HETA 2000-0139-2824
United Catalysts, Inc.
Louisville, Kentucky

Elena Page, MD, MPH
Joshua M. Harney, MS

PREFACE

The Hazard Evaluations and Technical Assistance Branch (HETAB) of the National Institute for Occupational Safety and Health (NIOSH) conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health (OSHA) Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

HETAB also provides, upon request, technical and consultative assistance to Federal, State, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by NIOSH.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Elena Page and Joshua Harney of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Desktop publishing was performed by Elaine Moore. Review and preparation for printing were performed by Penny Arthur.

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Highlights of the NIOSH Health Hazard Evaluation

Reviewing Records at United Catalyst, Inc.

The union at the United Catalyst, Inc. (UCI) South Plant worried that exposure to nickel catalyst dust and depleted uranium dust was causing cancer and breathing problems in the workers. To help answer this question, NIOSH reviewed UCI medical reports and air sampling data, and did a walk through inspection of building 1, building 2, and MAC-3.

What NIOSH Did

- We reviewed protocols on yearly medical examinations, including respirator physicals.
- We reviewed a report from an ongoing University of Louisville cancer study of UCI employees.
- We checked UCI air sampling data from the South Plant for 1998-2000.
- We did a walk-through inspection of buildings 1 and 2, and MAC-3.

What NIOSH Found

- Air samples showed nickel above NIOSH and OSHA limits.
- The cancer study did not show abnormal rates of cancer among UCI employees.
- Breathing tests are used to decide if employees can wear a respirator, and the results are given to management.
- Monitoring was done for depleted uranium (DU) radiation in MAC-3, but wasn't done for uranium itself.
- Some air samples in MAC-3 were above the limit for radioactivity.

What United Catalysts, Inc. Managers Can Do

- Use engineering controls to reduce nickel concentrations in air to levels below the NIOSH limit in all areas. Until this is done, respiratory protection is needed in all areas with air concentrations of nickel above the NIOSH limit.
- Figure out which MAC-3 operator tasks cause over exposures to DU. Install engineering controls so that DU exposures are below the limit for radioactivity.
- Uranium exposures in MAC-3 should be checked to assess the chemical hazard from uranium.
- Use ANSI Standard HPS N13.22-1995 to help with the uranium biological monitoring program.
- Do not use breathing tests alone to decide if workers can wear a respirator.
- Keep results of breathing tests and other medical tests confidential.

What the United Catalysts, Inc. Employees Can Do

- Report health concerns to an occupational medicine doctor, as well as to your boss.

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National Institute for Occupational Safety and Health
NIOSH

Health Hazard Evaluation Report 2000-0139-2824
United Catalysts, Inc
Louisville, Kentucky
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Elena Page, MD, MPH
Joshua M. Harney, MS

SUMMARY

On February 7, 2000, the National Institute for Occupational Safety and Health (NIOSH) received a request from Teamsters Local 89 for a health hazard evaluation (HHE) at the South Plant of United Catalysts, Inc. (UCI), which is owned by Sud Chemie, in Louisville, Kentucky. The request stated that employees may be experiencing adverse health effects, such as cancer and respiratory problems, due to exposure to a variety of metals, including nickel and depleted uranium. On March 3, 2000, NIOSH investigators visited the South Plant for an opening conference and walk-through inspection.

NIOSH investigators spoke to UCI's contract medical provider regarding annual medical surveillance. They also reviewed UCI documents: criteria for clearing employees for respirator use, cancer surveillance studies conducted by the University of Louisville (UL) for UCI, and the Occupational Safety and Health Administration (OSHA) Log and Summary of Occupational Injuries and Illnesses from 1998 and 1999. UCI air sampling data for the years 1998-2000 were reviewed, and a walk-through inspection in buildings 1 and 2, and MAC-3 was conducted.

We found that nickel exposures are consistently above the NIOSH recommended exposure limit (REL) in blending and batch operations, kiln- and dryer-related operations, lab work, product finishing/screening/packaging, and cleanup/maintenance. Uranium exposures in MAC-3 are well documented for radiologic hazard, but no sampling is performed to assess the chemical hazard. Over 10% of air samples collected by UCI in MAC-3 show radioactivity levels in excess of the legal limit. Annual medical surveillance consists of very broad screening, not all of which is related to occupational exposures. Determination of worker's ability to wear a respirator is primarily determined by spirometry, and the results of the spirometry are conveyed to management. The ongoing UL cancer study has not found elevated rates of cancer among UCI employees.

