

of these compressed gases. The tool design involved the development of assessment questions, each of which were categorized in the following management areas: 1) delivery processes; 2) system design; 3) operations and maintenance; 4) emergency response; and 5) gas detection systems. The assessment questions were implemented in a database management system, with the ability to develop a facility-specific checklist, depending on the types of compressed gases used. The questions themselves were developed from a variety of sources, including industry standards (ANSI, Compressed Gas Association, National Safety Council and others), OSHA standards, and input from facility and supplier personnel. The draft assessment instrument was tested at a manufacturing facility which used all of the priority compressed gases (ammonia, chlorine, carbon dioxide). Included in the database design was the ability to input findings from the assessment, comments or suggestions for improvement and a three-level priority assessment. The process was implemented at a total of 15 manufacturing facilities. The results showed a number of opportunities for improvement, including assessing qualifications of delivery contractors, specification of pressure relief valves, discharge location of pressure relief valves, equipment maintenance issues, coordination with local emergency response agencies, emergency response drills, installation of gas detection systems and maintenance/calibration of installed gas detection systems. The assessment design should have general application to similar process safety studies.

## 9

**EVALUATION AND CONTROL OF EXPOSURES DURING WASTE-TO-ENERGY FACILITY OPERATION AND MAINTENANCE.** M.E. Russell, Rust Environment & Infrastructure Minneapolis, MN; R. Dunnette, Olmsted Waste-To-Energy Facility, Rochester, MN

Groundwater protection initiatives and anticipated shortages of energy and landfill space created economic and regulatory incentives in the early 1980s for electric and steam power cogeneration through municipal solid waste (MSW) combustion. One such facility in Olmsted County, Minnesota, began operation in 1986 and currently operates two solid waste boilers. The labor-management safety committee retained an industrial hygiene consultant to assist in safety and health program development for this new process. The first step was to evaluate exposures in the plant and tipping floor. Analytes included total and respirable dust, silica, carbon monoxide, aluminum, arsenic, barium, cadmium, cobalt, copper, iron, lead, and zinc. Results indicated no exposures exceeding Occupational Safety and Health Administration (OSHA) permissible exposure limits (PELs) or American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit values (TLVs). Surface lead dust sampling results indicated adequate to excellent contamination control and cleaning. The highest airborne dust concentrations were measured during quarterly boiler shutdowns when operators and contractors perform cleaning, maintenance and repair activities.

During such events, many aspects of the facility safety and health programs and procedures are put to the test, such as lock-out/tag-out, confined space entry, personal protective equipment, and respiratory protection programs. Results of breathing zone air samples collected outside of the respirator during cleaning in the boiler exceeded the arsenic, cadmium, copper, lead and the particulate (total and respirable) PELs. Supplied air respirator use was instituted, as well as breathing air quality testing. With proper contamination control and use of ventilation, no exposures in excess of OSHA PELs or action levels were detected outside the boiler.

## 10

*Paper Withdrawn by Author*

## 11

**PROVISIONAL EXPANSION OF ENVIRONMENTAL IMPACTS FOR CHEMICAL HAZARD SCORING-FOR RISK MANAGEMENT.** D.A. Whaley, E.J. Bedillion, West Virginia University, Morgantown, WV; K. Walker OO-ALC/EMP Hill AFB, UT; S.S. Barrett, Purdue University, W. Lafayette, IN

