



DEPARTMENT OF HEALTH & HUMAN SERVICES

Memorandum

Date February 28, 2003  
From Principal Engineer, OEP, NIOSH  
Subject Final Progress Report for entry into NIOSHTIC2/NTIS for  
NIOSH Training Grant No. T42 CCT 510420  
To Vern P. Anderson, Chief, IRB, EID (C-18)

The enclosed report has been received from the Center Director to document work performed during the specified grant project period. The following information applies to the designated Education and Research Center (ERC):

Title: University of Cincinnati Education and Research Center

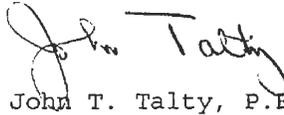
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Please place the report in DIDS and I also recommend it for entry into NIOSHTIC2 and submission to NTIS.

Thanks for your assistance.

  
John T. Talty, P.E., DEE

Enclosure

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**DEPARTMENT OF ENVIRONMENTAL HEALTH  
UNIVERSITY OF CINCINNATI  
Cincinnati, Ohio 45267-0056**

**EDUCATION AND RESEARCH CENTER (ERC)  
CDC / NIOSH Training Grant No. T42/CCT 510420**

**FINAL PROGRESS REPORT July 1, 1997 to June 30, 2002**



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Report Submitted: September 30, 2002

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## I Abstract

Since its inception nearly 25 years ago the University of Cincinnati (UC) Education and Research Center (ERC) has provided education, consultation, community service and research for workers, employees and citizens drawn from a catchment area including much of the Midwestern United States as well elsewhere in the United States and from many other countries. The Education and Research Center at the University of Cincinnati has a full complement of Core Programs. This Center provides multidisciplinary programs for academic and research training in the major fields of Occupational Safety and Health and related disciplines and Continuing Education/Outreach. These disciplines include: Occupational Medicine (OM), Occupational Health Nursing (OHN), Industrial Hygiene (IH), Occupational Safety and Ergonomics (OSE). All core educational units provide curricula not only for their own graduate students but contribute significantly to the teaching and research experiences of students in all programs. This interdisciplinary aspect of the ERC is the keystone of productive occupational and environmental health education, research and service. The interdisciplinary interactions are summarized for the ERC in a central location of this application in the Center Administration narrative. Interdisciplinary student research has been facilitated in the past two years using support from the ERC Pilot Research Project Program. Because of the diverse industries in the area and our very large number of research faculty with wide-ranging expertise, our ERC does not have a single focus area for its research efforts. The ERC faculty and students are involved in extensive, research efforts addressing three-fourths of the NORA priority research areas.

### **Interdisciplinary Interactions**

The major objective of the Occupational Safety and Health Education and Research Center at the University of Cincinnati is to provide interdisciplinary programs for professional and scientific training in Environmental and Industrial Hygiene, Occupational Health Nursing, Occupational Medicine and Occupational Safety and Ergonomics and related disciplines. While the major thrust of each program is specialized education at the graduate training level, there is a well-developed research and Continuing Education and Outreach effort in each of the core areas. The administrative component of the Center is located in the Department of Environmental Health. An Internal Advisory Committee consists of the Director, Deputy Director, and each of the Program Directors. An External Advisory Committee consists of appropriate representatives from each of the five program areas as well as a representative from labor, government and professional organizations.

**Industrial Hygiene:** The Industrial Hygiene Program has eight full-time faculty, four adjunct faculty and a large number of volunteer faculty and others who help in the program. The program is ABET accredited. A total of 28 M.S. and 12 Ph.D. degrees have been awarded during the September 1, 1997 through August 31, 2002 five-year reporting period.

The Environmental and Industrial Hygiene program in the Department of Environmental Health (DEH), University of Cincinnati (UC), continues to evolve from the training and research program initiated in 1952 by the late Professor Jacob Cholak to provide exposure assessment and control methods in an occupational medicine unit. As originally envisioned by Robert Kehoe, M.D., founding director, DEH, the overall unit brought together physicians, engineers, toxicologists and library specialists to identify, evaluate and control occupational hazards. The program builds on this early, creative recognition of the multi-disciplinary nature of practice and research in the hygiene profession, with required courses in a range of subject areas, team-building opportunities and required research. Both the M.S. and Ph.D. degrees are awarded. The M.S. program is generally completed in two academic years, and requires a written thesis with a testable hypothesis; the Ph.D. can be completed in about four years and requires a minimum of 18 credits of formal courses beyond the M.S. requirements, and a dissertation. The Hazardous Substance Academic Training option is available to M.S. students and includes two additional re-

quired classes (Human Biological Monitoring and Biomarkers; Applied Risk Assessment). The M.S. program is accredited by Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology, Inc. (EAC/ABET).

**Occupational Health Nursing:** Seven full-time students (4 M.S. and 3 Ph.D.) and 6 part-time students (5 M.S. and 1 Ph.D.) were enrolled during 2001-2002. Four M.S. student were graduated during 2001-2002. A deputy director has been recently named who will increase research activities within the program.

Since July 1, 1997 Occupational Health Nursing has increased the influence of occupational health nursing within the College of Nursing and the Education and Research Center (ERC) increased the number of doctoral students in occupational health nursing; and increase the scholarly productivity of students and faculty. Dr. Sue Davis, Director of the Occupational Health Nursing Program since 1994, provides consistency in leadership and a single focus on program outcomes that result in increased visibility and influence within the College of Nursing, the Education and Research Center, and practicing Occupational Health Nurses. These outcomes built on the curricular changes implemented in 1996 – 1997. The addition of Dr. Donna Gates in 2001 as Deputy Director increased opportunities for research mentoring of doctoral and master's students. Dr. Gates replaced Professor Christine Graeter who is pursuing doctoral education in epidemiology. Drs. Davis and Gates have workload assignments in both the Education and Research Center and the College of Nursing, thus ensuring quality interdisciplinary education and research opportunities with students and faculty from the other Colleges. Clinical faculty, Ms. Mary Lou Jones and Ursula Meyer, engage in active practice or in occupational health and safety projects within the community.

**Occupational Medicine:** The Program graduated one student in the 2001-2002 academic year. Two new full-time residents matriculated into the program, one as a Master of Science degree candidate, and the other in the practicum year.

The nation's first Occupational Medicine Training Program was established in 1947 at UC. As conceived by its founder, Dr. Robert Kehoe, the mission of the Residency Program is, to graduate trainees who will assume leadership positions in academic, governmental, and industrial and labor occupational health programs, as well as regional hospitals and clinics. The residency program has received NIOSH / ERC training program support since the inception of the ERC program, and was recently re-accredited by the Accreditation Council for Graduate Medical Education through 2007. The training program satisfies training requirements for board certification in occupational medicine by the American Board of Preventive Medicine, and the American Osteopathic Board of Preventive Medicine. Since inception of the program, there have been more than 200 graduates with two in the last year and three new students beginning studies during the 2002-2003 academic year. Unlike traditional programs which require one year of didactic training culminating in a Master of Public Health (M.P.H.) followed by one year of clinical work, the U.C. program affords the opportunity for integration of academic and clinical experiences throughout the two years. Three training tracks: clinical, research and business, offer career specific training options to the residents. The program leads to a Master of Science following completion of course work, clinical rotations and a required thesis project. Holders of degrees previously obtained, such as masters in public health may utilize the residency program for practicum training in occupational medicine.

**Occupational Safety/Ergonomics:** The Program in the 2001-2002 academic year had an enrollment of 3 M.S. and 5 Ph.D. full-time trainees. In addition there were 6 part-time M.S. trainees and 1 part-time Ph.D. student. The Program is designed to train safety specialists with engineering and safety skills as

well as provide an emphasis on mathematical/quantitative abilities and an orientation to manufacturing and system safety.

The occupational safety/ergonomics program (OS/E) is made possible through a wide range of UC courses and faculty, and the NIOSH funding support of the Cincinnati ERC. The majority of courses are taught by faculty from the colleges of Engineering and Medicine through the departments of Mechanical, Industrial and Nuclear Engineering (MINE) and Environmental Health (EH). The major objective of the occupational safety/ergonomics training and research program is to provide graduate engineers with specialized courses and experiences that will enable them to become practicing safety/ergonomics professionals or researchers in the field. A secondary objective is to provide an exposure and awareness of occupational safety/ergonomics to engineers that do not work as safety professionals or researchers but are employed in other engineering capacities and should include safety/ergonomics considerations in those activities. Several key occupational safety/ergonomics courses would not be offered without support from NIOSH. Safety engineering and ergonomics courses were initially developed at the undergraduate and graduate levels in 1975 coinciding with the beginning of the Industrial Engineering Program in the College of Engineering. Between 1975 and 1986, prior to NIOSH funding, several students completed M.S. degrees with course work that related to occupational safety/ergonomics. Also, during this time period the first Ph.D. with safety/ergonomics specialization was completed in 1987 by Linda Cahill-McQuiston (the first female to complete the Ph.D. in the MINE Department).

**Hazardous Substance Academic Training (HSAT):** Seven students were enrolled in the HSAT program, a specialty within Industrial Hygiene, during 2001-2002. The program includes two additional required classes plus the IH 40-hour HAZWOPER training in addition to the required courses.

The Hazardous Substances Academic Training (HSAT) program at UC is an emphasis area within the Environmental and Industrial Hygiene program. Students selecting the HSAT area have two additional required courses and also attend a 40-hour health and safety class for hazardous waste site workers. Several other industrial hygiene courses have been strengthened in hazardous substance content and additional courses have been developed. The program therefore impacts all students taking industrial hygiene core courses, whether taking courses as part of the Environmental and Industrial Hygiene major or as electives. The HSAT program requires additional training in Biological Monitoring and Risk Assessment for those students pursuing the HSAT program as an area of concentration or who select these courses for other reasons. The existing required industrial hygiene course in Hazardous Materials Management was strengthened through HSAT funding by the addition of field trips and by incorporation into the class of computer software such as those for the modeling of chemical releases into the air and ground-water and for risk assessment. A special laboratory exercise has been developed for a core industrial hygiene course where students make use of a chemical monitoring data set developed to simulate an actual industrial chemical release incident. Students attend hazardous waste worker training programs and related courses offered through the EPA-supported training center located in Cincinnati or through one of the local programs in the NIEHS-supported hazardous waste worker training centers with which the Department of Environmental Health is involved such as the Midwest Consortium for Hazardous Waste Worker Training and the ICWUC Center for Worker Health and Safety Education.

**Continuing Education:** Courses presented through this program range from one-day seminars on selected topics to four-week intensive training programs. For the nine-months of academic year 2001-2002, 105 courses were presented to 2889 trainees. These courses reflect the reputation, strength, and diversity of the ERC faculty. This program is also a partner with the Minnesota ERC/CE Program in the Great Lakes OSHA Regional Education Center.

The Office of Continuing Education, continues the tradition begun in 1949 of offering short courses in environmental and occupational health and safety. Established in 1983, the Office of Continuing Education assumed the coordination of the administrative and marketing functions of the program, allowing faculty to concentrate their efforts on course development. Through this cooperative effort the Office of Continuing Education has built a national reputation for offering excellence in environmental / occupational health and safety short courses. Continuing education courses presented through this program are multi-faceted, ranging from one-day seminars on selected topics to four-week intensive training programs. These courses reflect the reputation, strength, and diversity of the ERC faculty. The Office of Continuing Education offers courses in all four ERC core areas: occupational medicine, occupational health nursing, environmental / industrial hygiene, and occupational safety. The program is interdisciplinary, utilizing faculty from the College of Medicine, the College of Nursing and Health, the College of Engineering (both from the Clifton campus and Section Road facility), the University College Department of Math and Applied Sciences, and the College of Education. The role of the Continuing Education Office includes the development of new short courses, the coordination of interdepartmental continuing education programming, marketing, administration, and program evaluation.

**Pilot Research Project Training Program:** The Pilot Research Project Training Program (PRP) at UC was established on July 1, 1999. As initially established, the UC PRP included three other universities in the region: Purdue University, University of Kentucky and Western Kentucky University. Dr. Bhattacharya heads the UC PRP program. The program was expanded in 2001 to include four other institutions: Central State University, Eastern Kentucky University, Murray State University and Western Kentucky University. Pilot projects are intended to: develop research expertise, capacity, and understanding in ERC research trainees and new investigators and within regional occupational safety and health research training programs, provide initial support for new occupational safety and health investigators to establish new areas of research that address NORA topics, and encourage investigators from other relevant research areas to apply their expertise to NORA topics.

