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ALTERNATIVE SAMPLING STRATEGIES FOR ASSESSING PERSONAL EXPOSURES TO HAZARDOUS AIRBORNE SUBSTANCES. M. Pannell, Los Alamos National Laboratory, Los Alamos, NM.

There are numerous field scenarios where insufficient data exists to adequately estimate personal exposures. As an ES&H manager, the only prudent choice is often to overprescribe the use of protective measures. Four case studies are presented to discuss scenarios where alternate sampling strategies provided additional information to better quantify exposure potential. These strategies have been successfully utilized to better estimate and project worker exposures where standard strategies were inadequate. The first case study discusses the use of area samples as a means to project personal exposures. Area samples that represent the worst case airborne concentration may be manipulated with working area volume to estimate worker exposure. The second case study presents a technique to estimate personal exposures utilizing surface wipe samples. This strategy assumes that the maximum airborne concentration cannot exceed the concentration of material physically aerosolizable from a working surface. The use of personal high volume sampling as a means to ensure that the effective detection limit is adequate to make sound exposure management decisions is the topic of the third case study. This strategy has proven useful in scenarios where the contaminant is highly toxic, the amount of source material used is very small, and the activity duration is limited. The final case study applies the time weighting average formula to multiple characterized tasks performed within a single workday. Normalizing these multiple task averages provides a very close approximation to entire day samples. This strategy is effective in projecting workday exposures for personnel required to accomplish multiple, non-routine tasks. These case studies present strategies that have proven effective in estimating worker exposure when standard protocols are insufficient. They may additionally stimulate other sampling strategies to effectively manage worker activities within hazardous environments.

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DO CHEMICALS USED IN DENTAL OFFICES CONSTITUTE A RISK FOR THE PREGNANT WORKER? A. Filion, G. Lapointe, M. Paquette, Service du répertoire toxicologique, Commission de la santé et de la sécurité du travail, Montréal, PQ, Canada.

The purpose of this study is to identify dental products potentially dangerous to the pregnant worker or her unborn child through a rigorous evaluation. Many workers in dentistry are women in age of procreating: dentists, hygienists, assistants, etc. The Commission de la santé et de la sécurité du travail (CSST) has a program, "For a safe maternity experience," that ensures a safe working environment to the pregnant worker and allows her to be reassigned to other tasks presenting no danger during her pregnancy. Service du répertoire toxicologique provides a scientific expertise to the physician having to

decide if a pregnant woman exposed to chemicals at work must be reassigned. Approximately 600 dental products have been identified from requests addressed to Service du répertoire toxicologique. This allowed us to establish a list of 371 different ingredients to which we applied our method of evaluation. For each ingredient, data pertaining to pregnancy such as teratogenic, embryotoxic, fetotoxic, mutagenic and carcinogenic effects were evaluated through the analysis of information available in scientific literature. Most chemicals were eliminated at this stage since they did not present a danger for the pregnant worker. Relevant physico-chemical properties (physical state, volatility and water-oil partition coefficient), absorption routes and use were then taken into account to evaluate the dangers related to the 17 remaining ingredients. This allowed us to restrict to 6 the number of ingredients potentially dangerous to the pregnant worker. Our method of evaluation of the chemical risks incurred by pregnant women working in dental offices allowed us to point out, among the 371 ingredients evaluated, those presenting a risk for a pregnant worker. The physician in charge of the file can then direct his evaluation of the workstation towards these products to estimate the real level of exposition of the pregnant worker.

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A NOVEL METHOD TO ASSESS EXPOSURES. J. Elias, OHG Consulting Inc., St. Norbert, MB, Canada; L. Serbin, Enviro-test Laboratories, Edmonton, AB, Canada; R. Tetreault, T. Boulanger, Standard Aero, Winnipeg, AB, Canada.