The level of respiratory protection for nickel catalyst bagging operations needs to be increased immediately until improved engineering controls lower exposures there. UCI should determine how uranium exposures in the MAC-3 area compare to exposure limits (REL, threshold limit value [TLV], and permissible exposure limit [PEL]) set to protect workers from chemical hazards. In communicating medical results to the workforce, UCI should distinguish between general medical screening and screening done specifically to evaluate potential occupational exposures at UCI. Spirometry results should not be interpreted as a strict criterion to determine whether a worker is able to wear a respirator, and results of any medical tests should remain confidential.

Nickel exposures are consistently above the NIOSH REL in blending and batch operations, kiln- and dryer-related operations, lab work, product finishing/screening/packaging, and cleanup/maintenance. The level of respiratory protection for bagging operations should be modified immediately to full facepiece PAPRs/supplied air respirators. Uranium exposures in MAC-3 are well documented for radiologic hazard, but should be determined to assess the chemical hazard there. Over 10% of air samples collected by UCI in MAC-3 show radioactivity levels in excess of the legal limit.

Keywords: SIC 2819 (catalyst, chemicals) - depleted uranium, respiratory protection, nickel, APF, assigned protection factor, MUC, maximum use concentration, catalysts, medical monitoring, medical screening, medical surveillance

TABLE OF CONTENTS

INTRODUCTION

On February 7, 2000, the National Institute for Occupational Safety and Health (NIOSH) received a request from Teamsters Local 89 for a health hazard evaluation (HHE) at the South Plant of United Catalysts, Inc. (UCI), which is owned by Sud Chemie, in Louisville, Kentucky. The request stated that employees may be experiencing adverse health effects, such as cancer and respiratory problems, due to exposure to a variety of metals, including nickel and depleted uranium. On March 3, 2000, NIOSH investigators visited the South Plant for an opening conference and walk-through inspection.

BACKGROUND

The South Plant began operations in the 1940s as Girdler Catalyst Division of the Girdler Corporation. United Catalysts, Inc. was formed in 1977 by the merger of Catalysts and Chemicals, Inc. and Girdler under the German company, Sud Chemie. A chromic acid process, and other processes in the West and South Plants, were the subjects of NIOSH HHEs in 1982 and 1983, respectively.[1,2] Findings at that time included exposure to levels of nickel above the NIOSH Recommended Exposure Limit (REL), and to levels of copper above the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL). There was a high prevalence of work-related symptoms, with 49% of surveyed employees reporting cough, 35% reporting nasal sores, and 27% reporting skin rashes. The number and distribution of cancer cases did not appear unusual. Management now reports that since the time of the 1983 HHE in the South Plant the chromic acid process has been discontinued.

The South Plant is currently staffed by 113 production and maintenance workers, who are represented by Teamsters Local 89. In addition to these employees, there are approximately 20 laboratory workers, 5 office workers, 8 coordinators, and 2 production managers. A full-time industrial hygienist and a radiation safety officer are assigned to the plant. The company has a contract with a local medical group to provide medical surveillance, as well as evaluation of work-related injuries and illnesses.

Investigators at the University of Louisville (UL) have been conducting a study of cancer incidence and mortality at UCI since 1983. They have been performing case finding using UCI medical surveillance data, insurance claims data, plant mortality records, and the State of Kentucky's Mortality Database. Information on local cancer incidence rates was obtained from the Kentucky Cancer Registry and the National Cancer Institute's Surveillance, Epidemiology, and End Results program. Information on local cancer death rates was obtained from the Kentucky Annual Vital Statistics Reports. This study is ongoing, and researchers from UL periodically present their findings to UCI employees.

The primary processing areas at the South Plant are building 1, building 2, and MAC-3, where catalysts are made. Buildings 1 and 2 process catalysts using metals other than depleted uranium (DU), which is processed in MAC-3. Workers in the MAC-3 area (a 'restricted area,' access is limited to those who are adequately trained with regard to radiological hazards potentially present there, and who are wearing the required personal protective equipment) are required to wear Tyvek® coveralls and foot covers, and half-face elastomeric respirators with P100 filters. Workers rotate areas within the plant daily, choosing their work assignment each morning based on seniority. The plant operates continuously in 12-hour shifts. It is a non-smoking facility, although workers may smoke outdoors.