The authors presented previous work on a chemical hazard scoring system useful for (1) measuring progress in pollution prevention, (2) selecting safer chemicals for manufacturing, and (3) identifying priorities for emissions reductions by pollution prevention and waste minimization, when composition is known. Previously reported components were a score for hazard to environment, mainly aquatic ecosystem impact, and hazard to workers. We now report expansion of the environmental hazard score to include impacts on air pollution, soil contamination and stratospheric ozone depletion. This score impact expansion is provisional since it relies on federal US regulations for scoring data, rather than primary scientific data. However, provisional impact expansion is justified for our time-urgent purpose of assisting and encouraging industry to implement voluntary resource-effective emissions and waste reductions. Scoring each chemical requires up to 37 physicochemical and toxicity data entries, measured or estimated by structure-activity algorithms. Scores are presented for a list of 158 high hazard chemicals for worker hazard, expanded provisional environmental hazard, and combined hazard. A few anomalies appeared in past, using less complete scoring. As new environmental impacts are added, such anomalies tend to disappear, and the score becomes a relative quantitative measure of hazard, ever more consistent with industrial experience. Use of these scores to measure progress in pollution prevention has been pilot tested in Indiana. Candidate safer substitute chemicals are also being sought from Indiana industry for scoring. Our second purpose is to make this scoring information widely available to manufacturing industries.

## 12

**SENSITIVITY ANALYSIS FOR MISSING DATA AND TERM DOMINANCE TESTING FOR CHEMICAL HAZARD SCORING ALGORITHM FOR WORKERS AND ENVI-**

**RONMENT.** D.A. Whaley, E.J. Bedillion, West Virginia University Morgantown, WV; K. Walker OO-ALC/EMP Hill AFB, UT

Our purposes were to (1) test a chemical hazard scoring system for adequacy of data obtained for 158 high hazard chemicals and (2) check that scoring was not dominated by component term(s). Universities of Tennessee and Purdue developed a scoring for hazards to environment and workers for measuring pollution prevention, then scored these 158 chemicals.

When we could neither locate measurements nor estimate them by regression, and did not know whether the chemicals had been evaluated for the property, we called data "missing" (unknown). We tested worker, environmental and combined scores for sensitivity to changing missing data terms from default zero (no hazard) to maximum score term value (maximum hazard). In these tests, chemicals with greatest hazard tended to retain most hazardous scores when "missing" score terms were changed from default zero to maximum, suggesting that the data obtained were sufficient for the scores to be stable and robust.

We looked at the tendency for term(s) to dominate worker, environmental, and combined hazard scores. Twenty-four data measurements (or estimates) were sought for each chemical, in addition to the aquatic hazard term from the University of Tennessee. Based on statistical criteria used by University of Tennessee for US Environmental Protection Agency, no term unduly dominated worker or environmental hazard scores. In conclusion, worker and Purdue environmental scores for chemical hazard generally behaved well for 158 high hazard chemicals, scoring about the same, using either default zero or maximum values for missing data, without dominance by individual term(s) in final hazard scores.

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### 13

**EVALUATION OF OCCUPATIONAL EXPOSURES AMONG RADON MITIGATION WORKERS.** T.F. Bloom, NIOSH, Cincinnati, OH

Exposure to radon decay products (RDP) has been linked with development of lung cancer among miners of uranium bearing ores. There is currently little RDP data for another occupationally exposed work group—individuals employed in the business of reducing residential radon exposures. During a study of occupational exposures of workers employed at six radon mitigation companies, NIOSH investigators measured real time concentrations of RDP during 21 mitigations using a radon working level meter with data logger. The six companies were selected using state radon concentration data reported to the Environmental Protection Agency from states participating in the State Residential Radon Surveys. Exposures to continuous noise, organic vapors, and respirable dust were also measured. For two mitigations, the average concentrations of RDP over the

mitigation jobs were 106 milliWorking Levels (mWL) and 437 mWL, respectively. These levels, if experienced by workers on a 40 hour per week basis throughout the year, would exceed the NIOSH recommended exposure limit (REL) of 1000 mWL Month (1 Working Level Month) per year. For the remaining 19 mitigations, average RDP concentrations ranged from 2 mWL to 66 mWL. Study data indicated that ensuring adequate prevention prior to commencement of the mitigation can reduce unnecessary exposure to RDP. Exposures to short periods of continuous noise ranged from 99-112 dBA. Maximum organic vapor exposures, sampled from 1/2 to 4 hours, were 23 ppm of acetone, 67 ppm of methyl ethyl ketone, and 32 ppm of tetrahydrofuran. Respirable dust concentrations were below the limit of detection. Based on the limited exposure times, these levels were below the applicable 8-hour NIOSH RELs and Occupational Safety and Health Administration permissible exposure limits.