Two workers showed symptoms of acid exposure (skin rash) on their arms. Observation and discussion with the workers did not discover an obvious path of acid vapours or mists given the control measures used. A detailed Job Hazard Analysis concluded that the symptoms shown by the workers were not likely to be caused by the job. Although two reviews showed that the skin rash was unlikely to be related to the job, the continued presence of the rash was a concern to both management and workers. To rule out (or confirm) acid as the source of the rash, and to give direction to controls, an absorbent patch was placed on the workers' arm as they went about their normal tasks. A sample blank was placed on the workers' back. The patch was prepared by cutting a 3 X 3 inch square of cellulose filter paper (Whatman 40 or equivalent) which was impregnated with fixative solution as described in NIOSH 7902, "Fluorides, aerosol and gas by ISE." No acid was found on the patches after being exposed for a normal shift. The patch tests supported the conclusions of the observations, staff discussions, and Job Hazard Analysis, that the skin rash was not likely due to acid exposures on the job. The use of this non-standard method of evaluating exposures was a useful tool in assessing worker risk.

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AN ASSESSMENT OF SYNTHETIC VITREOUS FIBER (SVF) DEVITRIFICATION & CRYSTALLINE SILICA FORMATION BY INDUSTRY SEGMENT AND APPLICATION. D. Venturin, Unifrax Corporation, Amherst, NY.

As produced, synthetic vitreous fibers (SVF) are amorphous (glassy) materials which do not contain crystalline phase silica. Under some circumstances, continued exposure to elevated temperatures may cause portions of the otherwise vitreous fibers to devitrify (become crystalline). Based on phase dia-

grams, cristobalite formation takes place at sustained temperatures of 2192°F (1200°C), however; the formation of crystalline silica (cristobalite) is highly dependent on the duration of exposure to high temperatures, fiber chemistry and/or the presence of fluxing agents. The formation of crystalline phase silica can only be confirmed through laboratory analysis of the "hot face" fiber. Member companies of the refractory ceramic fibers coalition (RCFC) have conducted exposure monitoring of employees performing afterservice fiber insulation removals under an agreement with the USEPA. The findings demonstrate that although the formation of crystalline silica is possible, the vast majority of samples collected did not contain detectable levels of airborne respirable crystalline silica. The next phase of this study is to evaluate the "hot face" SVF insulation, prior to removal, to determine the extent of crystalline silica formation in the bulk materials. In addition to sampling of SVF's, bulk samples of other potential silica containing source materials (insulating firebrick) have also been collected, in order to identify other potential sources of crystalline silica. Data has also been collected to evaluate crystalline silica formation by industry segment and/or job task. This information is vital to advancing our understanding of what specific SVF applications have demonstrated the potential to form crystalline silica. This presentation will present data on crystalline silica formation resulting from specific SVF applications and within various industry segments.

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A CHECKLIST FOR QUALITATIVE ASSESSMENT OF METALWORKING FLUIDS. G. Piacitelli, D. O'Brien, W. Sieber, NIOSH, Cincinnati, OH; M. Sheehan, West Chester University, West Chester, PA.

Most OSHA health standards require that "initial monitoring" of worker exposures be conducted to determine the frequency of further exposure monitoring, to select appropriate respiratory protection, and to determine the need for engineering controls. In 1999, the OSHA Metalworking Fluids Standards Advisory Committee (MWF-SAC) recommended that an alternative approach to initial monitoring requirements be considered for the metalworking industry. The Committee recognized that some machining situations (such as low volume or well-ventilated operations) may not be expected to create exposures to metalworking fluids above applicable exposure limits. In these cases, it was felt that a qualitative assessment checklist could be utilized rather than air samples. This approach would particularly benefit small employers which lack industrial hygiene expertise and resources. Members from the MWF-SAC and NIOSH developed a checklist of qualitative information and observations thought to be useful for predicting the need for exposure monitoring. For validation, this checklist was sent to employers who had participated in a NIOSH study of MWF exposures in machine shops. Checklists were returned from 34 shops (a response rate of 43%) and analyzed to determine if there was a relationship between checklist responses and MWF concentrations measured previously by NIOSH. Linear regression was used to determine which checklist questions were most highly associated with MWF levels. Multi-variable models were then developed incorporating different variables which were significantly associated ($p < 0.05$) with the compliance fraction (i.e., the percentage of sample values over the NIOSH REL of 0.5 mg/m³). The best model ($R^2 = 0.93$) included factors for fluid management,

housekeeping, ventilation, and work practices. These findings suggest that an appropriate checklist could be used as objective evidence that a quantitative exposure assessment may not be necessary.

