensive and easily performed.

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SYNTHESIS OF ALDEHYDE OXIME STANDARDS. J. Tso, S. Que Hee, University of California, Los Angeles, CA

Carbonyl compounds (especially those that are low molecular weight aldehydes) are receiving increasing attention in workplace air exposures, indoor air quality, and as disinfection byproducts in drinking water. Formaldehyde, acetaldehyde, and crotonaldehyde are known animal carcinogens. There is need to have a method that can be utilized for both water and air samples at ppb-ppm concentrations. While 2,4-dinitrophenylhydrazine is presently the only method used in this manner, other methods need to be developed because of difficulties with this method. The reagent 0-(2,3,4,5,6-pentafluorophenyl)methylhydroxylamine hydrochloride (PFBHA) is the most promising alternative reagent. Unfortunately, there are no commercial standards for the oxime derivatives of the carbonyl compounds. The conditions to produce pure oxime standards at yields >80% have been optimized for a number of low molecular weight aldehydes relative to temperature, reaction time, and isolation procedures. The optimum synthesis procedure differs for different aldehydes. About 1.1 to 1.3 times PFBHA is usually necessary, and heating by turntable microwaving at 87 degrees C is important for three heating-cooling cycles. Cooling at room temperatures is more efficient

than ice water quenching. Three extractions with hexane are optimal except for formaldehyde oxime, which requires precipitation and centrifugation. Quantitative analyses for purity and yield were done by gas chromatography/electron capture detection and gas chromatography/mass spectrometry, using nonpolar capillary gas chromatographic columns.

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VOLATILE ORGANIC COMPOUND (VOC) OFF-GASSING FROM RESIN SYSTEMS DURING THE CURING PROCESS. G. Boothe, Gobbell Hays Partners, Nashville, TN

The curing process of most resin systems is an exothermic reaction with a resultant off-gassing of VOCs. The composition and concentration of the off-gassing is highly dependent upon the chemical composition of the resin system and the volume and ventilation in the area where the mixing and use of the chemicals occurs. A potential exists for exposure to concentrations of hazardous chemicals at concentrations exceeding OSHA's permissible exposure limits (PELS) and/or ACGIH's threshold limit values (TLVs). This study was conducted to determine the composition of VOCs in the off-gassing of six different resin systems and quantify concentrations is a confined space.

Three of the resin systems were vinyl ester based, two were phenol-formaldehyde based resins, and one was a proprietary resin system. The resins were catalyzed with a specific compound such as benzoyl peroxide, methyl ethyl ketone peroxide, formaldehyde, paraformaldehyde. The chemicals were mixed in a sealed nonventilated chamber and allowed to cure. Air samples were taken on triple bed sorbent tubes and analyzed by gas chromatography/mass spectrometry using thermal desorption.

Styrene, formaldehyde, and furfural were measured at concentrations which exceeded the applicable PELS/TLVs in five of the six resin systems. The sixth resin system off-gassed benzyl alcohol at 4.5 mg/m^3. These data indicate that a potential exists for worker exposure to several hazardous chemicals at concentrations exceeding the PEL and/or TLV. This potential is higher for work requiring extended use of the resins in confined spaces.

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A SAMPLING AND ANALYTICAL METHOD FOR THE SIMULTANEOUS DETERMINATION OF MULTIPLE ORGANONITROGEN PESTICIDES IN AIR. E.R. Kennedy, National Institute for Occupational Safety and Health, Cincinnati, OH; J.J. Lin, J.M. Reynolds, J.B. Perkins, DataChem Laboratories, Salt Lake City, UT

Lack of accurate exposure estimates has been a weak link in associations of pesticide exposures with occupational illnesses. To provide more accurate airborne exposure information, an air sampling and analytical method was developed for organonitrogen-pesticides using a combined filter and XAD-2 sorbent sampler and high performance liquid chromatography (HPLC)-ultraviolet detection (UV). The method was evaluated for 14 organonitrogen pesticides by NIOSH evaluation guidelines and procedures. Evaluation experiments addressed limits of detection and quantitation, analytical recovery, sampler capacity, sample stability and precision and bias over a range of 12 to 240 g per sample. Samples were stable when stored for up to 30 days under either ambient or refrigerated conditions. Based on the finding of this work, 10 (aldicarb, captan, carbaryl, carbofuran, chlorpropham, diuron, formetanate, methiocarb, oxamyl, propham)of the 14 compounds studied can be successfully determined simultaneously using one method with an accuracy of better than +25% of the true value with 95% confidence. Two other compounds(carbendazim/benomyl, methomyl) can be measured with the same accuracy over a more limited concentration range. The remaining two compounds (propoxur, thiobencarb) may meet this criterion, but additional samples would need to be included in the data analysis. With the current data, these two compounds can be determined with an accuracy of better than + 27% of the true value with 95% confidence, This method will be included in the next edition of the NIOSH Manual of Analytical Methods as Method 5601.