## II CENTER ADMINISTRATION AND INDIVIDUAL PROGRAM REPORTS

### A CENTER ADMINISTRATION

#### Administration of the Center

The administrative functions of the University of Cincinnati Education and Research Center are carried out through the Center Director, Deputy Director, the Senior Business Administrator and staff, and the individual Program Directors. Dr. Scott Clark has been Center Director since 1994 after serving four years as Deputy ERC Director under Dr. Roy Albert, who was ERC Director from 1985-1994. Dr. Carol Rice was appointed as Deputy ERC Director in 1999 following the departure from the University of Cincinnati of former Deputy Director Douglas Linz, M.D. Dr. Clark also serves as Director of the Division of Environmental and Industrial Hygiene at the Department of Environmental Health. Ms. Karen Silver serves in the capacity of senior business administrator and Ms. Stephanie Starkey oversees applicant and student records for the Department of Environmental Health ERC students. Ms. Karen Brackemyre serves as ERC Coordinator. Ms. Noreen Johnson handles business and administrative affairs for the Division of Environmental and Industrial Hygiene.

The Director of the Department of Environmental Health, since 1996, is Marshall Anderson, Ph.D. Dr. Anderson was previously a member of the Cancer Center of the University of Colorado Health Sciences Center and Director of Research at the Cancer Research Institute of St. Mary's Hospital in Colorado and prior to that he was the Chief of the Laboratory of Molecular Toxicology at the National Institute of Environmental Health Sciences. His major research interests are the role of oncogenes and tumor suppressor genes in lung cancer, the identification of susceptibility genes in human lung tumor development, and the early detection of lung cancer. Dr. Anderson has expressed a goal to increase occupational and environmental epidemiology studies that bring together the exposure assessment (Environmental and Industrial Hygiene), occupational medicine, epidemiology, biostatistics and molecular genetic strengths of the Department.

The ERC Director, with the help of the Deputy Director, maintains frequent communication with the individual programs. The Director has ultimate responsibility for the proper development and effective function of each program. Each program, however, functions with relative independence under the leadership of its own Program Director. The Center Director and Program Directors collectively discuss major policy decisions including teaching staff, research programs, curriculum development, program planning and implementation, allocation and utilization of funds, coordination of teaching and research efforts and program review and evaluation. Frequent meetings are held for these decisions as well as to facilitate communication.

The Senior Business Administrator and other financial staff associated with individual programs manage the financial operation of the ERC Center, prepare and maintain budgets of all component programs and advise the program directors on the fiscal aspects of each respective program.

#### External Advisory Committee

An External Advisory Committee has been established for the Center composed of individuals selected because of their specific knowledge of particular academic core(s), their interdisciplinary experience or because they represent a broader constituency, such as organized labor, government or professional organizations. The individual core programs also have frequent interactions with members of the Committee. The current composition of the External Advisory Committee is shown in Attachment A. Members of the External Advisory Committee have frequent interactions with ERC programs. For example, Nan Migliozzi from the Ohio Health Department interacts with Occupational Health Nursing faculty on re-

search projects. Mike Gunn from the City of Cincinnati lectures in the Hazardous Waste Management class and worked with a M.S. student in his research. Dr. Richard Fulwiler actively participates in U.C. Industrial Hygiene activities and at the annual AIHCE meetings.

### **Outside Support to Supplement the ERC**

Outside support to supplement the ERC is obtained from research grants and contracts, special training grants for the Continuing Education program, from private contributions and from the University. The University provides University Graduate Scholarships, for example, that are available for industrial hygiene, occupational medicine, occupational health nursing and occupational safety students. A limited number of University Graduate Assistantships are also available for qualifying doctoral students. During the past five years the Department of Environmental Health has steadily increased the minimum level of stipends for Ph.D. students from \$12,000 for 1996-97 to \$18,000 per year for 2001-2002. Supplemental funds are provided through grants and contracts available to the faculty and to a limited extent through faculty development funds available through the University. External support of ERC research is provided through numerous grants from the public or private sector with a total annual budget of over \$6 million.

### **Individual Programs and Locations**

This Education and Research Center is located on the contiguous East and West campuses of the University of Cincinnati. The Industrial Hygiene and Occupational Medicine Programs are located in the Department of Environmental Health of the College of Medicine; and the Occupational Health Nursing Program is located in the Department of Community, Administrative and Psychiatric Nursing in the College of Nursing. Both of these colleges are located in the large Medical Center complex (East Campus) comprised by the Colleges of Medicine, Nursing, Allied Health Services, and Pharmacy, three University affiliated hospitals--The University Hospital, the C.R. Holmes Hospital and the Children's Hospital Medical Center. The Occupational Safety/Ergonomics Program is located in the Department of Mechanical, Industrial, and Nuclear Engineering of the College of Engineering on the West Campus, approximately one mile from the Department of Environmental Health. The Occupational Health Nursing program in the College of Nursing is located midway between the College of Engineering and the Department of Environmental Health.

All trainees are able to avail themselves of course offerings of other University colleges, e.g.: Arts & Sciences, Business Administration and Law, and other local universities, e.g.: Xavier University, through a consortium among institutions of higher education in the Greater Cincinnati area. The University has a shuttle bus service operating on a very frequent basis between several locations on the East and West Campuses. This service that has been operating for the past couple of years, greatly enhances mobility for students and faculty.

There are a total of 39 full-time students in the ERC program with each program having at least five full-time students. Of the total of 72 full and part-time students, almost 50% are female, about 5% are minority.

### **Industrial Hygiene**

The Industrial Hygiene (IH) Program is directed from the Department of Environmental Health in the College of Medicine. The Program has three objectives. The first is to train professionals to the M.S. degree level to have the skills, scientific knowledge and state-of-the-art expertise to anticipate, identify, evaluate, implement and recommend measures to control health hazards and causes of discomfort in occupational environments. The second objective is to train research scientists to the Ph.D. level to contribute fundamental research in effective methods of anticipating measuring, evaluating and controlling exposures to hazardous physical, biological and chemical stressors in the workplace. The third objective is

to reach out into the community, locally, nationally and internationally, to offer opportunities to industrial hygiene field professionals and those in other fields to gain knowledge in industrial hygiene or advance their understanding in specific industrial hygiene areas. The IH program, therefore, provides courses to train industrial hygiene professionals who need a broad-based understanding of industrial hygiene practice, and it provides courses for industrial hygiene practitioners and others who wish to gain in-depth knowledge in a specific industrial hygiene or focused research area of specialization.

The Industrial Hygiene Program continues to maintain a strong graduate training program. During the 2001-2002 academic year 11 full-time M.S. students and 11 full-time Ph.D. students and 5 part-time M.S. and 9 part-time Ph.D. students were enrolled. There were, 4 M.S. degree and 4 Ph.D. degrees awarded. The program continues to emphasize practical as well as academic training with internships, field surveys, and consultations which are done on a multi-disciplinary basis. Both practitioner and research training tracks are offered in this program. The Industrial Hygiene M.S. Program was one of the initial groups that received accreditation from ABET in 1989 and revisited during the 2000-2001 academic year. Areas of emphasis are available within the program including aerosol science, biological monitoring, ergonomics/ biomechanics and the hazardous substance academic training (HSAT) option which is supported through the Hazardous Substances Academic Training program of the NIOSH ERC and is affiliated with other related training efforts.

Within the Industrial Hygiene program there is an option in Occupational Safety and Ergonomics for which one ERC-IH stipend is made available each year (see New Program Developments). This program was designed for a student interested in Occupational Safety and Ergonomics who does not have the engineering background needed for the program in the College of Engineering and/or who wishes to focus more on the environmental health aspects.

The current Deputy Director of this program, Dr. Carol Rice, directs the nationally-recognized NIEHS Midwest Consortium for Hazardous Waste Worker Training Program and is affiliated with another training center operated by the International Chemical Workers Union and the UBC Health and Safety Fund. Dr. Rice will become Director of the Industrial Hygiene program in July 2002 with Dr. Bhattacharya serving as Deputy Director. Both are eminently qualified with Dr. Rice serving as Deputy director from 1996 to 2002 and Dr. Bhattacharya serving as Acting Director in 1995 when both Drs. Clark and Rice were on Sabbatical. Dr. Bhattacharya also directs the Occupational Safety & Ergonomics option in the Industrial Hygiene Division.

#### **Hazardous Substance Academic Training (HSAT)**

The HSAT continues to be a very popular option within the Industrial Hygiene program. Students selecting this option take all the required courses in the Industrial Hygiene program and, in addition, take the two other required courses. Of the three new M.S. students in 2001-2002 all three have chosen this option. Dr. Carol Rice became Director of the HSAT July 2002 after serving as Deputy Director since its inception. Dr. Glenn Talaska, who teaches one of the two courses required specifically for the HSAT option, became Deputy Director.

#### **Occupational Health Nursing**

The Occupational Health Nursing Program is directed from the Department of Community, Administrative and Psychiatric Health Nursing in the College of Nursing. The Program represents a curriculum option within the Community Health Nursing Program in which nurses are prepared to function as clinical specialists, educators, administrators or researchers in occupational health settings. Recognition and evaluation of hazards within the work environment and the need for epidemiologic studies of the occupational health setting are stressed. Initial planning has occurred to expand the occupational health nursing

program to include an OH practitioner option. Dr. Linda Sue Davis has been Director of this program since 1997.

The Occupational Health Nursing program has the following objectives: 1) to prepare nurse specialists at the graduate level with advanced knowledge of occupational health and safety science and management of occupational health services; 2) to integrate content on occupational health and safety into the undergraduate nursing program and offer opportunities for expanded clinical experience in occupational health; 3) to provide the skills to plan, develop, implement and systematically evaluate programs in the occupational setting; 4) to prepare nurses to collaborate with members of the interdisciplinary occupational health team in planning, implementing and evaluating occupational health programs; 5) to utilize skills of scientific investigation in research to identify existing or potential health problems in the occupational setting. There currently are 4 full-time and 5 part-time students in the M.S. program and 3 full-time and 1 part-time students in the Ph.D. program. During the 2001-2002 academic year 2 M.S. degrees and 2 Ph.D. degrees were awarded.

The recent designation of Dr. Donna Gates as Deputy Program Director and the substantial reduction of her undergraduate teaching responsibilities will facilitate successful completion of her expanding externally funded research efforts. This is expected to substantially enhance the amount of interdisciplinary research involving Occupational Health Nursing through the additional time she will have available for research and her assuming a more prominent position in the program.

### Occupational Medicine

The Occupational Medicine Program is directed from the Department of Environmental Health in the College of Medicine. It is the oldest continuously running residency program with over 200 graduates since its inception in 1947. The two-year residency satisfies the training requirement of physicians for certification in Occupational Medicine by the American Board of Preventive Medicine and is fully accredited by the Accreditation Council for Graduate Medical Education. The training program also leads to a Master of Science degree, which requires a thesis. The residency has sufficient flexibility to accommodate physicians with a variety of interests and ultimate career objectives including 1) the delivery of medical care in an industrial setting, hospital-based or free-standing clinical practice, or 2) research and teaching in an academic unit or national agency, or 3) health affairs administration at a corporate or governmental level.

During academic year 2001-02, there were six trainees (one part-time and five full-time). The Program graduated one trainee in the 2001-2002 academic year. Two full-time residents have matriculated into the program, one as Master of Science degree candidate, the other in the practicum year. The Occupational Medicine Program has developed three tracks including a 2-year residency, a 3-year research track, and a combined MS/Business program. Other activities of the program include extensive research, community service, consultation and continuing education efforts. The Director of the Occupational Medicine Program is Dr. James Donovan and Dr. Andrew Freeman serves as Deputy Director.

