measurements in the field: the Dräger CMS and the UltraRAE specific vapor monitor. The former is essentially an automated tube reader and the latter a photoionization detector with a pre-tube that removes interferences. In a series of tests at oil refineries, these two methods were compared with established methods including the Photovac Snapshot portable GC, and laboratory GC analysis.

All the field instruments gave detection limits of 0.1 ppm and were relatively unaffected by humidity. The advantages of the CMS included small size, simple operation, and no calibration requirements; its range was up to 10 ppm benzene. The UltraRAE had rapid response time (<2 min.), small size, simple operation, and good accuracy; its range was up to about 100 ppm benzene and 500 ppm total hydrocarbons. The Snapshot gave good accuracy in the presence of at least 1000 ppm total hydrocarbons. The field methods gave enough accuracy to make them useful for personal protective equipment decisions.

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A COMPARISON OF TRACER GAS ANALYTICAL TECHNIQUES: INFRARED ABSORPTION AND GAS CHROMATOGRAPHY-ELECTRON CAPTURE DETECTION. C.B. Keil, Bowling Green State University, Bowling Green, OH

Sulfur hexafluoride (SF6) is commonly used as a tracer gas for a variety of occupational health applications. SF6 has been used in evaluating general ventilation and air mixing indoors, testing the effectiveness of local exhaust ventilation, and checking for the recirculation of exhaust air.

Two common methods of analyzing air samples for SF6 concentrations are the use of infrared absorption and gas chromatography. These methods were compared under both laboratory and field conditions. One method was a factory calibrated Foxboro Miran 1B portable infrared analyzer. The other method consisted of whole air syringe sampling with subsequent analysis on a calibrated bench-top gas chromatograph equipped with an electron capture detector (GC-ECD).

Comparison tests were done for four scenarios. The first was the analysis of a known concentration lab standard. Next, SF6 was released at a known rate in a room that approached well-mixed conditions due to the use of fans to mix the air in the room. The last scenario consisted of known SF6 release rates in two rooms under normal ventilation conditions. When room sampling was done, syringe samples were taken immediately adjacent to the Miran inlet.

For well-mixed situations the two methods were in good agreement at concentrations greater than 3 ppm ($p<0.05$). In situations where the air was less than well-mixed and may have had concentration gradients, the Miran results were significantly lower than the GC-ECD results ($p<0.05$). This may be the result of the flow field induced by the Miran sampling, but requires further study. Additional investigation of these tracer gas analysis techniques is needed to ensure their appropriate use in industrial hygiene investigations.

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PERFORMANCE COMPARISON OF RESPIRABLE SAMPLERS. C-C. Chen, C. Lai, National Taiwan University, Taipei, Taiwan; T. Shih, Institute of Occupational Safety and Health, Council of Labor Affairs, Taipei, Taiwan

Three products of respirable samplers (nylon cyclone, SKC cyclone, and foam sampler) were tested for aerosol penetration as a function of aerosol size, to examine the precision and the accuracy with respect to the newly defined respirable convention. An ultrasonic atomizing nozzle was used to generate micrometer-sized liquid DOP or solid potassium sodium tartrate aerosol particles, with count median diameters of 3 to 8 mm, and geometric standard deviation of 1.65. The aerosol number concentration and size distribution upstream and downstream of the sampler were measured by using an Aerodynamic Particle Sizer.

The newly designed foam sampler was found to be ideal for sampling liquid aerosols, provided the airborne pollutants do not react chemically with the foam, as this may result in change in foam filtration properties, such as packing density and foam thickness. Foam samplers had a better fit to the ISO respirable convention and, therefore, the bias caused by the foam sample was less. Extra attention was paid to the manual fabrication process of foam samplers, since only a small number of foam samplers were needed in present study. Thus, it may be unjust to conclude on the higher precision of the foam sampler compared with the cyclone samplers, as the latter were mass-produced. Indeed, the nylon cyclone and SKC cyclone showed approximately the same level of precision and bias. In order to consider both accuracy and precision, the mean square error should be used to judge the performance of the samplers. The foam sampler was found to be ideal for liquid DOP aerosols. The foam was comparatively better than the cyclones when solid particles like potassium sodium tartrate were used, provided the particle size was smaller than 5 mm. The foam sampler performed very poorly when solid particles larger than 10 mm were used.