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IMPROVED METHOD FOR QUANTIFYING ASBESTOS BELOW 1% BY WEIGHT IN BULK SAMPLES BY TRANSMISSION ELECTRON MICROSCOPY. M. Floyd, J. Fisher, B. Beadnell, A. Cuthbertson, Forensic Analytical Specialties, Inc., Hayward, CA

Regulatory pressures, the acknowledged imprecision of the traditional polarized light microscopy (PLM) analysis at low levels, and PLMs 1% detection limit have prompted the application of transmission electron microscopy (TEM) in determining the asbestos content in bulk samples at or below the 1% by weight level. The semiquantitative TEM floor tile (i.e, "Chatfield) procedure is well suited for that matrix, but has serious drawbacks when applied to other bulk sample types. Gravimetric residue suspensions are not uniformly represented in aliquots, particle distribution on prepared TEM grids is uneven, and the assumption that semiquantitatively determined area percent and actual weight percent are equivalent is suspect. An improved method is presented in which gravimetry is first performed to remove organic and acid-soluble components from the sample. Aliquots of the resulting residue are then filtered and mounted on TEM grids following standard procedures. Properly loaded grids are scanned at 2500x for large asbestos structures, and at 20,000x for smaller structures and fibers. Different aliquot volumes may be used for each scan, depending on the particle loading in the size of interest in the scan. The dimensions of detected asbestos structures are recorded and, using the known densities of the asbestos varieties detected, the mass of each structure is determined. Back-calculating through the sample preparation procedures results in the weight of asbestos in a known starting weight of sample, or weight percent asbestos. Detection limits as low as 0.0001 weight percent may be attained. The accuracy of this procedure has tested favorably against NIST standards and proficiency samples.

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COMPARISON OF THE PRECISION OF DUPLICATE FIELD SAMPLES FOR VOLATILE ORGANIC COMPOUNDS (VOCs) ANALYZED BY SUMMA CANISTER AND MULTISORBENT METHODS. G.E. Hadwen, J.F. McCarthy, Environmental Health & Engineering, Inc., Newton, MA; S. Womble, U.S. Environmental Protection Agency, Washington, DC

The purpose of the Environmental Protection Agency's (EPA's) Building Assessment and Survey Evaluation (BASE) study is to characterize many of the parameters associated with indoor environmental quality in non-problem office buildings. For the BASE study, the EPA attempts to collect measurements with the greatest degree of precision and accuracy possible. This analysis compares the precision of duplicate volatile organic compound (VOC) samples collected for the BASE study by two methods. For the BASE study, over 200 evacuated canister samples for VOCs, including 66 duplicate pairs, were collected in 34 buildings and analyzed by EPA Method TO-14. Twenty-eight multisorbent media samples, including 8 duplicate pairs, were collected in 4 of the 34 buildings and analyzed by a modified version of EPA Method TO-1. Each canister and multisorbent sample was analyzed for between 29 and 59 analytes. Precision was determined by calculating the duplicate residual for each analyte of each duplicate pair. The duplicate residual is the absolute value of the difference between the concentrations of the given analyte on each sample of the duplicate pair. This analysis indicated that the mean duplicate residual by multisorbent media, 0.29 parts per billion (ppb), was significantly lower ($p<0.00001$) than the mean duplicate residual by the canister method, 1.59 ppb. For many studies, the precision of either method may be adequate. Selection of appropriate sampling method depends upon the needs of the particular study, the analytes of concern, the precision required, and the convenience of the methods. Future needs include a comparison of the accuracy of the two methods.

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AN EVALUATION OF AN ENERGY DISPERSIVE PORTABLE SPECTROMETER FOR DIRECT MONITORING OF INORGANIC CONTAMINANTS. H.M. West, F.N. Medes Sheffield Hallam University, Sheffield, UK

The advent of portable X-ray spectrometers with energy dispersive detectors that do not require liquid nitrogen cooling offers the opportunity for direct measurements of workplace contamination. This study assessed analyser software and determined lower limits of detection for a range of analytes of interest.A critical comparison was made between a pre-calibrated portable energy dispersive X-ray fluorescence spectrometer (Spectrace SP9000) and a conventional laboratory based wavelength dispersive system (Philips PW2400). The ability of the SP9000 thin film calibration to convert measured intensities into meaningful concentration data was tested by measuring known amount of oxides deposited on AA Millipore filters. Line overlaps and inter-ele-

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