### Occupational Safety/Ergonomics

Occupational safety/ergonomics at the University of Cincinnati was initiated in 1975 and became a core area in the ERC in 1986. This Program is directed through the Department of Mechanical, Industrial, and Nuclear Engineering in the College of Engineering. The primary objective of the Occupational Safety/Ergonomics program is to train individuals that already possess general undergraduate engineering skills in the specialty of occupational safety and ergonomics, leading to the degree(s) of M.S. and/or Ph.D. in Industrial Engineering. A secondary objective is to provide selected engineering and occupational safety/ergonomics training (one or more courses) to a wide range of graduate students or profes-

sionals in fields such as: environmental health, nursing, industrial hygiene, occupational medicine, health physics, and business administration.

The curriculum includes occupational safety/ergonomics theory and practice, support courses, and research skills for safety/ergonomic-related investigations. Training methods are comprised of formal courses, special topics, thesis and dissertation, and continuing education seminars. The program utilizes core courses in the Department of Mechanical, Industrial and Nuclear Engineering (MINE), and Environmental Health (EH), supplemented with graduate courses offered in other UC departments.

The Program in the 2001-2002 academic year has an enrollment of 11 M.S. ( 5 part-time and 6 full-time) and 7 Ph.D. full-time trainees. During the 2001-2002 there were 4 M.S. and 1 Ph.D. graduates. The Program is designed to train occupational / ergonomics safety specialists with engineering, safety and ergonomics skills as well as provide an emphasis on mathematical/quantitative abilities and an orientation to manufacturing and system safety. The Occupational Safety/Ergonomic program is headed by Dr. Richard Shell, as Director; Dr. Ash Genaidy serves as Deputy Director.

#### **Continuing Education/Outreach**

The Continuing Education/Outreach Program is based in the Department of Environmental Health. The major purpose of the Continuing Education Component of the ERC at the University of Cincinnati is to develop and present a multi-disciplinary program of courses in the fields of occupational health, industrial hygiene, occupational safety/ergonomics, and occupational health nursing. These courses are offered to enhance the education and expand the knowledge and skills of the practicing professional in the areas of occupational health and safety. This above purpose is accomplished through objectives including the following: 1) to provide formalized training in occupational health and safety at different levels; 2) to meet the educational needs of practicing professionals through regional needs assessment; 3) to serve as a resource to the community through awareness presentations; and 4) to provide services to occupational health professionals.

The Program has expanded with the addition of courses in lead abatement, toxicology and industrial hygiene including asbestos removal and the hazard communication standard, etc. During the first nine months of the 2001-2002 year a total of 105 courses were offered and attended by a total of 2,889 students. This Program conducts a vigorous evaluation and needs assessment survey that assists each of the other ERC Programs in developing their course offerings. These courses may range from one day presentations to two week workshops. Students who register for CE courses come from a variety of occupational and environmental health settings including governments, union, and industry. The backgrounds of the students vary also from those just beginning to work in an occupational health field to those with experience needing a refresher course in basic material. Other students include professionals keeping abreast of current thought and technology in a field. Some students such as managers, production engineers, or insurance personnel do not work directly with occupational safety and health matters but do require certain information about those aspects of their disciplines. Recently our CE program is a member of the Great Lakes Regional OSHA Education Consortium (with another ERC-Minnesota-and the Minnesota Safety Council). This addition has strengthened the program's interaction with OSHA and the number of safety course offerings.

#### **New Program Developments**

With the addition of Dr. Kermit Davis to the faculty of the Industrial Hygiene program, collaboration between the ERC academic core programs is expected to be further enhanced because his interests in the interaction between psychosocial and biomechanical factors coincides with that of faculty in the other programs. This interaction is expected to be further stimulated by the naming of Dr. Donna Gates to Deputy Director of Occupational Health Nursing. Over the next few years it is expected that one or more

new ergonomics-related courses, jointly meeting the needs of students in several of the ERC academic core programs, will be developed.

Additional opportunities for academic and research program development will occur through the recent expansion of the academic institution collaborating in the ERC Pilot Research Project (PRP) program. The PRP, when initially developed in the 1999-2000 academic year, included the University of Kentucky, Western Kentucky University and Purdue University. The recent expansion of the PRP beginning July 1, 2001, will also include Murray State University (Murray, KY), Eastern Kentucky University (Richmond, KY), Kentucky State University (Frankfort, KY) and Central State University (Wilberforce, OH). The latter two are predominantly minority institutions. Developments are expected to occur in the research area and in addition may lead to increases in the number of applicants to ERC academic program, particularly minority applicants.

The Occupational Safety and Ergonomics option within the Industrial Hygiene core program, which was developed just prior to the current five year project period, has continued to be productive. This program takes most of its required courses from existing courses in the Department of Environmental Health and the Department of Mechanical, Industrial and Nuclear Engineering. There were 7 students enrolled during academic year 2001-2002 – four full-time and three part-time Ph.D. students. Thus far, there have been 3 M.S. and 3 Ph.D. graduates from this program.

A new interdisciplinary course that was developed during the current five-year period, the Occupational Health and Safety Team, has both an interdisciplinary faculty and interdisciplinary students, and will be described in more detail under Interdisciplinary interaction.

#### **Interdisciplinary Interaction**

Interdisciplinary interaction is enhanced by the ERC components being in close proximity to each other and by the Center being based in a comprehensive Department of Environmental Health, which also contains faculty in other disciplines involved in occupational safety, and health such as biostatistics, epidemiology and toxicology.

The students in the four core academic programs are involved in interdisciplinary interactions on several levels through research, field experiences and classroom activities: research projects involving interdisciplinary interactions among faculty, students and staff, clinical field projects and worker training activities the interdisciplinary workshop series and team classes academic courses with students from other occupational safety and health disciplines,

#### **Research projects involving interdisciplinary interactions include the following**

The ERC Pilot Research Project program (PRP) has provided funding for several interdisciplinary research projects involving trainees. A doctoral student in Occupational Safety/Ergonomics (N. Dareish) collaborated with a doctoral student in Occupational Health Nursing (M. Burton) to pilot test two instruments designed to study the interaction between work factors and individual factors involved in work related musculoskeletal disorders (WRMD). The instruments were administered to two high risk classifications of nursing personnel. Each of these students will be using results of the pilot project as the basis for their Ph.D. research.

A doctoral student in Environmental & Industrial Hygiene (P.L. Rao) examined pesticide exposures among farm workers and their families in India with support from an interdisciplinary faculty group: Dr. L. McCauley, R.N. (Center for Research in Occupational and Environmental Toxicology, Oregon Health Sciences Center), Dr. S. Mukherjee (Community Medicine Physician, Pramukhswami Medical College, India), Dr. S. Clark, Dr. G. Talaska, Dr. C. Rice (University of Cincinnati, Environmental and Industrial

Hygiene). This project has resulted in two proposals: R03 (NIOSH) and a Fogarty International Research collaboration application with colleagues at the Oregon Health Sciences Center and the National Institute of Occupational Health (India).

In a project designed to determine the occupational health knowledge and needs of genetic counselors, how they collected occupational information and how they utilize occupational history information, a genetic counseling student (G. Hepler) surveyed 300 genetic counselors using a survey instrument developed with support of an interdisciplinary faculty of genetics counselors (N. Warren, R. Hopkins, K. Huelsmon), industrial hygienist (C. Rice), and behavioral researcher (P. Berger, Univ. of Kentucky).

A doctoral student in Occupational Safety and Ergonomics (L. Kincl) worked with a behavioral psychologist (K. Deitrich) to evaluate injury trends for adolescents with childhood lead poisoning.

Another pilot research involving Ming-Lun Lu (Ph.D., IH) and Laurel Kincl (Ph.D., Occupational Safety and Ergonomics-Environmental Health) investigated slippery surfaces and risk of falls in an automobile parts assembly plant. This project has resulted in a R01 application by a Ph.D. student in Occupational Safety/Ergonomics-College of Engineering.

Funds received as a special ERC Administration Supplement for the year 2000-2001 were used to support research of an occupational medicine resident in a study of the immunologic aspects of exposure to jet fuel. This project involves occupational medicine, epidemiology and biostatistics.

Prior to the PRP program, special funds received from NIOSH to foster trainee research, were used in a pilot study of pesticide exposures and postural stability impacts on migrant farm worker families in Northern Ohio.

Refractory ceramic fibers study:

A long-term study of health effects of current and former workers at US plants focusing on respiratory system (morbidity and mortality) and exposure assessments.

Faculty involved: Lockett (Occupational Medicine), Rice (Industrial Hygiene) and Lemasters (Occupational Epidemiology). A number of ERC students from the past several years (Industrial Hygiene) and (Occupational Medicine) have been involved including Ruishon Wu, a current M.S. student in Industrial Hygiene.

NIOSH-supported Study of Ergonomics of Task Performances on Slippery Surfaces.

This study, conducted in the collaboration with the Greater Cincinnati Occupational Health Center, involved three recent Ph.D. graduates, Occupational Safety/Ergonomics-Engineering (Bingshi Wang), Industrial Hygiene (Shiow-Yi Chiou), and Chwan-Fu Lai (Occupational Safety and Ergonomics-Environmental Health). Three publications resulted: Chiou et al, 1998, Chiou, et al 2000 and Wang et al 1999.

US Air Force-supported Study of Personnel Exposed to Low Levels of Jet Fuel

Two Industrial Hygiene M.S. students (Les Smith and Ed Puhala) completed their research with interdisciplinary committees composed of Drs. Bhattacharya (Industrial Hygiene/Ergonomics), Lemasters (Occupational Medicine/Epidemiology) and Col. John Joyce (Industrial Hygienist-US Air Force). Two publications based on their research appeared in 1997 (Puhala et al, 1997 and Smith et al, 1997). Four other students have been involved: Auyang (M.S., IH), Gordon (M.S., IH), Kincl (M.S., HSAT/IH; Ph.D., Occ'l. Safety & Ergonomics) and Lu (Ph.D., EH).

#### Task Performance on Inclined and Elevated Surfaces:

This study determines the ability to carry out tasks, as measured by postural stability and the risk factors for falls among workers such as iron workers, and others who work on scaffolds and ladders. Intervention strategies are also developed. Students involved are Ph.D. students in IH (Ming-Lun Lu) and Occupational Safety & Ergonomics (L. Kincl) and a M.S. student in IH (J. Gordon).

#### Fernald Cancer Study

A new study of incident cases of cancer of lung, female breast, prostate, urinary system and malignant melanoma has begun in April 2001 among participants of the Fernald Medical Monitoring program. Dr. Susan Pinney (Epidemiology), Dr. Richard Hornung (Biostatistics) and Dr. Scott Clark (Industrial Hygiene) are among those involved. Two industrial hygiene students (Andrea Armstrong, M.S and Jeff Lodwick, Ph.D.) have already been involved and other students will join the project in the future.

#### Solvent Study

A new research project involving Occupational Safety/Ergonomics (Dr. Richard Shell), Industrial Hygiene (Dr. Glenn Talaska) and Nutrition (Dr. Grace Falciglia) is being developed. This project will include the impact of dietary lipids on solvent exposure. One Ph.D. student from Occupational Safety/Ergonomics (College of Engineering) is currently involved, Brian Beimer.

#### Interdisciplinary Workshop and Team Classes

All students in the four core academic programs are required to participate in the three-quarter Occupational Health, Hygiene and Safety Workshop, which are offered for one graduate credit each quarter. The goal of this workshop is to enhance the ability of the trainees to work effectively in small interdisciplinary groups. This is accomplished through a series of seminars by interdisciplinary teams of occupational safety and health professionals, from local industries, through small group discussions and through projects that the teams select and work on throughout the year. The teams are in general composed of at least one trainee from each of the four core disciplines wherever possible; a faculty member from one of the cores serves as advisor. During the Spring Quarter final reports are presented by the teams with each participant being involved in the presentation. Topics of the workshop projects from the recent years are as follows:

- Survey of Occupational Noise Exposure (Machine Tool Industry, Cincinnati, OH)
- Facility Wide Sound Mapping with In-Depth Hazardous Noise Evaluation of Selected High Noise Work Areas (manufacturing company)
- Noise Study at Greer Brothers Industrial Packaging (industrial packaging)
- Safety Analysis of a Township Fire Department Service Building
- Evaluation of Bioaerosol Exposures During "Conditioning" of Biofilter Compost Beds (for wastewater treatment)
- Evaluation of Newly Designed Pressure Nozzle to reduce Workstation Noise (engine manufacturer)
- A Noise Exposure Assessment of the College of Design, Architecture, Art, and Planning, University of Cincinnati
- Health and Safety Issues at the University of Cincinnati (College of DAAP)
- Noise Assessment at the Cincinnati Engine Manufacturer
- Occupational Health and Safety Implementation Program at Candy/Ice Cream Manufacturer
- Solution of Ergonomic Issues for the "Automatic" at container manufacturer
- Occupational Health, Hygiene, and Safety Study at a paper Bag Manufacturer

Two other courses have been developed to compliment the Occupational Health, Hygiene and Safety Workshop series: The Occupational Health and Safety Team; Team-Building in Occupational Safety and Health Settings, each are one credit courses – one Fall quarter and one Winter quarter.