Kentucky is a U.S. Nuclear Regulatory Commission (NRC) agreement state. Through the NRC Agreement State Program, Kentucky has a formal agreement with the NRC, by which it has assumed regulatory responsibility over certain byproduct, source, and small quantities of special nuclear material. NRC reviews agreement state programs for continued adequacy to protect public health and safety and compatibility with NRC's regulatory program. Through the NRC agreement, the Radioactive Materials Unit, Cabinet for Health Services, Commonwealth of Kentucky, regulates the use of DU in the UCI plant and reviews written protocols for all aspects of its use, including environmental sampling and biological monitoring.

Kentucky has an OSHA approved state occupational safety and health program, administered by the Kentucky Labor Cabinet (KLC). Employees of UCI filed a complaint with the KLC in the spring of 2000, after they filed the HHE request, which resulted in a KLC inspection at the South Plant in May 2000. The KLC inspection resulted in citations for failure to make provisions for use of prescription eyewear by those wearing full-face piece respirators, failure to terminate a confined space entry permit upon completion of confined space entry, and over exposure to nickel dust. This inspection was closed in September 2000, after UCI's citation abatement plan was approved by KLC.

METHODS

NIOSH investigators spoke to the contract medical provider by telephone regarding annual medical surveillance, reviewed criteria used to determine whether an employee is cleared for respirator use, and reviewed the most recent report from the UL study and the OSHA Log and Summary of Occupational Injuries and Illnesses (OSHA 200 log) from 1998 and 1999. NIOSH investigators also reviewed UCI air sampling data from the South Plant for the years 1998-2000, conducted a walk-through inspection in buildings 1 and 2, and MAC-3, spoke to several employees during the site visit, and reviewed the KLC inspection report.

EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects even though their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increases the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH RELs,[3] (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®),[4] and (3) the U.S. Department of Labor, OSHA PELs.[5] Employers are encouraged to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criterion.

OSHA requires an employer to furnish employees a place of employment that is free from recognized hazards that are causing or are likely to cause death or serious physical harm [Occupational Safety and Health Act of 1970, Public Law 95–596, sec. 5.(a)(1)]. Thus, employers should understand that not all hazardous chemicals have specific OSHA exposure limits such as PELs and short-term exposure limits (STELs). An employer is still required by OSHA to protect their employees from hazards, even in the absence of a specific OSHA PEL.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8 to 10-hour workday. Some substances have recommended STEL or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short-term.

Nickel

Nickel is a hard, silvery-white metal. Most nickel is used to make stainless steel. Compounds of nickel are used to produce nickel plating, batteries, and catalysts. Nickel is an essential trace element in humans, and the diet contributes 0.3-0.6 milligrams (mg) of nickel daily.[6] Foods high in nickel include chocolate, soy beans, nuts, and oatmeal.[7] Nickel is found in soil, is emitted from volcanoes, and is present in water and cigarette smoke.[7]

The most common adverse health effect from exposure to nickel is allergic contact dermatitis. The condition has been seen in various occupations, including hairdressers, nickel platers, and jewelers, who have skin contact with nickel. Once a worker is sensitized to nickel, the sensitivity persists even after the exposure is removed.[8] The major route of occupational exposure to nickel and nickel compounds is through inhalation.[9] Inhalation exposures have been associated with cancer of the lung and of the nasal sinuses in workers employed in nickel refineries and smelters.[10] The International Agency for Research on Cancer classifies nickel compounds as carcinogenic to humans, and metallic nickel as possibly carcinogenic to humans.[11] Other health effects of nickel inhalation exposures include nasal irritation, damage to the nasal mucosa, perforation of the nasal septum, and loss of sense of smell.[9]

The NIOSH REL for nickel is 0.015 milligrams per cubic meter of air (mg/m^3), up to 10-hr TWA. NIOSH considers nickel to be an occupational carcinogen, based upon research suggesting a relationship between nickel exposures and the development of lung and nasal cancers, and recommends exposure be reduced to the lowest feasible level.[3] The ACGIH TLVs (for 8-hr TWA exposures) are 0.1 mg/m^3 for soluble nickel compounds, 1.5 mg/m^3 for metallic nickel, and 0.2 mg/m^3 for insoluble nickel.[4] The nickel present at UCI is predominantly insoluble nickel: nickle oxide, nickel carbonate, and metallic nickel. The OSHA PEL is 1 mg/m^3, 8-hr TWA, for all forms of this element.[5]