## 14

THE HEALTH STATUS OF MICROWAVE COMMUNICATION WORKERS UNDER THE HYGIENE STANDARD. P. Meng, S. Yu, Shangdong Medical University, Jinan, Shandong, Taiwan

The Chinese national hygienic standard for microwave radiation in the work environment is  $50 \mu\text{w}/\text{cm}^2$  (8 hs/d). However, there are few reports about industrial hygiene of microwave communication workers under the standard data from large-scale studies. Given the increasing concern about the safety of the microwave, a cross-sectional study among 151 workers in 3 microwave communication stations was undertaken. The workers' health examination and the exposure measurements in the work environment were conducted. A control group of 127 administrative personnel in the same station were also investigated. The microwave was a kind of continuous wave. The workers work 4 hs/d without any protective clothes and glasses. The leakage energy density of microwave in the work environment was  $0-20 \mu\text{w}/\text{m}^2$ . The prevalence rate of neurasthenic syndrome in personal exposures showed significantly higher than the controls (59.51%, 29.02%). The score of sight in personal exposures was lower than those in the controls. Personal exposures also showed significantly higher prevalence rate of abnormal electrocardiograms than the controls (01.68%, 7.00%). Obvious differences in IgG, IgA and IgM between exposures and unexposures were found. Also, the incidence of micronucleus in human lymphocytes was obviously higher in exposed group than that in controls (1.87%, 0.87%). No significant differences were found for percentage of T-lymphocytes, white blood cell counts and abnormal menstruation. Health status should be protected though the workers work under the standard limit. The workers must put on protective clothes and glasses.

## 15

AN EVALUATION OF PERSONAL EXPOSURES TO MAGNETIC FIELDS IN THE FIBER GLASS MANUFACTURING INDUSTRY. M. Van de Weert, R. Klawitter, C. Carter,

J. Tefft, Schuller International Inc., Littleton, CO

Magnetic fields are created by the use of electric current and can be found around all types of electrical wiring and motors. One method of producing fiber glass wool uses an electric melter with a submerged electrode to melt the components of glass prior to fiberization. Employees working near these electric melters voiced a concern after viewing media coverage of various scientific studies which have indicated that electromagnetic field (EMF) radiation may cause adverse health effects. Not knowing our employees' exposures to EMF prompted this study. Personal monitoring of magnetic fields created by electrical currents was conducted at nine fiber glass manufacturing facilities utilizing the submerged electrode melting process. Each of the five facilities utilized different rates of electricity in the melting process. These rates were in excess of 1000 kilowatts (kW) of electricity per hour. The measuring instruments used in our study were gaussmeters measuring at the 60 Hertz (Hz) frequency. These instruments were the Emdex Mate measuring between 0.0-1000 milligauss (mG) and the Emdex Lite measuring between 0.1-700 Gauss (G). Each unit sampled at a rate of one reading every four seconds. Seventy employees were monitored to determine their full-shift exposures to magnetic fields. Full-shift average exposures ranged from 0.01 to 2.33 G, averaging 0.32 G. Ceiling values were as high as 117 G. The results presented above were compared to the recommended standards of the International Commission on Non-Ionizing Radiation Protection (ICNIRP) full workday occupational limit of 0.5 millitesla (mT) or 5 G and the American Conference of Governmental Industrial Hygienists' threshold limit value (ACGIH TLV) whole body ceiling value of 1 mT or 10 G for magnetic fields. The eight hour exposure for employees is well below the ICNIRP standard of 5 G. However, employees exceeded the ACGIH ceiling value of 10 G when checking the molten glass levels. The power cables leading to the electrodes were the primary source of magnetic radiation and the highest ceiling exposures were related to the employees' and melter inspection doors' proximity to these power cables.