The Occupational Health and Safety Team course has been taught by Dr. Talaska (IH), Dr. Donovan (Occ. Med.) and Ms. Graeter, Course Director (Occ. Hlth. Nsg.) for the past three years. Functions of the team are taught through discussions and participation in a workplace walk-through that is specially designed to illustrate the role of each member of the Occupational Health and Safety Team. During the current year multi-disciplinary walk throughs were conducted at a steel barrel manufacturing plant and a chemical production plant. The Team-Building course is intensively taught over a two day period and involves an industrial hygienist with extensive management experience (Dr. Fulwiler) and an experienced Occupational Health Nurse instructor (Ms. Graeter). This class involves small group activities and considerable interaction among students and faculty. Outlines for each of these courses are included in the Occupational Health Nursing program description.

### **Clinic and Field Projects and Worker Training**

The course on Methods to Obtain Complete Occupational Histories facilitates involvement of ERC and other students in activities of the Center for Occupational Health. Several Industrial Hygiene and Nursing students gained experience in occupational history-taking. This course, recommended as an elective for occupational health nursing students, is being considered as a required class. Drs. Rice (Industrial Hygiene), and Donovan (Occupational Medicine) are involved in this practicum course.

The Midwest Consortium for Hazardous Waste Worker Training and the ICWC Center for Worker Health and Safety Education both provide students with opportunities to interact with other occupational health and safety disciplines in the operation and evaluation of worker training activities. Examples of such activities are pretraining physicals provided by occupational medicine residents, observation of training delivery using participatory techniques and assistance with delivery of training. A number of students have also been involved in field projects with NIOSH staff.

Using funds from the Supplemental Administration Budget allocations for the year 2000-2001, a special interdisciplinary trip was arranged to an underground coal mine in Western Kentucky during Spring break. The trip was attended by three Occupational Nursing students, four Industrial Hygiene students, three Occupational Safety and Ergonomics students and two Industrial Hygiene faculty.

### **Classroom Activities**

Classroom and field activities provide important opportunities for student interaction. Each is outlined below.

Many classes required, of one or more ERC cores are attended by students from a variety of disciplines. For example the biostatistics and epidemiology classes serve students from many departments from across the University. Among the courses required or frequently taken by students from more than one of the core occupational safety and health disciplines are:

Principles of Occupational Exposure Assessment (26-EIH-707): required by Industrial Hygiene, Occupational Safety/Ergonomics (Engineering and Environmental Health programs), Occupational Medicine and Occupational Health Nursing. This class has been modified to make it more useful to all ERC disciplines by adding a lecture, more practice problems and an extra math review session, all for mathematical procedures.

Programmatic Aspects of Occupational Health & Safety (26-EIH-781): required of industrial hygiene students and selected lectures are required by Occupational Health Nursing; Occupational Safety/Ergonomics (elective).

Practice in Occupational Exposure Assessment I (26-EIH-741). Required by Industrial Hygiene and Occupational Safety/Ergonomics (elective).

Basics of Occupational Medicine (26-EIH-786). Required by Occupational Medicine, Industrial Hygiene (elective), Occupational Safety/Ergonomics (elective) and Occupational Health Nursing (elective).

Identification of Potential Workplace Exposures (26-EIH-905) Required by Industrial Hygiene, Occupational Safety/Ergonomics (elective), Occupational Medicine (elective).

Hazardous Waste Management (26-EIH-834) Required by Industrial Hygiene, Occupational Safety/Ergonomics (elective).

Survey of Environmental Toxicology (26-EIH-782) Required by Industrial Hygiene and Occupational Health Nursing.

### **Meeting Regional Needs and Evaluation of Impact of Program**

Frequent contact with employers, alumni and advisory panels assist us in constantly improving our programs to make them more useful to regional, national and international needs. Results of a needs assessment for Occupational Health Nursing (OHN) are presented in the OHN section and the form used for the needs assessment for Industrial Hygiene (IH) is included in the IH section. The needs assessment conducted by Continuing Education also provides information for the core academic program. Each of the core programs has their own methods for program evaluations and through contact with each other, provides useful information regarding interdisciplinary needs. For example, interaction between Industrial Hygiene and Occupational Safety/Ergonomics core faculty lead to the development of the Occupational Safety and Ergonomics program as an option within the Industrial Hygiene core, meeting the needs of students applying to each of the core programs. Similarly, the need for more worker training expertise by occupational safety and health students, stimulated in part by the inclusion of worker training requirements in many regulations (e.g.: Hazardous Waste, Lead Abatement, and permit-required Confined Space Entry), resulted in the formal development of a course in Worker Training. Results of needs assessments are presented in the core program section.

The ERC has collaborative efforts with two NIOSH Training Program Grantees (Purdue University and Western Kentucky University). Both are participants in the ERC Pilot Research Project Program. Dr. McGlothlin of Purdue University continues to collaborate with Dr. Amit Bhattacharya in research activities. Dr. McGlothlin also teaches in the ERC CE program. For several years there have been get-togethers arranged for Western Kentucky University and University of Cincinnati faculty and students at both locations. The expansion of the Pilot Research Project Program (July 1, 2001) included Murray State University, another NIOSH Training Program Grantee.

ERC courses serve important needs of students in other programs in the Department of Environmental Health (e.g. Epidemiology and Toxicology), other Colleges (e.g. College of Engineering, Department of Civil & Environmental Engineering) and other institutions (e.g. Miami University).

The employers of our most recent graduates are indicated in Appendix A for each core academic program. Of the 15 current year graduates who have already accepted employment positions, ten are located in Ohio or adjacent states; four are working in the Federal government, three in state/local government, six in the private sector, one is on the faculty in an academic institution and one is pursuing an advanced degree.

**Attachment A**

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## **B INDUSTRIAL HYGIENE**

### **BACKGROUND**

The Environmental and Industrial Hygiene program in the Department of Environmental Health (DEH), University of Cincinnati, continues to evolve from the training and research program initiated in 1952 by the late Professor Jacob Cholak to provide exposure assessment and control methods in an occupational medicine unit. As originally envisioned by Robert Kehoe, M.D., founding director to DEH, the overall unit brought together physicians, engineers, toxicologists and library specialists to identify, evaluate and control occupational hazards. Over time, and with the development of formal academic programs in occupational hygiene, the engineering aspect expanded to include those with training in the basic sciences. This multi-disciplinary working environment provided a venue where potentially hazardous exposures and the strategies for exposure reduction could be studied in both the laboratory and the workplace. The program builds on this early, creative recognition of the multi-disciplinary nature of practice and research in the hygiene profession, with required courses in a range of subject areas, team-building opportunities and required research. Both the M.S. and Ph.D. degrees are awarded. The M.S. program is generally completed in two academic years, and requires a written thesis with a testable hypothesis; the Ph.D. can be completed in about four years and requires a minimum of 18 credits of formal courses beyond the M.S. requirements, and a dissertation. The Hazardous Substance Academic Training option is available to M.S. students and includes two additional required classes (Human Biological Monitoring and Bio-markers; Applied Risk Assessment). The M.S. program is accredited by Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology, Inc. (EAC/ABET).

### **ACADEMIC TRAINING**

#### **Goals and Objectives**

The mission of the Environmental and Industrial Hygiene program at the University of Cincinnati is to provide comprehensive training to enable graduates to assume leadership roles in occupational health programs in government, labor, the private sector and education. The Ph.D. program primarily prepares candidates for research and/or teaching careers; M.S. graduates are employed as practitioners. Students at both levels receive training in research methods, development/collection of data and in the interpretation of results. This goal is achieved through three phases of the training program: classroom education, field experience and research conducted with mentors. The emphasis on hygienists as part of the occupational health team begins in the first quarter of the program, during which students observe industrial operations and meet local practitioners in industrial hygiene, occupational safety/ergonomics, occupational medicine and occupational health nursing. The environmental and industrial hygiene science and practice courses during the first year of the program prepare the student to design and conduct industrial hygiene surveys, work with laboratory personnel for the analysis of samples, interpret analytical and observational results and make recommendations in clearly written reports. The survey design and data collection activities are conducted as a group, enhancing the experience of each student in working in a team; preparation of reports by each student develops writing skills. Students design and conduct a series of industrial hygiene surveys in workplaces throughout the Greater Cincinnati area at the end of the first year.

#### **Graduates**

A total of 28 M.S. and 12 Ph.D. degrees have been awarded during the September 1, 1997 through August 31, 2002 five-year reporting period. The number of each, by year is shown below:

<b>Degrees Awarded 9/1/97 through 8/31/02</b>		
<b>Year</b>	<b>M.S.</b>	<b>Ph.D.</b>
1997-1998	8	1
1998-1999	7	2
1999-2000	5	1
2000-2001	4	4
2001-2002	4	4

**PhD. Graduates**

Laurel Kincl	Ph.D. / OS-Ergo.
Mei Juan Chen	Ph.D. / IH
Kyoo-Tae Choe	Ph.D. / IH
Ming-Lun Lu	Ph.D. / OS-Ergo.
Linda Faye Grimsley	Ph.D. / IH
Chwan-Fu Lai	Ph.D. / OS-Ergo.
Vitaly Aizenburg	Ph.D. / IH
Gediminas Mainelis	Ph.D. / IH
John Cardarelli	Ph.D. / IH
Xuejun Lin	Ph.D. / IH
Edward Burroughs	Ph.D. / IH
Yinge Qian	Ph.D. / IH

**MS Graduates**

Andrea M. Armstrong	MS / IH-HSAT
Edward L. Bock III	MS / IH
Craig D. Evans	MS / IH-HSAT
Teo Keong Kok	MS / IH
Scott Henn	MS / IH-HSAT
Erin Snyder	MS / IH-HSAT
Timothy Rittgers	MS / IH
Terry Bliss	MS / IH
Edward D. Auyang	MS / OS-Ergo., IH-HSAT
Ruohong Liang	MS / IH
Lisa DeLaney	MS / IH
Zheng Wang	MS / IH
Steven Wurzelbacher	MS / OS-Ergo.
Tonya Solomon	MS / IH

Daniel Woody	MS / IH
Krystyn R. Clark (Nee: Bussa)	MS / IH-HSAT
Ming Lun Lu	MS / IH
Kincl, Laurel	MS / IH-HSAT
Javier Ortega-Cesena	MS / IH
Joshua Harney	MS / IH-HSAT
Lynn Borland	MS / IH
Jean Mangharam	MS / OS-Ergo.
Laura Stambaugh	MS / IH
Xiaojie Xu Zavon	MS / IH
Darren Burks	MS / IH-HSAT
Guo-Hua Liu	MS / IH
Clinton Morley	MS / IH
Christine Newman	MS / IH-HSAT

#### Thesis/Dissertations

M.S. students complete a research thesis. Ph.D. students complete a dissertation. Titles, student name, degree and placement are shown in Appendix A. Abstracts of dissertations and theses are shown in Appendix B. Students are encouraged to present research findings at national and international meetings. Titles and abstracts of presentations are shown in Appendix C. During 1997-2002, a total of 65 presentations were made. A listing of 130 publications involving students is shown in Appendix D.

#### Faculty Growth

Since 1997, the following faculty promotions have been awarded:

- Sergey Grinshpun- Visiting Scientist to Associate Professor (with tenure)
- Tiina Reponen-Visiting Scientist to Associate Professor (with tenure)
- Carol Rice- Associate Professor to Professor
- Glenn Talaska- Assistant to Associate Professor (with tenure)
- Ed Burroughs, Richard Fulwiler, John Kominsky, and Thurman Wenzl were appointed as adjunct faculty.