Depleted uranium (DU)

DU is a byproduct of uranium enrichment for nuclear fuel. DU contains less than 0.711% ^{235}U. Natural uranium contains 0.72% ^{235}U and 99.27% ^{238}U.[12] DU decays by alpha emission, and the total alpha radioactivity of DU is about 40% less than that of natural uranium.[13,14] Cancer has not been documented in humans as a result of exposure to either natural or DU.[15] The primary toxicity concern is due to its chemical, not radiological, properties. Data, however, indicate that uranium compounds are not highly toxic in humans.[15]

Chemical toxicity depends on several factors, including solubility and route of exposure. The more soluble a uranium compound is, the more likely it is to be absorbed into the bloodstream and distributed in the body. Gastrointestinal absorption is minimal, even for soluble compounds. Absorption from the lung into the bloodstream depends on the solubility of the compound, but ranges from less than 1% to 5%. Less soluble compounds can remain in the lungs for years. The DU used at UCI has low solubility. The majority of absorbed uranium is excreted in the urine within 24 hours of exposure.[16,17] What is not excreted accumulates primarily in the kidney and bone.[15,17] Since a portion of absorbed uranium accumulates in the kidney, it is a potential target organ for toxicity. However, a recent study of Gulf War veterans with retained fragments of DU shrapnel did not show any evidence of renal dysfunction 7 years after first exposure, despite persistently elevated urine levels of uranium.[14] Epidemiological studies of uranium miners and millers have not shown elevated rates of kidney disease.[15]

The vast majority of uranium that enters the body is not absorbed, and unabsorbed uranium is eliminated in the feces. This includes uranium that is inhaled, brought out of the lungs via mucociliary action and ingested, or initially deposited in the upper respiratory tract and subsequently swallowed. Uranium appears in the feces within several hours after exposure, so fecal analysis is a rapid method of determining if exposure has taken place.

The Kentucky Cabinet for Health Services has set an exposure limit for uranium with regard to its radiologic hazard. Both the OSHA and Kentucky Cabinet for Health Services limits are legally enforceable. The ACGIH TLV for uranium is 0.2 mg/m^3, 8-hr TWA.[4] The NIOSH REL is 0.05 mg/m^3 for soluble uranium compounds, and 0.2 mg/m^3 for insoluble uranium compounds, both as full-shift (up to 10 hours) TWA. NIOSH considers both forms to be occupational carcinogens, and recommends that workplace exposures be reduced to the lowest feasible level.[3] The OSHA PEL for uranium is 0.5 mg/m^3, 8-hr TWA for soluble compounds, and 0.25 mg/m^3 for insoluble compounds. The Kentucky Cabinet for Health Services sets the Derived Air Concentration (DAC) activity limit at 2 x 10^{-6} microcuries per milliliter air (µCi/mL).[18] The DAC is the airborne activity level which, if breathed for one working year, will yield the annual limit of intake for that nuclide.

Respiratory Protection

The OSHA respiratory protection standard states that preventing atmospheric contamination of the workplace "shall be accomplished as far as possible by accepted engineering control measures (for example, enclosure or confinement of the operation, general and local ventilation, and substitution of less toxic materials). When effective engineering controls are not feasible, or while they are being instituted, appropriate respirators shall be used pursuant to this section."[19] Furthermore, it defines the necessary components of a written respiratory protection program: procedures for selecting respirators for use in the workplace; medical evaluations of employees required to use respirators; fit testing procedures for tight-fitting respirators; procedures for proper use of respirators in routine and reasonable foreseeable emergency situations; procedures and schedules for cleaning, disinfecting, storing, inspecting, repairing, discarding, and otherwise maintaining respirators; procedures to assure adequate air quality, quantity, and flow of breathing air for atmosphere-supplying respirators; training of employees in the respiratory hazards to which they are potentially exposed during routine and emergency situations; training of employees in the proper use of respirators, including putting on and removing them, any limitations on their use, and their maintenance. OSHA also makes provisions for voluntary respirator use, for which the reader should refer to the standard. NIOSH provides guidance for selecting an appropriate respirator in its Guide to Industrial Respiratory Protection.[20]

One important aspect of a respiratory protection program is to ensure that a respirator adequately protects its wearer at the contaminant concentrations that they encounter. To select a respirator for use in a particular task, the contaminant concentration that will be encountered should be known. When this information is available, the minimum level of needed protection can be determined by dividing the highest exposure measurement by an occupational exposure limit. Using the results of this division, one can then choose a type of respirator that has a protection factor equal to or exceeding this minimum level of protection.