## 16

ASSESSMENT OF ELECTROMAGNETIC FIELDS IN A METAL TUBING MANUFACTURING FACILITY. C. Moss, NIOSH, Cincinnati, OH

The manufacturing of specialized metal tubing for use in the automobile and refrigeration industries requires the use of welding and annealing equipment that generates various types of electromagnetic fields (EMFs). The National Institute for Occupational Safety and Health (NIOSH) conducted a health hazard evaluation at a facility which used butt welders and annealing sources. The butt welder joins rolls of strip metal using high resistance heating produced by power line frequencies, mainly 60 hertz (Hz). The strip metal is then slowly bent by special machinery to form metal tubing that will be welded using either a direct current (DC), alternating

current (AC), or a high frequency (450 kilohertz [kHz]) welding source. After welding, the tube is annealed using a resistance annealer or a 10 kHz annealer. Workers at this facility asked NIOSH to evaluate occupational exposure to the EMFs generated in the facility. Due to the wide range of frequencies generated by the various sources at the facility, it was necessary to use a large assortment of EMF equipment and meters. It soon became clear that it was not possible to obtain simultaneous measurements from any of the sources due to the need to use different meters, often at different locations, over wide frequency ranges.

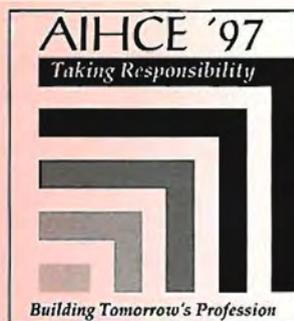
The results obtained from this evaluation suggest that workers in the facility who operate butt welder units, 400-Hz AC welders, or the 10-kHz annealer units may be exposed to magnetic fields in excess of occupational guidelines. Electromagnetic field exposure from other sources, as measured on the days of evaluation, appears to be below these guidelines. Excessive exposures are influenced by location of the worker relative to the EMF source, and exposure of extremities (often 10 times higher than the body exposure). Significant exposure reduction can be accomplished by locating workers further from EMF sources, and by determining whether tasks that require insertion of hands in close proximity to various sources are appropriate or necessary.

## 17

EXPOSURES OF ELECTRICIANS OF A POWER GENERATION FACILITY TO EXTREMELY LOW FREQUENCY MAGNETIC FIELDS (ELF MF). F. Akbar-Khanzadeh, T. Carroll, Medical College of Ohio at Toledo, Toledo, OH

This study was conducted to determine occupational and nonoccupational exposures of electrical maintenance workers (electricians) to ELF MF compared to the exposures of office workers in an electrical generation facility. Seven electricians and 7 office workers participated in the study. Exposure of each subject was monitored via the subjects' wearing an ELF MF personal dosimeter (EmdexC, EFM Company) for 24 hours. Each participant kept a log, noting his/her activities and equipment used. The 1-min average occupational exposure for all electricians ranged from 0.1-998.0 mG with a total mean  $\pm$  SD of  $4.0 \pm 23.8$ , and the individual means ranged from 0.1-9.2 mG. In comparison, the 1-min average occupational exposure for all office workers ranged from 0.1 - 110.0 mG with a total mean  $\pm$  SD of  $1.0 \pm 2.7$  mG, and the individual nonoccupational mean exposures ranged from 0.1-2.6 mG. The 1-min average occupational exposure for all office workers ranged from 0.1-27.5 mG with a total mean  $\pm$  SD of  $1.7 \pm 1.8$  mG, and the individual means ranged from 0.4-3.4 mG. The 1-min average nonoccupational exposure for all office workers ranged from 0.1-38.0 mG with a total mean  $\pm$  SD of  $1.3 \pm 2.9$  mG, and the individual means ranged from 0.3-3.4 mG. None of the subjects' exposure exceeded the current recommended limits. Exposure of electricians exceeded 2 mG in 18.1% of the time spent at