Each action documents the recognized stature of the program in the College of Medicine.

- Kermit Davis, Ph.D., was appointed to Assistant Professor in 2001, adding to faculty strength in ergonomics/biomechanics.

### IH Faculty / Adjuncts and their Academic Responsibilities

The teaching program faculty are listed below. For full-time university faculty the research focus and teaching responsibilities are shown below; for adjunct faculty, only the name and teaching responsibilities are listed.

Hygiene Faculty	Academic Responsibilities
Amit Bhattacharya, Ph.D., CPE	Special Populations at Risk, Intervention Effectiveness Research, Surveillance Research Methods, Ergonomics/Biomechanics – Responsible for (1) Principles of Ergonomics (2) Biomechanical and Physiological Aspects of Muscular Activities (3) Physical Aspects of the Environment
Scott Clark, Ph.D., PE, CIH	Intervention Research, Exposure Assessment – Responsible for (1) Hazardous Waste Management, Assists with (2-3) Practice in Occupational Exposure Assessment I and II
Kermit Davis, Ph.D.	Low Back Disorders, Mixed Exposures of Biomechanical/Psychosocial Stressors, Exposure Assessment Methods for Ergonomics – Responsible for (1) Friday Industrial Hygiene Seminar.
Sergey Grinshpun, Ph.D.	Aerosol Exposure Assessment Methods – Responsible for (1) Occupational Health, Hygiene & Safety Workshop, Assists with (2) Physical & Biological Aspects of Aerosols (3-4) Practice in Occupational Exposure Assessment I and II.
Tiina Reponen, Ph.D.	Bioaerosols, Indoor Environment, Control Technologies for Bioaerosols – Responsible for (1-2) Practice in Occupational Exposure Assessment I and II, Assists with (3) Physical & Biological Aspects of Aerosols.
Carol Rice, Ph.D., CIH	Exposure Assessment Methods, Chronic Pulmonary Disease, Intervention Effectiveness Research – Responsible for (1) Evaluation of Workplace Exposures (2) Effective Methods of Worker Health and Safety Training (3) Methods to Obtain Complete Occupational Histories, Assists with (4-5) Practice in Occupational Exposure Assessment I & II
Glenn Talaska, Ph.D., CIH	Cancer Research Methods, Exposure Assessment Methods using biomonitoring – Responsible for (1) Principles of Occupational Exposure Assessment (2) Human Biological Monitoring and Biological Markers, Assists with (3-4) Practice in Occupational Exposure Assessment I & II (5) Occupational Safety and Health Team
Klaus Willeke, Ph.D., CIH	Aerosol Science Emerging Technologies, Control Technologies for Particles – Responsible for Physical & Biological Aspects of Aerosols
Edward Burroughs, Ph.D., CIH*	Assists with (1) Practice in Occupational Exposure Assessment I
Richard Fulwiler, ScD, CIH*	Responsible for (1) Programmatic Aspects of Occupational Health & Safety, (2) Team Building in Occupational Health and Safety Settings
John Kominsky, M.Sc., CIH, CSP*	Responsible for (1-2) Identification of Potential Workplace Exposures
Jon Reid, Ph.D., DABT**	Toxicology – Responsible for (1) Applied Risk Assessment
Thurman Wenzl, Sc.D., CIH*	Assists with (1) Physical Aspects of the Environment

\* Adjunct Faculty

\*\* Active Retired Faculty

### C. OCCUPATIONAL HEALTH NURSING

The goals for Occupational Health Nursing from July 1, 1997 to June 30, 2002 were, 1) increase the influence of occupational health nursing within the College of Nursing and the Education and Research Center (ERC); 2) increase the number of doctoral students in occupational health nursing; and 3) increase the scholarly productivity of students and faculty.

Dr. Sue Davis has been the Director of the Occupational Health Nursing Program, since 1994. This consistency in leadership provided a single focus on program outcomes and resulted in increased visibility and influence within the College of Nursing, the Education and Research Center, and practicing Occupational Health Nurses. These outcomes built on the curricular changes implemented in 1996 – 1997. Dr. Donna Gates was appointed Deputy Director in 2001, replacing Professor Christine Graeter who is pursuing doctoral education in epidemiology. The addition of Dr. Gates increased opportunities for research mentoring of doctoral and master's students. Drs. Davis and Gates have workload assignments in both the Education and Research Center and the College of Nursing, thus ensuring quality interdisciplinary education and research opportunities with students and faculty from the other Colleges.

Clinical faculty, Ms. Mary Lou Jones and Ursula Meyer, engage in active practice or in occupational health and safety projects within the community. Their understanding of contemporary practice, as well as, their ties with the occupational health and safety professionals ensures quality practice experiences and opportunities for accessing research populations essential for capstone projects and pilot research studies.

#### Support for Occupational Nursing

Faculty members contributing to Occupational Health Nursing are listed in Table I. Core and support faculty have functioned as a team for over five years, and have defined the knowledge and skills essential for preparing advance practice occupational health nurses and researchers: occupational nursing, epidemiology, policy, ethics, administration, environmental health, and strong research courses accompanied by mentoring in actual research projects. The Department of Community Health, Administrative and Psychiatric Nursing (CAP) is highly supportive of the OHN team and their efforts to make system changes for the benefit of the program, such as streamlining the curriculum, providing technology support for developing web-based courses, and supporting acquisition of research supplies and equipment. Examples of the latter include computer hardware and software, research incentives, body composition analysis equipment, activity monitors, reproduction of surveys.

**Table 1: Core, Supporting and Adjunct Volunteer Faculty**

<u>Name and Title</u>	<u>A. Expertise</u>	<u>Contribution to OHN Program</u>
<b>Core Faculty:</b>		
L. Sue Davis, PhD, Professor. Director OHN	CHN, OHN, Research Methods, & Hlth Systems. <u>Research:</u> WRMD in nurses, work design, & health outcomes	Coordinates PhD & MSN courses; academic advisement; OHN program administration, recruitment, evaluation; & outreach. Participates in interdisciplinary activities, co-teaches interdisciplinary courses, member/chair of dissertation/thesis and capstone project committees, for nursing and other disciplines as appropriate.
Donna Gates, RN, EdD, Associate Professor; Deputy Director	Health Behaviors, CHN, OHN, & Epi. <u>Research:</u> violence in the workplace	Teaches master's OHN courses, lectures in PhD program, supervises practica experiences, assists in program administration, outreach activities and recruitment efforts. Member of dissertation/theses & project committees.
Ursula Meyer, RN, MSN, Adjunct Asst. Professor	OHN, CHN, health systems management, consultation	Teaches graduate OHN courses, undergraduate OHN field experiences; coordinates Advisory Committee, participates in outreach activities. Member of master's capstone project committees.
Mary Lou Jones, RN, MSN, CCM, COHN-S, Adj. Clin. Instructor	OHN, case management, direct care services	Teaches OHN courses, supervises practica experiences, and serves on master's thesis and capstone projects. Supports student recruitment, and coordinates special projects.
<b>Support Faculty:</b>		
Christine Savage, RN, PhD, Assist. Professor	CHN, Hlth Syst Mgt. <u>Research:</u> addictions	Teaches organizational management and graduate CHN courses. Member of dissertation/theses & project committees. Mentors student research. Provides intense informatics experiences for students in practicum courses.
Janice Dyehouse, RN, PhD, Professor, Dept. Head, CAP	Mental health. <u>Research:</u> alcohol use & injury	Teaches research methods. Member/chair of dissertation/thesis & project committees. Mentors student research in substance use & injury in the workplace.
Evelyn Fitzwater, RN, DNS, Assistant Professor	Aging, CHN. <u>Research:</u> workplace violence in nursing homes	Teaches undergraduate CHN field experiences. Member of dissertation/theses & project committees. Mentors doctoral students in aging & work-related disorders
Elizabeth Betemps, RN,	Epidemiology, mental	Teaches epidemiology. Member/chair of

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PhD, Assoc. Professor	health. <u>Research</u> : mental health	dissertation/thesis & project committees. Mentors doctoral students in research methods. Mentors faculty in Rasch modeling.
Linda Workman, RN, PhD, Assoc. Professor	Administration. <u>Research</u> : work redesign.	Teaches core management courses for OHN students. Mentors doctoral & master's students in research.
Kathleen Driscoll, RN, JD Professor	Ethics and policy research: policy & ethics.	Teaches legal and ethical issues in workplace, supervises projects related to work policy analysis and development. Active in recruitment of non-traditional students.
<b>Volunteer Faculty</b> Nan Migliozi, RN, MSN, COHN-S, OH Dept. Health	OHN, management, regulatory issues	Guest lecturer in OHN courses, student preceptor & provides research opportunities. Member of ERC Advisory Committee.
Carolyn Klinger, RN, MSN, COHN-S, FNP, CCM.	Corporate health management, case management	Lecturer, Preceptor
Doronna Bolser-Moster, RN, MSN, Business owner	Small business, Case Management	Lecturer, Preceptor
Julie Snow, RN, MSN, Legal Consultant in OH&S	Occupational Health and Safety	Lecturer, Preceptor
Christine Graeter, RN, MSN, COHN-S.	Occ.hlth. mgt, epidemiology, team building	Lecturer, teaches interdisciplinary team building.
Janet Ehlers, RN, MSN, NIOSH.	OHN, Policy	Lecturer, preceptor.
Robert Nester, RN, PhD, COHN-S, National OSHA office	OHN, Research	Consultant on programmatic issues.

The Volunteer Faculty brings years of OHN experience in diverse practice settings to the program. Each has presented extensively at the local, state and national levels; published multiple journal articles; and received awards for their contributions to OHN.

In addition to an increase in the number of regularly offered interdisciplinary courses, interdisciplinary faculty give guest lectures, and participation on research/project committees within nursing courses, and likewise, nursing faculty members provide lectures in other disciplines. Occupational health nursing is also supported through a rich network of community resources. The ERC has graduated alumnae for approximately 20 years, many of whom are deeply committed to program excellence. These community practitioners provide guest lectures, precepting opportunities, and participate in advisory Boards.

An OHN advisory committee provides direction to the OHN program and is a link between the program, business, and occupational health and safety communities. Topics addressed by the committee include recruitment and networking mechanisms for advanced practice OHN.

### Needs Assessment

A needs survey of 122 occupational health nurses from a broad range of practice settings, including business, industry, academia, government and independent consultants, was conducted in the Spring of 2001, with a 49% response rate (n=60). The need for occupational health nurses remains consistent at all levels of management and direct services. The skills most frequently identified for master's prepared OHN's were cost benefit analysis, management, health promotion, injury prevention and safety. Additionally, recruiters who contact the College seek graduates with skills in interdisciplinary problem solving, program planning, evaluation, budgeting, and cost accounting. Students frequently have job offers prior to graduation, with many of these offers coming from employers who provided student practice opportunities and were aware of the graduate's competencies. Although not addressed in the needs assessment, doctorally prepared occupational health nurses are needed for academic, research and policy positions nationally and regionally. Many universities contact the Director of the Doctoral Program, requesting names of individuals graduating from the program. One of the most recent PhD graduates is on the faculty of a near-by university and he is collaborating with Dr. Davis and Dr. Genaidy on the WRMD research. He has been successful in obtaining research funds from his institution. Currently, he is being actively recruited for an OSHA position in Washington, D.C.

### Program Goals and Objectives

The goals of the OHN program are:

1. Maintain excellence in OHN academic (MSN) and research training (PhD) through continuous internal and external evaluation and through continued maintenance of community OHN relationships.
2. Increase enrollment in masters and doctoral study in OHN, through active recruitment, outreach activities.
3. Increase visibility within the University and ERC through interdisciplinary interaction; and within the College by engaging all faculty members with an occupational health focus or interest to present lectures in OHN courses and mentor masters and doctoral students.
4. Continue to develop research foci in workplace violence and work-related musculoskeletal disorders; and mentor junior faculty and students in OH&S research.

### Master's Curriculum

The master's OHN program is five quarters in length, for a total of 71-quarter credits (Table 2).