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NEW PROTOCOL FOR TESTING PERSONAL INHALABLE AEROSOL SAMPLERS: WIND TUNNEL EVALUATION. V. Aizenberg, S. Grinshpun, K. Willeke, O. Witschger, University of Cincinnati, OH; J. Smith, P. Baron, NIOSH, Cincinnati, OH

Modern industrial hygiene puts ever-increasing demands on the monitoring of workplace airborne particular contaminants. Several personal inhalable aerosol samplers are currently widely used and more are under development. Accordingly, it is well recognized that establishing an accurate, precise, and less costly sampler performance testing protocol is essential.

In our recent study, we introduced a simplified aerosol sampler performance testing protocol. The main innovation of this protocol was a small rectangular simplified torso, 33 H 21 H 21 cm^3, that can be used in significantly smaller wind tunnels. The simplified torso simultaneously collects samples in three primary orientations: 0 , 90, and 180 degrees. In the present study, we extensively tested and substantially enhanced this new protocol. Three commercially available samplers (the GSP, IOM, and 37-mm closed-faced cassette) and a recently developed "button" sampler were evaluated in a large cross-section wind tunnel. The samplers were tested at two wind velocities (50 and 200 cm/s) and three orientations (0, 90, and 180 degrees). Three particle sizes (7, 29, and 70 mm) were used.

Analysis of variance has been done on the samplers' performance data. It shows that aerosol sampling efficiency demonstrated by all four samplers mounted on the simplified torso is statistically not different from when they are mounted on the full-size manikin. Thus, the simplified protocol to a large extent meets requirements set by the IH and aerosol communities on the testing of personal aerosol samplers.

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OCCUPATIONAL HEALTH STANDARDS AND THE ROLE OF THE OCCUPATIONAL HYGIENE SPECIALIST: AN OUTSIDER'S VIEW OF THE RUSSIAN EXPERIENCE. J.H. Vincent, University of Minnesota, Minneapolis, MN; Y. Thomassen, National Institute of Occupational Health, Oslo, Norway; E. Nieboer, McMaster University Hamilton, ON, Canada

The authors visited Russia in February 1997 and met with senior officials in the Russian Federation Department of Sanitary and Epidemiological Surveillance in both Moscow and St. Petersburg. The purpose of the visit was to learn about the development and application of occupational health standards in that country, and to see how these were similar to and different from the approaches taken in other countries. Russian occupational exposure standards are very stringent and so, in principle, provide a very high level of protection of workers. However, based on experience in the West, we know that these are difficult to enforce. Indeed, it is not clear to what extent the Russian exposure standards are enforced. Based on the observations of these outsiders, it is suggested that the development of a strong and distinctive occupational hygiene discipline and profession in Russia would provide a bridge to enable more effective implementation and interpretation of those standards.

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OCCUPATIONAL HYGIENE IN VIETNAM: CHALLENGES AND OPPORTUNITIES. M.A. Waters, T. Meinhardt, R. Mullan, M. Nguyen, NIOSH, Cincinnati, OH

NIOSH representatives were hosted by the Vietnamese National Institute of Occupational and Environmental Health (VNIOEH) in the Ministry of Health to determine needs for the development of occupational hygiene in Vietnam. Occupational health organizations and workplaces visited included VNIOEH, Labour Protection Institute, provincial preventive medicine and occupational health centers, medical and public health schools, coal mine, tobacco factory, rubber plantation and manufacturing facility, farms, construction sites, and small business enterprises.