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1

*Paper Withdrawn by Author*

2

PRAGMATIC PRINCIPLES FOR AVOIDING MANAGEMENT PITFALLS. M.L. Sanders, Naval Engineering Field Activity, Poulosbo, WA

Making the transition from an industrial hygienist managing programs to a manager programming industrial hygienists can be traumatic and career damaging. Keen technical and verbal skills are common entrance requirements to the people-management arena, but industrial hygienists who desire to make that professional move must be aware of three particularly dangerous pitfalls which neither of those skills will protect against.

One pitfall results from failure to distinguish between leadership and management, another from failing to distinguish between organizational process and function, and the third for failing to recognize the customer. Industrial hygienists must have the insight to recognize and evaluate those pitfalls, avoiding or back-filling in order to walk safely over them.

Specific and succinct descriptions of principles for both the prevention and the resolution of these problem areas have been developed; use of these principles is the catalyst for efficacious management. Whether the profes-

sional industrial hygienist is in the private or the public sector, assuming the responsibility for a controlled management response using these principles in the face of business adversity can turn impending failure into resounding success and ensure career growth.

3

SCIENTIFIC CONTRIBUTIONS TO THE REVISION OF THE OSHA'S 1,3-BUTADIENE HEALTH STANDARDS. C.T. Chen, OSHA, Washington, DC

The current OSHA's 1,3-butadiene (BD) health standard is an 8-hour time-weighted average (TWA) exposure of 1,000 ppm for workers exposure to BD which is adopted from 1968 American Conference of Governmental Industrial Hygienist's (ACGIH's) threshold limit values (TLVs®) in 1971 to prevent irritation and narcosis effects. Due to the demonstration that BD causes multiple cancers in two animal studies in 1983, OSHA was petitioned by unions in 1984 and referred by EPA in 1985 for regulatory action. In 1990, OSHA published a proposed BD standard with an 8-hour TWA exposure of 2 ppm, a short-term exposure limit (STEL) of 10 ppm, and the ancillary provisions. There are many scientific studies contained in OSHA BD docket which enhanced the completion of a BD standard. Animal bioassays, human epidemiologic studies, experimental investigations on the metabolites and their mechanism in vitro and in vivo systems provides convincing evidence that BD is a probable human carcinogen. Three out of five quantitative risk assessments used NTP study with exposures of 6.25-625 ppm BD to calculate their best estimates of risk. Due to the availability of

three breakthrough studies on BD, OSHA was able to allow the use of cartridges and canisters for respiratory protection that would enhance workers' protection, address industry's concerns, and reduce compliance cost. A series of plant visits conducted by the National Institute of Occupational Safety and Health (NIOSH) produced worker exposure profiles and information on technological feasibility which greatly helped in economic analysis. An epidemiologic study sponsored by the International Institute of Synthetic Rubber Producers (IISRP) completed in late 1995 clearly demonstrated an excess risk of cancer among workers exposed to BD which is complementary to the animal studies. This promoted IISRP to engage with unions to reach agreement on a standard with an 8-hour TWA exposure of 1 ppm, a STEL of 5 ppm, and other aspects of standard. This demonstrates that studies from various disciplines of science will greatly enhance the development of a workplace health standard. The opinion expressed here is sole of author.

4

CIH PLUS IHIT UTILIZATION BY INDUSTRY OR INDUSTRY GROUP, AND PRELIMINARY PROJECTIONS OF FUTURE NEED FOR SUCH INDUSTRIAL HYGIENE PROFESSIONALS. L.W. Whitehead, CIH University of Texas-Houston Houston, TX, M. West Baylor College of Medicine, Houston, TX

Estimates of future need for public health professionals are very useful for planning educational programs and incentives for graduate education, and for staffing projections. No such estimates are known to exist for