**Table 2: Occupational Health Nursing (OHN) Curriculum**

<u>CORE MASTERS COURSES</u>	<u>19 QUARTER CREDITS</u>
Theoretical Perspectives (29-NURS-800)	3 credits
Informatics (29-NURS-801)	2 credits
Role/Issues & Ethics (29-NURS-802)	3 credits
Health Care Policy & Finance (29-NURS-803)	3 credits
Statistics (29-NURS-804)	3 credits
Research Process (29-NURS-805)	3 credits
Master's Capstone (29-NURS-832)	2 credits

**HEALTH SERVICES MGMT. CORE** **12 QUARTER CREDITS**

Health Planning (29-NURS-814)	3 credits
Human Resources (29-NURS-816)	3 credits
Financial Mgt (29-NURS-815)	3 credits
Organization & Management (29-NURS-817)	3 credits

**OCCUPATIONAL HEALTH NURSING COURSES** **26 QUARTER CREDITS**

Intro to OHN (29-ANCH-810)	2 credits
Adv Practice in OHN (29-ANCH-811)	3 credits
Adv Practice OHN Practicum (29-ANCH-812)	2 credits
OHN Practicum (29-ANCH-817)	5 credits
Health Promotion & Risk Reduction (29-ANCH-852)	3 credits
Leadership in OHN (29-ANCH-813)	3 credits
Leadership OHN Practicum (29-ANCH-814)	2 credits
Epidemiology (29-ANCH-851)	3 credits
Health Promotion & Risk Reduction (29-NURS-852)	3 credits

**INTERDISCIPLINARY COURSES** **14 QUARTER CREDITS**

Environmental Health & Hygiene Technology (26-EIH-707)	3 credits
Survey of Toxicology (26-TOX-782)	3 credits
Occ Health & Hygiene Workshop (26-EIH-819; 820; 821)	3 credit
Occupational Safety Engineering (20-INDS-520)	3 credits
Team building in OHN (29-ANCH-816)	1 credit
OH&S Team (29-ANCH-815)	1 credit

**Core Masters Courses**

The occupational health curriculum incorporates core nursing courses, interdisciplinary occupational health and safety courses and OHN courses. There are 19 credits of core courses taken by all master's students in the college, and additional core courses taken in one of two tracks depending on the student's career goals: nurse practitioner or health systems. The health systems courses focus on services for aggregate populations, including occupational health, community health and nursing service administration. These courses include health planning and evaluation, organizational theory & behavior, financial and human resource management. The core nurse practitioner courses include physiology, pathophysiology, pharmacology, and health assessment. The OHN Faculty work closely with non-OHN faculty teaching these courses to ensure incorporation of occupational health and safety examples, case studies and directed activities.

**Occupational Health Nursing Courses**

There are three classroom courses in occupational health nursing: *Introduction to Occupational Health Nursing*, *Leadership Skills in Occupational Health Nursing* and *Advanced Practice in Occupational Health Nursing*. The first two courses are open as electives to nursing and non-nursing graduate students. Alumni often serve as guest lecturers to provide role modeling, networking opportunities, and a contemporary view of occupational health nursing.

*Introduction to Occupational Health Nursing* introduces students to OHN roles, practice settings, research priorities, legislative standards and the interdisciplinary nature of occupational health and safety. The course is offered concurrently with the *Occupational Health and Safety (OH&S) Team* course, so that OHN roles are explored along with the roles of other OH&S disciplines.

*Advanced Practice in OHN* emphasizes prevention, treatment and rehabilitation of occupational disease and injury. The course builds on content from *Toxicology, Environmental Health & Safety, Epidemiology* and *Health Planning*. The course is taken concurrently with the *Health Promotion and Risk Reduction* course, which includes social, behavioral and biological theories and interventions of health promotion and risk reduction.

*Leadership Skills in OHN* is taken the last quarter of study. This course emphasizes application of management concepts to occupational health services. The course enhances the occupational health nurse's ability to provide quality services in a cost effective manner. Quantification and communication of the OHN role is emphasized.

Three practice courses provide 'hands-on' experiences. *Advanced Practice in OHN Practicum* focuses on the clinical role of OHN while the *Leadership in OHN Practicum* focuses on leadership and consultative roles. The *Practicum in OHN* (internship) allows an in-depth experience in occupational health. Experiences are selected to expand skills in a role consistent with the student's learning needs and career goals. Students select preceptors based on their learning needs, career goals and faculty coaching. They are responsible for negotiating a learning contract to meet faculty and preceptor expectations. Evaluation criteria measure students' ability to negotiate a learning contract, complete the contracted activities and synthesize the experience. Recent students have had internship experiences with the national and area OSHA offices, NIOSH, and large industries such as Procter and Gamble, International Paper, Toyota and Gap.

#### **Interdisciplinary Courses**

*Environmental Health and Hygiene Technology, Survey of Toxicology* and *Occupational Safety Engineering* are required interdisciplinary courses. The three quarter, interdisciplinary *Occupational Health, Hygiene and Safety Workshop* allows interdisciplinary student teams to work collaboratively on community projects in occupational health and safety. The *Occupational Health & Safety Team* and *Team Building in Occupational Health Settings* are each one credit hour courses developed with input from all ERC disciplines, and taught collaboratively.

The *Occupational Health & Safety Team* course exposes students to the four core disciplines using lectures, case studies and occupational walk-through evaluations. Non-ERC master's students are invited to take the course as a way to increase awareness of occupational health and safety careers. The *Team building* course is an interactive workshop for developing team skills, primarily among interdisciplinary OH&S teams.

#### **Nurse Practitioner Option**

Students interested in obtaining occupational health nurse practitioner skills have two options. First, students may complete the master's degree in occupational health nursing and then complete a post-master's certificate family nurse practitioner program. Clinical experiences are carefully planned to include practice experiences in occupational health settings. In the second option, students may combine their occupational health master's with the nurse practitioner master's. Students taking this option work closely with directors of both programs to develop a program of study that includes core, specialty and interdisciplinary courses. Practice experiences are offered toward the end of the program and are carefully planned to incorporate occupational health and safety experiences. Option one can be completed in three additional quarters. Option two requires 25 additional quarter credits and can be completed in two additional quarters. Students are eligible to take the ANCC certification examination for family nurse practitioner.

### **Admission Criteria**

The qualifications and criteria for selection of students are a minimum of a 3.0 cumulative grade point average (on a 4.0 scale) from a baccalaureate nursing program, a satisfactory score on the Graduate Record Examination (GRE), successful completion of an undergraduate statistics course, acceptable professional references; and acceptable professional goal statement. In the last three years only students with a minimum of 1500 on the GRE and strong occupational health and safety goal statements have been accepted into the program.

### **Recruitment**

Recruitment activities include exhibits at professional meetings and career fairs, presentations about occupational health nursing in undergraduate courses, and placement of undergraduate students in occupational settings. This last activity resulted in an undergraduate student publishing her work with wives of corporate officials (Nakamura, 2001).

Additionally, students in the MSN-Accelerated program and RN to BSN program are targeted for recruitment. These groups are generally unfamiliar with occupational health roles and have been interested in attending informational seminars with professors. Four of the most recently admitted students have come from this group.

Overall, there has been a decrease in the number of students applying for the master's program in the last three years. This is reflective of the overall decrease in nursing enrollment locally and nationally. In addressing this issue, the Dean appointed a recruitment committee to formulate strategies for increasing enrollment, with implementation of the strategies to begin Academic Year 2001-02. There has been, however, an increased interest in the doctoral program. From 1997 to 2002 there have been 13 master's graduates, two post-master's graduates and four doctoral graduates from the program.

### **Training Facilities and Resources**

The College is well endowed with resources to support education of students. The Center for Academic Technologies and Educational Resources (CATER) provides a comprehensive nursing information resource center that offers instructional media consultation, classroom media support, and a networked computer facility providing a wide selection of computer resources. Classrooms are adequate and equipped with state-of-art teaching equipment capable of accessing remote sites and Internet resources during class time. Most courses will be web-based by 2005. Currently, two OHN courses are web-based.

The College Institute for Nursing Research provides research support for faculty and graduate students. In addition to faculty research, the Institute offers graduate students opportunities to participate in grant development, and research activities, such as data collection, data entry, budget reviews, and literature reviews. Several positions for graduate research assistants are available from the University and are administered through the Institute. Funded faculty research is shown in Table 3. Pending research funding is shown in Table 4.

A Windograph real-time physiological monitor with pressure transducers, a Futrex-6000 near-infrared body composition analyzer, and three ML 2010AB Mini-Loggers for collecting simultaneous measurements of upper and lower body activity with heart rate and inter-beat interval data are available for physiological studies. A Scanmark 2000 scantron is available for survey research, and several laptop computers are available for collecting and downloading data at research sites. A variety of data analysis packages are available (SPSS, SAS, WinSteps/BigSteps, and Facets), along with faculty expertise to guide students in learning the applications. Locked and secure research space is provided for faculty and student funded projects.

The nursing library has a collection of more than 100,000 books and 450 journal titles. The library provides many of its services electronically, allowing easy access for faculty and students from distant sites. Electronic options include a library information database, Ohiolink and electronic reference resources, including many journals. Students also have on and off campus access to the Health Sciences and Langsom Libraries at the University.

The OHN program is located in close proximity to many occupational health settings, a national office for NIOSH and an area OSHA office. Student opportunities for field experiences, internships, independent studies and research topics are plentiful across diverse OHN practice settings. This depth of resources allows for selection of learning opportunities, and support preceptors individualized to each student's career goals and interests. Additionally, the ERC Continuing Education Program allows students to attend offered programs at a reduced or lowered rate depending on available space. Students have used this mechanism to obtain certification in pulmonary function testing and hearing conservation.

Students are also welcomed at activities of the Ohio Association of Occupational Health Nurses and at the District Association. They have participated in telephone surveys, and have designed a statewide needs assessment of the Association's membership.

#### **Continuing Education/Outreach**

Outreach efforts have encompassed a wide range of activities including the development of health and safety educational modules, presentations to increase awareness of occupational health nursing, environmental and worker screening, and safety. A luncheon for baccalaureate students from the area is sponsored annually to increase awareness of occupational health nursing roles and educational opportunities in the field. Health and environmental screenings carried out by student faculty teams are routinely implemented in businesses, industry, and the University community. Examples are noise / hearing, cardiovascular and lifestyle risk assessments. Safety and educational modules have been developed for OSHA, NIOSH and the Midwest Safety Center, and faculty and students have given numerous health and safety presentations to professional and non-professional audiences. Faculty members have consulted with health care organizations to assist them in designing safe, efficient and effective work environments that promote worker well-being and productivity. Faculty have also led, or participated in, international consultations with representatives from Singapore, Sweden, Thailand, India and Poland.

#### **Research Training**

The purpose of this portion of the OHN program is to strengthen and expand existing research in occupational health nursing at the University of Cincinnati ERC, and incorporate the research priorities identified by NIOSH and the American Association of Occupational Nursing into doctoral research training.

The doctoral program prepares nurses at the highest level of academic scholarship. Graduates are expected to discover, test, interpret, extend and transmit knowledge in the discipline of nursing. The curriculum consists of a core of required courses and a cognate area to support preparation for research in a defined area. Minimum course requirements are: philosophy of science (3 credits), theory analysis and development (6 credits), research methods (9 credits), seminar courses (6 credits), nursing electives (9 credits), cognate courses (15 credits), advanced statistics (9 credits) and dissertation research (27 credits). Additional course work may be required to support the student's area of research. Students with a master's in nursing may transfer in 45 of the required 135 credits required for the program. Baccalaureate students entering the doctoral program must take a minimum of 45 master's credits in nursing in addition to the doctoral courses.

Occupational health doctoral students take electives in occupational health nursing and select the majority of cognates from the interdisciplinary courses in the Department of Environmental Health, Occupa-

tional Medicine, or Department of Mechanical, Industrial and Nuclear Engineering. They also collaborate with faculty from these Departments in developing their research focus.

Research opportunities are numerous within the College, other units of the ERC, and outside the University with NIOSH and private business. Procter and Gamble, NIOSH and the Kellogg Foundation are currently supporting or have supported doctoral student research. Students are expected to complete pilot studies or work on established studies as they progress through their program. Examples of pilot projects include risks related to employment in nursing homes, health survey of construction workers exposed to silica, use of personal protective measures by migrant workers, changes in life-style behaviors related to an employee incentive plan, and organizational factors contributing to work-related musculoskeletal disorders in hospital personnel.