To help determine the appropriateness of a particular respirator for a given exposure, each class of respirator is given an "assigned protection factor" (APF).[21] The APF is the expected level of protection that would be provided by a properly functioning respirator when properly fitted to and worn by a trained user. When one multiplies a respirator's APF by an occupational exposure limit (REL, PEL, or TLV, etc.) for the contaminant of concern, a "maximum use concentration" (MUC) is generated, i.e., APF x REL = MUC. The MUC serves as the upper limit of exposure above which the respirator should not be used. Eye protection in the form of respirators with full facepieces, helmets, or hoods is required for routine exposures to airborne contaminants that cause any eye irritation.[20]

RESULTS

Medical

Annual medical surveillance at UCI includes a questionnaire to assist in determination of fitness to wear a respirator, a complete blood count (CBC), prostate specific antigen (PSA) screening for men, a blood chemistry panel that includes electrolytes, thyroid function tests, liver function tests, and lipid profile, electrocardiogram, spirometry, stool occult blood testing, vision testing, audiometry, urinalysis, and a physical examination by the physician. Chest radiography is performed every 5 years.

The ability to wear a respirator at UCI is primarily determined by spirometry results. If the forced expiratory volume in one second (FEV_1) is greater than 70%, there are no restrictions regarding respirator use. If the FEV_1 is 60-69%, negative pressure respirator use is restricted to 2 hours in any 12-hour shift, but there are no restrictions on air-assisted or air-supplied respirators. If the FEV_1 is 50-59%, negative pressure respirator use is prohibited, but there are no restrictions on air-assisted or air supplied respirators. If the FEV_1 is less than 50% employees are altogether restricted from respirator use. This information is conveyed to the UCI management by the medical provider on a checksheet that lists both the FEV_1 and the restrictions. Employees who have an FEV_1 less than 50% are referred to a pulmonologist for evaluation.

Biological monitoring for uranium is done on all employees at the time of initial employment to obtain a baseline, and then annually, even if they do not work in MAC-3. This is accomplished by spot urine testing; specimens are sent to a reference lab for analysis. Results are reported in micrograms of uranium per liter of urine (mg/L), and are not corrected for creatinine.

The most recent conclusion of the UL study, reported in January 1998, was that neither the cancer incidence rate nor the death rate from cancer among employees at UCI were elevated. The UL investigators also noted there were no unusual cancers among employees. The OSHA 200 log did not have any respiratory ailments or cancers listed. Most entries were contusions, sprains, and strains.

Industrial Hygiene

Area air sampling for depleted uranium is done daily in MAC-3; at least four samples per shift in unrestricted areas and three samples per shift in restricted areas, as well as at other times, such as at each addition of uranium to batch processes. Personal breathing zone air samples (PBZ) are collected on the operator and the helper in MAC-3 every other day, and on maintenance workers once each week.

Environmental samples are analyzed for radioactivity in the plant laboratory via proportional counting; twice a year a minimum of 6 samples are sent to an outside lab for validation. A PBZ result above the DAC results in the collection of a spot urine sample for uranium from the overexposed individual. Urine levels above 14 mg/L require immediate urine resampling and removal from the area until the level is below 10 mg/L. The radiation safety officer reports there has never been a level above 14 mg/L that has remained elevated upon re-testing.

We reviewed air sampling records for 1998-2000. In 1998, nickel concentrations in 20 of 22 PBZ samples exceeded the NIOSH REL of 0.015 mg/m^3; concentrations of nickel ranged from

0.012 to 2.96 mg/m^3, 8-hr TWA. The exposures occurred among employees in blending and batch operations, kiln and dryer-related operations, product finishing/screening/packaging, and cleanup/maintenance. In one of these samples the nickel concentration exceeded the OSHA PEL. In 1999, nickel concentrations in 15 of 16 PBZ samples exceeded the REL, ranging from 0.005 to 16.15 mg/m^3, 8-hr TWA. The two highest exposures (both exceeding 10 mg/m^3) occurred among employees in the finishing/screening/packaging operations. Five of eight samples collected in 2000 had nickel concentrations which exceeded the REL; none exceeded the PEL. These samples were collected mainly from workers in the finishing/packaging/screening areas. Of 726 PBZ radionuclide air samples collected in 1998 in the MAC-3 area, radioactivity in 92 (12.7%) was above the DAC. Of 629 PBZ samples from 1999, radioactivity in 126 (20%) was above the DAC.