The Vietnamese work as part of an informal economy in which the vast majority (approxi-

mately 90% of all workers) are engaged in agriculture. Only 10% of workers are employed in the formal economy, with the labor structure as follows: 29% agriculture/fishing/forestry, 24% mining/manufacturing, 14% trade/small business, 6% construction, 4% transportation, and 23% public administration, financial, and other services. As in many developing countries, the economy is disadvantaged and mostly rural and agricultural. Basic needs include improved sanitation and environmental health. Factors identified that influence the assessment and control of occupational hazards include the small scale of many work enterprises with the complications that typify small businesses, low capital investment in occupational health activities, and an insufficient number of occupational hygienists. Occupational hygienists are usually physicians with extra training, often with a focus on development of disease or clinical symptoms rather than on assessment of exposure. Factors that may affect the way exposure limits are applied include the use of child labor; genetic differences; long working hours; and economic, social, and climatic factors. Child labor is particularly prevalent in agriculture, fishing, and small enterprises. Working hours are much longer in Vietnam than in industrialized countries, and workers often have several jobs. Additional needs and barriers for the development of occupational hygiene are identified.

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ENGINEERING CONTROL TO PREVENT THE SPREAD OF TUBERCULOSIS AMONG HEALTH CARE WORKERS IN THAILAND. P.A. Jensen, NIOSH, Cincinnati, OH; W. Uthaivorawit, Chiang Rai Regional Hospital, Chiang Rai, Thailand; D. Garrett, P. Zuber, Centers for Disease Control and Prevention, Atlanta, GA; K. Limpakarnjanarat, CDC-Thailand HIV/AIDS Collaboration, Bangkok, Thailand

After decades of declining incidence, tuberculosis (TB) is once again a major public health problem. From 1990 through 1994 the annual number of patients with TB at a hospital in Thailand increased from 257 to 455, largely related to an increase in HIV+ TB cases. A separate study of health care workers (HCWs) at this time showed a pattern of higher tuberculin skin test (TST) positivity among persons working in direct contact with patients and who had been employed for $1 year. These results suggest that HCWs are at risk of *M. tuberculosis* infection (i.e., TST positivity) that may be related to occupational exposure.

Three hospitals in Chiang Rai District were surveyed. The path of the patient was followed through each hospital (inpatient and outpatient) along with all diagnostic procedures. Ventilation measurements, architecture, and general observations were noted. This project is focused on implementing interventions to reduce the risk of nosocomial transmission of *M. tuberculosis* and to reduce the development of active TB disease among HCWs. The general infection control program with specific engineering controls is reported here.

The challenge was the development of inexpensive, low maintenance engineering controls that were easy to implement by developing countries. The following recommendations were made. All outpatient TB activities should be consolidated into one area rather than having infectious TB patients walking throughout the hospital. The general TB ward is of open construction and should be so maintained. An exhaust ventilation system serving two multipatient and two single-patient negative pressure isolation rooms was designed and is currently being installed at a cost of less than $3000. Class I biological safety cabinets were evaluated (face velocities of 35-400 ft/min were observed) and recommendations made to modify airflow rates. Bronchoscopy is an extremely high-risk procedure. Ventilation for this bronchoscopy room should be designed to provide directional airflow from the HCW to the patient and out of the room. In addition, the system should also minimize transmission to other areas within the surgical suite. Other recommendations were made for maximizing air exchange rooms, counseling rooms, radiology, waiting rooms, and other areas of the hospital.

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DEVELOPMENT AND IMPLEMENTATION OF AN ENVIRONMENTAL AND OCCUPATIONAL HEALTH PROGRAM FOR DOWNSTREAM PETROLEUM IN LATIN AMERICA AND THE CARIBBEAN. F.C. Zampello, Exxon Co., International Florham Park, NJ; R. Gelatt, Esso Inter-America, Inc., Coral Gables, FL

As businesses expand internationally in areas of the world where worker health, safety, and environmental (HSE) resources are limited or absent, HSE professionals will be responsible for setting up programs in these new areas. This report describes how an environmental and worker health program was developed and implemented for downstream petroleum operations in Central American, South American, and Caribbean countries that were largely absent of HSE regulations and a supporting infrastructure.