### **Leadership and Faculty Research Qualification**

The leadership for research training in OHN is the responsibility of all participating faculty that serve as advisors and committee members on research projects and dissertations. Appointing an OHN Deputy Director with a doctorate and a funded program of research has strengthened research training in occupational health nursing. Dr. Donna Gates provides mentorship, and research direction for the doctoral students and guides master's students in capstone projects. Dr. Davis has developed and offers on-going seminars for doctoral students to explore research interests, methods, and resources. She and Dr. Betemps meet regularly with students interested in developing objective measurements in nursing, teach elective courses in Rasch measurement modeling, and facilitate student attendance at the biannual meetings of the Center for Objective Measurement at the University of Illinois. This last opportunity provides students an opportunity to share findings from pilot projects and exchange ideas with nationally known experts in the field. Drs. Davis and Betemps are members of the College Doctoral Committee, which provides direction to the PhD program. Drs. Davis and Gates have served on the Doctoral Examination Panel that designs, administers, and evaluates the examinations for doctoral candidacy, and Dr. Davis was chair of this Panel for two years. Dr. Davis chairs and serves on doctoral committees in nursing and engineering. Dr. Gates serves on doctoral committees and will serve as a chair as more doctoral students are admitted who match with her area of research. Drs. Baas, Betemps, Dyehouse, Fitzwater and Workman also mentor OHN doctoral students. Drs. Talaska, Bhattacharya, Bornschein, and Pinney from Environmental Health and Dr. Genaidy from the College of Engineering have mentored OHN doctoral students in research. Drs. Baas, Betemps, Davis, Dyehouse, Fitzwater, Gates, and Workman are all actively engaged in research. Dr. Driscoll is actively involved in scholarly areas of policy analysis and ethics.

OHN faculty interact with other ERC faculty and NIOSH scientists to identify and develop opportunities for research. Drs. Davis and Genaidy and two doctoral students are studying work-related musculoskeletal disorders. Two other doctoral students, one from nursing and one from engineering have worked previously on the research. A new faculty member in Environmental Health, Dr. Kermit Davis, is interested in working with nursing in the area of psychosocial aspects of musculoskeletal injuries, an area of research that fits well with the research interests of Drs. S. Davis and Gates.

### **Program Evaluation**

The graduate program evaluation format used in the College is a comprehensive survey of key people and components that make up the graduate program, as well as, those employers and agencies that use program graduates. The College systematic Evaluation plan has specific components to maintain an on-going evaluation for determining achievement of each program's objectives. The evaluation data are collected in the following areas: 1) Archival Data, those data obtained from graduate student records; 2) Data from current students; 3) Data from program graduates which is specific to their majors; 4) Data from employers; 5) Faculty data; 6) Data from the Annual Systematic Evaluation Report that includes data on administration, resources, curriculum, faculty, and students.

Additionally, the Division of Graduate Studies conducts a brief evaluation of each graduate program annually. Every four years the Division of Research and Advanced Studies conducts a thorough assessment of each graduate program in the University. The OHN Director assesses the flexibility of the curriculum and interactions with related departments, and reviews the coursework and research plans of doctoral students with an occupational health focus

#### **Special Contribution to the Discipline**

The opportunities to interact with OSHA and NIOSH increase students' understanding of policy analysis, development and implementation, thus increasing their ability to bridge the public and private domains in research and practice. Examples of this ability include active recruitment of a recent doctoral graduate to a Research Scientist position with the National OSHA Office and the request of the area OSHA office to have a student-faculty team survey construction workers exposed to silica. In both of these instances, there is clear recognition of the students' ability to bridge public and private domains.

Students' exposure to interdisciplinary interaction during the training, establishes strong practice and research expectations for team and interdisciplinary work. Current and past doctoral students continue to show interdisciplinary activities, for example, serving on an advisory board for migrant worker health, and working with a team to develop an interdisciplinary rural health & safety course.

Faculty and student research in health and safety, agricultural and migrant health, musculoskeletal disorders and workplace violence bring a strong environmental component to the current body of nursing research which is primarily psychosocial and physiological in nature. Students and faculty are actively involved in local, state and national occupational health nursing associations, holding offices, making presentations, and writing for newsletters. One doctoral student was recently appointed as member of the Kentucky Board of Nursing by Governor Patton, and was elected to serve on the Education and Research Cabinet of the Kentucky Nurses Association. This same student received the Nurse Excellence Award from the Critical Care/Emergency Council, Kentucky Nurses Association for efforts in creating a pilot project to reduce agricultural illnesses/injuries in rural areas.

#### **Program Support from Other Sources**

University Graduate Scholarships and teaching/research assistantships are available. All OHN doctoral and master's students supported through the ERC grant receive these awards. Doctoral students are provided the support to compete for University Summer Research Fellowships from the University of Cincinnati Division of Graduate Studies. The Institute for Nursing Research provides grant writing assistance and opportunities for doctoral students to engage in on-going faculty research. The College has three funds that provide financial assistance to faculty for their research and teaching endeavors: the Rabinowitz, the Dean's Research and the Dean's teaching award for developing innovations in teaching. In addition, the University offers a faculty fellowship program, which provides a stipend for faculty to conduct pilot work. Students, as part of their research training, actively participate with faculty in writing and conducting intramural and extramural research (see Tables 3 & 4).

Doctoral students actively seek external funding for research projects from private and public funding sources. A recent doctoral graduate completed a NIOSH pre-doctoral fellowship supporting his doctoral research, and a current doctoral student received extended research support from Procter and Gamble. A second doctoral student received funding from W.K. Kellogg Foundation to study interventions for empowering farmwomen to reduce hazards to family health and safety. The same student was also funded from the National Institute of Health, Division of Nursing Research to investigate interventions for reducing rural adolescent risks.

Three nursing doctoral students successfully competed for NIOSH-ERC Pilot Research awards. Two projects are completed and students reported the findings at the First Annual Pilot Research Project Symposium. One of these students, Ms. Kelly, received additional support for her study from Procter and Gamble. Another student is funded for the current year and is collaborating with a student from engineering. The extra mural funding is listed below:

- Jones, Susan. (1999) "Cooperative Agreement Programs for Centers for Agricultural Education & Disease & Injury Prevention", University of Kentucky Research Foundation, 1999. Funded in the amount of \$21,000.
- Jones, Susan. (1999). Assessing factors contributing to the use of respiratory protection of workers in swine confinement buildings. NIOSH-ERC Pilot Research Project, University of Cincinnati, \$2326.
- Kelly, C. (1999) Cardiovascular health rating scale development. NIOSH – ERC Pilot Research Project, University of Cincinnati, \$4,452.
- Kelly, C. (1999) Cardiovascular health rating scale development. Procter and Gamble pre-doctoral support, \$10,000.
- Daraiseh, Nancy & Burton, Mattie. (2000) Work-related musculoskeletal disorders in nursing personnel: an instrument validation. NIOSH-ERC Pilot Research Project, University of Cincinnati, \$4220.

**Table 3: Research grants and contracts by College of Nursing faculty, 2000-2001**

<i>Date</i>	<i>Grant/Project Name/CON Principal Investigator</i>	<i>Funding Source</i>	<i>Amount</i>
1998-2000	Violence against caregivers in nursing homes (Gates, Fitzwater, Succop, Sommers)	National Institute of Nursing Research	\$107,664
1999-2002	Reducing violence against nursing home caregivers (Gates, Fitzwater, Succop, Sommers)	NIOSH	\$679,500
2000-2001	Folic acid awareness among college freshman women (Felblinger, Akers, Dulin)	March of Dimes	\$10,000
2001	Culture of safety (Deets)	V A Med. Center	\$5,946
2000-2002	Effects of a ketogenic diet on body weight and cardiovascular risk factors (Brehm)	American Heart Association	\$69,972
2000-2002	Effects of the dietary supplement Cordyceps Sinensis on endurance in college students (Brehm)	Pharmanex Pharmaceuticals	\$12,750
2000-2002	Effects of the dietary supplement Cordyceps Sinensis on endurance on an elderly population (Brehm)	Pharmanex Pharmaceuticals	\$7,250
2000-2001	Use of sensory-preparatory teaching (Kirchner, MSN student)	Am. Assoc. of Crit. Care Nurses	\$10,000
2000	Spiritual & emotional needs of patients & families at the end of life (Dwyer)	University Research Council	\$3440
2001	Genetics faculty development grant (Hern, Workman, Prows, Martin)	Faculty Develop. Council	\$7,000
2000	Preliminary work: Alcohol use before and during pregnancy (Savage, Wray)	Faculty Support Grant	\$15,579
Winter 2001	Impact of community-based nursing on cancer readmission (Lovell)	Dean's Special Award	\$10,000
Winter 2001	Testing a body-awareness intervention for symptom management (Baas)	Dean's Award	\$5,000
Winter 2001	Development of the primary appraisal instrument (Fitzwater, Gates)	Dean's Award	\$5,000
Winter 2001	Developing the integration of technology tool (Beery)	Rabinowitz	\$2,500
Winter 2001	Developing & expanding UC College of Nursing collaborative partnerships in the Middle East (Deets, Davis, Lindell)	Globalization Grant	\$4,750

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Spring 2001	Testing a body-awareness intervention for symptom management (Baas)	Univ. Research Council	\$5,000
2000-2001	Collaborative advising, orientation, and educational experiences for students in professional colleges (Brehm)	Success Challenge Collaboration Grant, UC	
2000-2002	Effects of a ketogenic diet on body weight and cardiovascular risk factors (Brehm)	Obesity Research Center., U.C.	\$10,000
2000-2001	Nutrition education: Integration into a service learning literacy project (Brehm)	Advanc. Of Service Learning, UC	\$1,500

**Table 4: Research grants pending by College of Nursing faculty, 2000-2001**

<i>Date</i>	<i>Grant/Project Name/CON Principal Investigator</i>		<i>Amount</i>
2001	Alcohol use before and during pregnancy (Savage)	Nat. Inst. Of Alcohol Abuse and Alcoholism	\$1,530,000
2001	Sensitivity of colposcopy exam (Sommers)	National Institute of Nursing Research	\$906,340
2001	Role of macronutrients in alternative weight loss (Brehm)	National Ctr. For Complementary/Alternative Med	\$382,500
2001	Leadership grant (Kennerly, L. Workman)	Helene Fuld Trust	\$75,000
2001	Sexual assault nurse examiner program, April submission (Sommers)	OH Department of Health	\$50,000
2001	Workplace stressors in nursing home assistants (Gates, Fitzwater)	NIOSH	\$2,020,030

**Research Trainee Publications and Theses**

Research Trainee (PhD) Dissertations and Publications are listed below.

**Dissertations**

Kelly, Cynthia (2002). Psychometric Instrument Development: Using Resch rating scale method to develop a cognitive measure for the Healthy Lifestyle Behavior Scale. Doctoral dissertation, University of Cincinnati, Cincinnati.

Nester, RM (1999). Adolescent occupational safety and health in the vocational-technical environment: The relationship of organizational climate, safety awareness-concern-interest, the characteristics of the innovation to the intention to adopt a safety curriculum. Doctoral dissertation, University of Cincinnati, Cincinnati.

Perng, Shoa Jen (2002). Life stress, approach coping, and health-risk behaviors in TAIWANESE adolescents. Doctoral dissertation, University of Cincinnati, Cincinnati.

Randolph, Jo Ann. (2000). A comparison of flexion and extension exercises for workers at risk for developing cumulative trauma disorders. Doctoral dissertation, University of Cincinnati.

**Publications**

Gibbs, C & Burton, M. (1999). Lung cancer. *ADVANCES for Administrators in Radiology*.

Jones, M. S., Bussey, D. & Morgan, C. (2000). Community-based education at the campsite. *Journal of Nursing Education*, 39 (6), 283-284.

McClellan, V.H., Luchok, K.J. & Jones, M. S. (submitted). Promoting farm health and safety practices in a rural community. *Journal of Agricultural Safety and Health*.

Jones, M.S. & Siegrist, B. (1999). Community-based education: Health promotion in country stores. *Nurse Educator*, 24 (5), 16-18.