Upon completing their inspection of the South Plant in May 2000, KLC issued three citations. Citations were issued for respiratory protection standard and confined space entry permit violations, and a third violation was issued for overexposure to nickel, based on PBZ air sampling done by KLC during nickel catalyst drum filling operations. The 8-hr TWA exposure of the nickel catalyst drum filler was 2.51 mg/m^3, above both the OSHA PEL of 1 mg/m^3 and the NIOSH REL of 0.015 mg/m^3. UCI abated the respiratory protection and confined space violations by the end of July 2000, and agreed to abate the nickel hazards by improving engineering controls by June 2001. Currently, workers filling drums are required to wear full-facepiece air-purifying respirators with P100 filters.

DISCUSSION AND CONCLUSIONS

Cancer

UL has been conducting a study of cancer incidence and mortality for 17 years, and has concluded that the rate of cancer among UCI employees was not elevated. They found no unusual cancers among employees. This study is ongoing, and an additional NIOSH investigation of cancer incidence is unlikely to add any useful information.

Medical Screening and Surveillance

Very broad medical screening is performed for UCI employees by a contract medical group. Many components of the medical evaluation are not related to occupational exposures. Medical screening and medical surveillance are not synonymous. Screening has a clinical focus. Screening tests are performed on asymptomatic persons to detect disease at an early stage when treatment is most effective. Medical surveillance in the workplace is the systematic collection and analysis of health information on a group of workers.[22] A medical screening and surveillance program requires a physician knowledgeable not only in clinical medicine, but also in toxicology and epidemiology. Familiarity with the applicability of industrial hygiene measurements is essential, as is a firm grasp of the operational characteristics of medical screening tests, i.e., sensitivity, specificity, and predictive value. The physician should visit the work site in order to be familiar with the specific exposures in the workplace.[22] In addition, the physician must be aware of applicable laws and regulations.

Feedback of both individual and overall results of screening and surveillance is essential; however, results of individual medical screening must remain confidential. Employers should be notified of an individual employee's fitness to work, ability to wear personal protective equipment, recommended medical removal protection, follow-up recommendations, recommended accommodations if necessary, as well as overall group findings. Information provided to employees should include their test findings, overall findings, and recommendations for prevention of adverse health effects.[22]

Exposure Assessment

Biological Monitoring

Biological monitoring is the measurement of a chemical, a metabolite of that chemical, or a nonadverse health effect in a biological specimen to determine exposure.[23] It can be used to augment environmental monitoring and the occupational history. Biological monitoring assesses the exposure of workers regardless of the route of exposure, but it does not provide direct evidence of adverse health effects. Biological monitoring techniques are currently available to estimate workplace exposure to more than 100 substances.[23] The responsible physician must be knowledgeable regarding the methods for collecting and performing the appropriate tests, as well as other factors that may affect results, i.e., work practices, non-occupational exposures, and personal characteristics of the worker.

Since most of absorbed uranium is excreted in the urine, and collection of urine is non-invasive, it is the preferred choice for biological monitoring of exposure to soluble uranium compounds. However, the forms of uranium to which workers at UCI are exposed are primarily insoluble uranium oxides; therefore, absorption into the bloodstream is minimal, rendering biological monitoring of urine samples less useful for assessing exposure to insoluble uranium compounds.[24] Fecal analysis may be more useful for monitoring exposure to insoluble forms of uranium, and is especially well-suited for evaluation of intake after an acute exposure.[15,24] (Guidelines for biological monitoring of uranium exposure can be found in the American National Standard HPS N13.22-1995.)[24]

Nickel is excreted in the urine regardless of the route of exposure, with soluble compounds being excreted at higher levels than less soluble compounds.[7] Increased concentrations of nickel in those exposed to less soluble compounds indicates significant exposure, but the absence of elevated levels does not mean there is no risk for health effects such as cancer. Also, nickel concentrations in body fluids cannot be used as an indicator of specific health risks.[25] Since the majority of the nickel exposure at the South Plant is to nickel oxide, which is water-insoluble, biological monitoring would not be very useful.