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USE OF RISK DENSITY MAPPING TO REFINE RISK ESTIMATES FOR BERYLLIUM EXPOSURE AT HANFORD. K. Ertell, University of Washington, Richland, WA; T. Takaro, B. Stover, University of Washington, Seattle, WA.

Beryllium was used in nuclear fuel rod research and manufacturing at the Department of Energy's Hanford site in eastern Washington from approximately 1950 to 1988. With the increased recognition of chronic beryllium disease as an occupational health issue, there has been great interest in identifying buildings where beryllium was used and characterizing risk for workers. Although there are workplace exposure records and other records indicating where beryllium was used at Hanford, the records are not believed to be complete. Using job histories, an exposure matrix, results of medical screening tests (beryllium LPT test) for both current and retired Hanford workers, and recent building characterization data, risk density maps of Hanford work locations have been produced. These maps show person-years of beryllium exposure and job titles by work location for both sensitized and non-sensitized exposed workers. By combining and comparing these multiple sources of information for the risk density mapping, the list of buildings where beryllium was used has been refined; information about the types of work performed by sensitized workers has been gathered; and the work locations for beryllium-exposed workers have been defined in greater depth. The results of the risk density mapping will help prioritize future building characterization, guide work planning for decontamination and decommissioning, and refine risk estimates for current and former workers.

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SELECTION OF A STUDY POPULATION OF FLIGHT CREW EXPOSED TO COSMIC RADIATION FOR AN EPIDEMIOLOGIC STUDY. M. Waters, E. Whelan, L. Yong, E. Ward, NIOSH, Cincinnati, OH.

Aircraft flight crew are exposed to cosmic radiation of galactic and solar origin, and cosmic radiation dose (CRD) depends primarily on altitude, geomagnetic latitude and solar activity. Epidemiologic studies of flight crew currently underway at NIOSH are evaluating relationships between cumulative CRD and a variety of health outcomes. The quality of the historical CRD reconstruction for individual crewmembers is a prime determinant of the strength of these studies. The objective of this work was to develop criteria for and select a single domicile (home base) with sufficient flight crew at the high end of the range of cumulative CRD. Eleven domiciles were initially selected based on high numbers of international flight crew stationed there, then narrowed to five domiciles based on number and frequency of international destinations and more northerly latitude of the domicile. CRDs were estimated using an FAA computer model for every non-equatorial international flight into each of these domiciles. The model requires origin and destination cities, number and height of in-flight altitudes, and flight duration as input variables, and estimates dose based on the most efficient route incorporating the input constraints. Estimated flight durations were

obtained from published schedules and altitude assumptions were based on pilot estimates for several flight duration and route categories. CRD estimates were computed and ranged from 24.6 to 58.4 uSv/flight. The final domicile was selected balancing the highest dose range for the domicile and frequency and multiplicity of the highest dose routes. This approach allowed selection of a highly exposed study population to be used for recruitment into an epidemiologic study. Future work will include calculation of individual cumulative CRDs for study participants based at the selected domicile using detailed flight histories obtained from the company. Estimation of individual quantitative exposure estimates will strengthen the exposure-response analyses in this study.

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THE USE OF A JOB EXPOSURE MATRIX TO CHARACTERIZE OCCUPATIONAL EXPOSURES IN THE NATURAL GAS INDUSTRY. N. Maher, Occupational Health Clinic for Ontario Worker, Sarnia-Lambton, Point Edward, ON, Canada.