The presentation covers key elements of program development such as HSE policies that provided overall support for the program; a needs assessment survey that was performed to identify priority issues; and training programs, tools, procedures, systems, and resources. Implementation aspects are also discussed including organizational roles, external resources, working in diverse cultures, and systems to provide management stewardship.

This experience points out that although many of the same risks need to be addressed for similar operations conducted in the United States, the limited availability of in-country HSE professionals, equipment, and supplies make development and implementation of these programs far more challenging.

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BUILDING OCCUPATIONAL HEALTH CAPACITY IN MEXICO: AN ONGOING COLLABORATION. A.L. Sussell, S. Baron, NIOSH, Cincinnati, OH; M. Tennassee, Pan American Health Organization, Washington, DC

In 1995, at the request of the Pan American Health Organization (PAHO) and the Secretary of Health of Mexico, NIOSH detailed a medical epidemiologist to Mexico to develop long-term collaboration with Mexican institutions to improve occupational safety and health. A collaboration was begun with the Mexican Institute for Social Security (IMSS), which has the most extensive research and training role in occupational safety and health. IMSS is supported by payroll taxes and provides comprehensive services for health and welfare to about 9.5 million workers and 30 million family members.

In February and March 1997 the speaker went to Mexico to develop a plan for industrial hygiene research and training in support of the NIOSH/PAHO project. He interviewed leading industrial hygienists in government and industry, accompanied IMSS and other government inspectors during 10 plant site visits, collaborated with Mexican investigators during 2 health hazard evaluations, and developed and taught 2 industrial hygiene courses. The plant site visits included small and medium-sized Mexican enterprises, as well as foreign-owned maquiladoras. At the current time, industrial hygiene is only beginning to develop as a profession in Mexico. There is lack of university training programs, and the regulatory agencies have not developed industrial hygiene expertise, promoting instead third-party private inspections. However, only a small group of the private industrial hygienists have education and professional experience comparable with U.S. standards. These hygienists reported that better government enforcement of the new Mexican occupational safety and health law of 1997 is needed to expand the market for their services in Mexico.

NIOSH, PAHO, and the World Health Organization are working with other public and private institutions to help develop industrial hygiene in Latin America. Planned activities are to develop a standard curriculum and promote continuing education of professionals.

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OCCUPATIONAL SAFETY AND HEALTH IN THE YEAR 2050: AN INTERNATIONAL LABOUR ORGANIZATION PERSPECTIVE. N.T. Watfa, International Labour Office, Geneva, Switzerland

The background of injury and disease against which the International Labour Organization (ILO) was established in 1919 was profoundly different from that of today. For example, 3197 miners died in the United States in 1907. In India a fatal accident rate of 1.29 per 1000 coal miners was registered in the period 1911 to 1920. By 1970 the U.S. fatalities in coal mines went down to about 150 year and the rate in India dropped to 0.34 in the 1980s. At the end of the century, accident rates in industrialized countries are typically 10 to 25% of their values in the first decades. Accident-free work can be achieved by the year 2050. This has been demonstrated by a few enterprises thanks to engineering control, self-regulation, harmonization of standards, and the future widespread of a safety culture. At the national level, the enforcing agencies will improve their techniques of enforcement. At the international level, data collection will depend on harmonized procedures that can be used for a global safety and health quality control system. The situation regarding health is more confused. Asbestos and silica dust-related diseases will, on a global scale, have lead to the premature deaths of millions of workers by 2030. The scale and significance of musculoskeletal diseases is just beginning to be recognized.

Abstracts

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