Air Sampling

The previous NIOSH HHE results, UCI air sampling data, and the KLC inspection in May 2000 document that nickel exposures are consistently above the NIOSH REL in blending and batch operations, kiln- and dryer-related operations, lab work, product finishing/screening/packaging, and cleanup/maintenance. Therefore, current engineering and administrative controls are not sufficiently protecting the workers in these areas. When properly fit and correctly worn, the full-face respirators with P100 filters used during bagging operations have an assigned protection factor of 100, meaning that the MUC would be 1.5 mg/m^3, based on the NIOSH REL of 0.015 mg/m^3. Air sampling data from both KLC and UCI show personal exposures exceeding this MUC for drum filling. Therefore, full-face, air-purifying respirators have not offered sufficient protection in these conditions. Based on the KLC air sampling results (2.5 mg/m^3, 8-hr TWA), the minimum APF needed by a respirator would be 167 (2.5 $mg/m^3 \div 0.015$ mg/m^3). Respirators providing a sufficient APF in this case include powered air- or atmosphere-supplying respirators with a full facepiece or helmet/hood respiratory inlet coverings; both have an APF of 1000.[21]

While it may be possible to estimate the mass concentration of airborne uranium in MAC-3 based on the results of air samples analyzed via proportional counting, it is preferable that separate air samples be collected and analyzed for elemental uranium. The results should then be compared to the REL, TLV, and PEL. If this analysis cannot be conducted onsite and/or it is not possible to have them analyzed commercially because of their radioactivity, then estimating the mass concentration of airborne uranium based on the air sample activity level may suffice. A health-conservative determination of whether adequate respiratory protection is being used with regard to the chemical hazard presented by uranium can then be made. The type of respiratory protection used in MAC-3 should sufficiently protect against both the chemical and radioactive hazards encountered in MAC-3.

Respiratory Protection

To determine a worker's ability to wear a respirator, several factors need to be considered, including the worker's health and fitness for work, characteristics of the job, and the properties of the respirator. Familiarity with the physiologic effects of respirator use is essential. Compliance with OSHA's Respiratory Protection Standard, 29 CFR 1910.134, is mandatory. While spirometry may be useful in screening workers for the effects of substances known or suspected of reducing lung function, it should not be the only part of the medical evaluation for respirator use.[26] Spirometry, if determined to be necessary by the physician, should be used as a component of a complete assessment of an individual's pulmonary status.

RECOMMENDATIONS

To reduce worker exposure to nickel and depleted uranium at UCI, and to improve the overall health and safety of workers there, the following recommendations are made:

1. Engineering controls should be used to reduce nickel concentrations in air to levels below the REL in all areas. Until this is accomplished, appropriate respiratory protection will be needed in all areas with air concentrations of nickel above the REL: blending and batch operations, kiln and dryer-related operations, lab work, product finishing/screening/packaging, and cleanup/maintenance. The level of respiratory protection for bagging operations should be modified immediately to full facepiece PAPRs/supplied air respirators.

2. Identify the specific MAC-3 operator tasks that contribute to over exposures to depleted uranium. Engineering controls, such as improved local exhaust ventilation at point-source locations to be identified by air sampling, should be implemented in MAC-3 so that DU exposures there fall below the DAC.

3. Uranium exposures in MAC-3 should be determined to assess the chemical risks. This information should be used to determine whether sufficient respiratory protection is being used by the workers in MAC-3 to ensure adequate protection from all uranium hazards.

4. Refer to ANSI Standard HPS N13.22-1995 for guidance on the uranium biological monitoring program; this program must also continue to maintain compliance with the Radioactive Materials Unit, Cabinet for Health Services, Commonwealth of Kentucky standards. Fecal analysis may be more useful than urinalysis alone for monitoring exposure to insoluble forms of uranium. Fecal analysis is especially well-suited for post-exposure follow-up after an acute exposure, for example, if air concentrations are found to be above the DAC. Analysis of the biological monitoring results should be done for individual workers and also with regard to the entire group of monitored workers.

5. Do not use spirometry results as a strict criterion for the ability to wear a respirator. Spirometry, if determined to be necessary by the physician, should be used as a component of a complete assessment of an individual's pulmonary status. Ensure that results of spirometry or other medical test results are kept confidential.

6. If you choose to continue performing broad medical screening, it may be useful to employees to distinguish between general medical screening tests and screening tests done specifically to evaluate potential occupational exposures at UCI.

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