A questionnaire was designed, implemented and analyzed, using a job exposure matrix format, to profile jobs in a natural gas pipeline system with respect to possible hazardous exposures. The categories of chemical, physical, ergonomic, biological and psychological hazards were surveyed. A list of hazardous agents existing in the pipeline operations was formulated and confirmed, by on-site observations, interviews with hygiene and safety supervisors and workers, and review of the literature. The second stage of the project entailed the collection of data about whether or not a particular hazard was present at a location, and if so, which workers had exposure to it, and at what intensity and frequency they were exposed. This assessment was made by groups of expert assessors, senior workers who were familiar with the processes and range of job titles at their location. These experienced workers rated all job titles for workers at that site. Finally, the data were critically examined in three spheres: validity, agreement and sureness. A comparison of similar exposure groups for hazardous noise as defined by the expert assessors, with known outcomes of 1995 hearing tests was performed. Secondly, the agreement between the rating done by the expert assessor group and the rating done by the job holder was examined, resulting in fair to moderate agreement (Kappa scores of 0.31, 0.41 and 0.44). When there was disagreement, most often the expert assessors identified a hazardous exposure which the job holder did not, resulting in most errors falling on the more protective rather than less protective side.

Consideration was given to the sureness expressed by each of the rating groups about the analysis they provided. Similar exposure groups across a geographically and functionally diverse industry were identified so that hygiene, safety and medical surveillance initiatives could be appropriately targeted.

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FUZZY INDUSTRIAL HYGIENE. J. Jankovic, Oak Ridge National Laboratory, Oak Ridge, TN.

A fuzzy number represents a range of possible values and as such has a possibility or belief associ-

ated with it. Fuzzy numbers, just as fuzzy logic, has its origin in fuzzy set theory developed in the 1960s; here the similarity ends. Fuzzy numbers describe uncertain quantities in terms of belief, "best guess," or professional judgment. Hazard assessments made by industrial hygienists are often constructed of just such uncertainties. Difficulties sometimes arise when "bottom line" people just want the number. Fuzzy number analysis provides an approach when hard numbers are not available. This is accomplished by mathematically combining uncertain numbers to produce a belief graph which looks statistical in nature. However, it is not; it is biased towards what one believes most strongly. Two applications involving possible contaminant generation and exposure are developed which demonstrate the process. A third application is provided which is associated with asbestos quantification from bulk samples in which the asbestos amount in the matrix is believed to be small, i.e., in the 1% region. This last example is added to demonstrate the wide ranging applications possible using the fuzzy analysis process.

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A BERYLLIUM SURFACE CONTAMINATION RISK ASSESSMENT METHODOLOGY. J. Jankovic, C. Wilson, Oak Ridge National Laboratory, Oak Ridge, TN.

The process the industrial hygiene group at Oak Ridge National Laboratory is using to find and evaluate the potential risk of "legacy" beryllium possibly remaining from post WWII nuclear technology development is presented. The first step in the process is to identify facilities where beryllium was used by reviewing historical records, equipment designations, and the institutional memory of employees. The second step in the assessment is to find the beryllium. A statistical sampling protocol using the binomial distribution was developed to estimate the number of samples needed to have a 95% probability of finding a positive surface if existing. A length by width grid system is applied to each area with sets of coordinates drawn at random to match the sample number requirement. Each sample grid surface is wiped using an inexpensive beryllium colorimetric screening test (BCST). Areas returning positive results for beryllium on surfaces are risk categorized by using a specialized surface sampling system that measures the resuspension potential of the beryllium in terms of predicted air concentration. Category 0 represents no resuspension potential, category 1 represents a resuspension potential < OEL, and category 2 represents a resuspension level \geq OEL. Category classification is used to establish administrative controls as well as remediation priorities.

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OXYGEN DEFICIENCY HAZARD ASSESSMENT AT THE SPALLATION NEUTRON SOURCE. J. Jankovic, R. Cornwell, Oak Ridge National Laboratory, Oak Ridge, TN.

Oak Ridge's linear accelerator portion (LINAC) of the spallation neutron source (SNS) is superconducting in order to enhance beam output and reduce energy operating costs. Helium cryogenic cooling requires a large inventory, a substantial portion of which is circulating in the limited space of the LINAC tunnel. Large inventory coupled with an expansion ratio of approximately 754:1, going from liquid to gas, makes the potential for oxygen deficiency a primary concern during non-beam periods when the tunnel may be occupied. At SNS a hazard

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