Jones, M.S. & Goldy, D. (1998). Green tobacco sickness. *The Nurse Practitioner: The American Journal of Primary Care* 23 (9), 15-16.

Jones, M. S., Luchok, K.J. & McKnight, R.H. (1998). Empowering farm women to reduce hazards to family health and safety on the farm. *Journal for Agromedicine*, 5 (2), 91-98.

Jones, Susan (1998) Building Partnerships to Promote Safety and Health in Rural Communities. *Kentucky Agricultural News*, Spring/Summer, 30 (1).

Nester, RM (1998). Occupational safety & health programs: a summary of state departments of education, vocational education requirements. Cincinnati, OH: National Institute for Occupational Safety & Health. Unpublished manuscript.

Randolph, Jo Ann. (2000). Carpel tunnel syndrome: Testing the sensitivity and validity of four "localized discomfort" instruments. *AAOHN Journal*, 48, 385-394.

University of Cincinnati, College of Nursing  
 Masters Component of the Graduate Program  
 Full Time Program Plan  
 Occupational Health Nursing

Quarter I (Fall)	Quarter II (Winter)	Quarter III (Spring)	Quarter IV (Summer)	Quarter V (Fall)
29-NURS-801 Informatics 2 credits Prof: Faculty	29-NURS-816 Human Resources 3 credits Prof: Workman	29-NURS-800 Theory 3 credits Prof: Faculty	29-NURS-804 Statistics 3 credits Prof: Davis	29-NURS-802 Role/Issues/Ethics 3 credits Prof: Driscoll
29-NURS-814 Health Planning 3 credits Prof: Davis & Gates	29-ANCH-811 Adv Practice in OHN 3 credits Prof: Gates	29-NURS-803 Health Care Policy & Finance 3 credits Prof: Workman	29-NURS-805 Research Process 3 credits Prof: Savage	29-NURS-817 Organization & Management 3 credits Prof: Workman
29-ANCH-810 Intro to OHN 2 credits Prof: Meyer	29-ANCH-816 Team building in OHN 1 credit Prof: Graeter	29-NURS-815 Financial Mgt 3 credits Prof: Workman	29-ANCH-817 OHN Practicum 5 credits Prof : Jones/Davis	29-ANCH-814 Leadership Prac. 2 credits Prof: Jones
29-ANCH-815 OH&S Team 1 credit Prof: Gates	29-ANCH-852 Health Promotion & Risk Reduction 3 credits Prof: Gates	29-ANCH-812 AP OHN Practicum 2 credits Prof: Jones	29-NURS-832 Master's Capstone 2 credits Prof: Faculty	29-ANCH-813 Leadership in OHN 3 credits Prof: Davis / Jones
29-ANCH-851 Epidemiology 3 credits Prof: Gates	26-TOX-782 Survey of Tox. 3 credits Prof: Baxter			
26-EIH-707 Envir. Hlth & Hygiene Tech. 3 credits Prof: Talaska				

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26-EIH-819 OH & Hygiene Workshop* 1 credit Prof: Davis	26-EIH-820 OH & Hygiene Workshop* 1 credit Prof: Davis	26-EIH-821 OH & Hygiene Workshop* 1 credit Prof: Davis		20-INDS-520 Occ. Safety Engi- neering 3 credits Prof: Shell
15 credits	14 credits	12 credits	13 credits	14 credits
TOTAL CREDITS: 70				

\*Clinical interdisciplinary course. FacOrg2/25/97; GradCouncil6/10/97; Revised 9/13/00

## D. OCCUPATIONAL MEDICINE

### BACKGROUND

The nation's first Occupational Medicine Training Program was established in 1947 at the University of Cincinnati. As conceived by its founder, Dr. Robert Kehoe, the mission of the Residency Program was, and is, to graduate trainees who will assume leadership positions in academic, governmental, and industrial and labor occupational health programs, as well as regional hospitals and clinics. The residency program has received NIOSH / ERC training program support since the inception of the ERC program, and was recently re-accredited by the Accreditation Council for Graduate Medical Education through 2007. The training program satisfies training requirements for board certification in occupational medicine by the American Board of Preventive Medicine, as well as the American Osteopathic Board of Preventive Medicine. Since inception of the program, there have been more than 200 graduates, with two in the last year and three new students beginning studies during the 2002-2003 academic year. Many times that number of graduate and medical students, residents, and practicing physicians have been trained in Occupational and Environmental Medicine as part of the AHEC medical student rotation, rotations for visiting physicians, and continuing education efforts, such as the occupational medicine residency training course (formerly the Mini-Residency). The singular approach to occupational medicine training is expressed through this program in the variety of experiences and flexible training options offered to resident physicians. The UC residency training program provides a unique approach to occupational medicine training in its curricular configuration, the breadth of experience offered, and its departmental faculty support. Unlike traditional programs which require one year of didactic training culminating in a Master of Public Health (M.P.H.), followed by one year of clinical work, the U.C. program affords the opportunity for integration of academic and clinical experiences throughout the two years. Three training tracks, clinical, research and business, offer career specific training options to the residents. The program leads to a Master of Science following completion of course work, clinical rotations and a required thesis project. Holders of degrees previously obtained, such as masters in public health may utilize the residency program for practicum training in occupational medicine. There is a combined track leading to a master's of business administration through Xavier University.

### SIGNIFICANT FINDINGS

The residency training program at the University of Cincinnati continues to do quite well in all aspects of graduate medical education. Since 1996 there have been 31 residency program graduates (Attachment B) who have ultimately passed the American Board of Preventive Medicine certification exam in occupational medicine, on the first try. Each of the graduates are currently employed full time in occupational and environmental medicine practices. These practices run the gamut of occupational medicine, from military to corporate to private practice. In addition, a number of the graduates are involved in governmental or academic practice. Specific positions include Dr. Gayle Rhodes currently working with the United States Air Force in Warner Robins, Georgia; Dr. Robert Gabel in private practice; Dr. Loren Tapp with NIOSH, and Dr. Ted Moody with Carle Clinic in Illinois. Dr. Rhodes has also received a pilot Research Project Award from NIOSH as has Dr. Ed Balsink, the current chief resident. Research activities continue to be a prime focus of the residency training program. (Attachment C). Dr. Steven Borron contributed to an historical research project on asbestosis published in the *American Journal of Industrial Medicine*; Dr. Douglas Trout participated in *Efforts of Evaluating Hypersensitivity Pneumonitis in a Machinist* published in the *American Journal of Industrial Medicine*; Dr. Jeffrey Kirschman wrote the section on ATSDR Case Studies in Environmental Medicine focusing on environmental asthma; Dr. James Keller evaluated a cluster analysis of building-related illness published by the *Journal of Occupational and Environmental Medicine*; and Dr. John Dahlsten authored a paper to the American Thoracic Society discussing Bronchiolitis Obliterans in the Food Flavoring Manufacturing Industry. Both these private

project research grants and published papers show a continuing strong emphasis on research efforts exemplified within the residency training program.

## CONCLUSIONS

As the real world of occupational medicine continues to change through the 21<sup>st</sup> Century, so does the training program in occupational and environmental medicine. New course offerings have evolved, including Specials Topics for Toxicology, Survey of Public Health, taught by Dr. James Donovan, and Introduction to Environmental Medicine taught by Dr. Ann Middaugh. (Attachment D). New preceptorships have been developed, including a sports medicine offering in the Medical Arts Building, a rotation with the City of Cincinnati Health Department focusing on both environmental and occupational health, employee health training at the Children's Hospital Medical Center, and compensation and pension examination through the Cincinnati Veteran's Administration Hospital. The occupational medicine residents are also attendees at the Occupational Medicine Training Course, formerly titled the Mini Residency in Occupational Medicine. This latter course in addition to the ERC Hazard Evaluation Course and Indoor Air Quality courses, (see Continuing Education report) afford the resident opportunity to interact with allied health professionals, such as occupational health nurses, nurse practitioners, physician assistants, safety engineers, and industrial hygienists. As has been the case in the last five years, the one month long Area Health Education Center (AHEC) program has been quite popular among senior medical students. During the last three years all available positions have been filled early in the academic year, with training currently offered for eighteen medical students per year. In addition, at various times throughout the calendar year, visiting residents and residents from other training programs will take a one month elective in the department. The ACGME has recently re-certified the Occupational Medicine Residency Training Program without any deficiencies through 2007.

### Attachment B

#### Occupational Medicine Residents

##### 1996

Robin Bayer, MD  
Robert Boyer, MD  
James Keller, MD  
Douglas McKimm, MD  
Denise Agetap, MD  
Thomas Forte, DO  
Brian Knapp, MD

##### 1997

Deepak, Azad, MD, MPH  
Marsha Bailey, MD, MPH  
Andrew Freeman, MD, MS  
Mark O'Brien, MD, M S  
Douglas Trout, MD, MHS

##### 1998

Jacob Kammer, MD, MS  
Jeff Kirschman, MD, MS  
Ali Lopez, MD, MS  
Matthew Maurer, DO, MPH  
Patrick Quigley, MD, MS

Srini Sundarum, MD, MPH

1999

Beverly Deck, MD, MPH  
Palma Jones, MD  
Edward Moody, MD, MSE  
Sue Ting, MD, MPH  
Carlos Rodriguez, MD, MS  
Marie Walton, M D

2000 – 2001

Robert Gabel, MD, MS  
Gayle Rhodes, MD, MS  
Lauren Tapp, MD, MS  
John Dahlsten, MD

2001 – 2002

Patrick Lowry, MD  
Jeffrey Hess, MD  
James Wallis, MD

Current Residents:

Kelvin Wren, MD  
Edward Balsink, MD  
Brian Case, MD  
Trang Nguyen, MD

**Attachment C      Faculty Publications: 1997 – 2002**

**1997**

- Bhattacharya A, Greathouse L (student), Warren J (student), Li Y, Dimov M (student), Applegate H, Stinson R, Lemasters G. An ergonomic walkthrough observation of carpentry tasks: A pilot study. *Applied Occupational and Environmental Hygiene Journal* 1997;12(4):278-87.
- Borron SW, Forman SA, Lockey SA, Lockey JE, Lemasters GK, Yee LM. An early study of pulmonary asbestosis among manufacturing workers: Original data and reconstruction of the 1932 cohort. *American Journal of Industrial Medicine* 1997;31:324-34.
- Eis NJ, Linz DH. Elevated blood lead in children and antisocial behavior: The benefits of screening and lead paint abatement versus the medical and societal costs of adult criminal behavior. (Submitted to *J Amer Med Assoc*, July, 1997.)
- Freeman AG, McKay RT. An evaluation of pressure-monitored user seal checks in detecting respirator leakage. 1998 AIHCE, October 1997.
- Lemasters GK, Livingston GK, Lockey JE, Olsen DM, Shukla R, New G, Selevan SG, Yiin JH. Genotoxic changes after low-level solvent and fuel exposure on aircraft maintenance personnel. *Mutagenesis* 1997;12(4):237-43.
- Lemasters GK, Shukla R, Li YD, Lockey JE. Balancing Cost and Precision in Exposure Assessment Studies. *JOEM* 1996;38(1):39-45. (Selected for the Year Book of Occupational and Environmental Medicine (The "Work") St. Louis: Mosby-Year Book, Inc., 1997.)

- Lentz TJ, Rice CH, Succop PA, Lockey JE, Lemasters GK. Pulmonary deposition modeling in a study of workers who manufacture refractory ceramic fibers. American Industrial Hygiene Conference, May 17-23, 1997, Dallas, Texas
- McKay RT. Air purifying respiratory protection. *Chemical Health & Safety* 1997;4:20-5 (September / October).
- McKay RT, Davies E. Capability of aerosolized qualitative fit test agents (Sweetener and Bitrex) to detect known leakage in half mask respirators. 1998 AIHCE, October 1997.
- Smith LB, Bhattacharya A, Lemasters GK, Succop P, Puhala E, Medvedovic M, Joyce J. Effect of chronic low level exposure to jet fuel on postural balance of U.S. Air Force Personnel. *JOEL* 1997;39(7):623-32.
- Sonntag DM (student), Jederberg W, Lemasters GK, Simpson S, Still KR. Military personnel. In: Greenberg M, Hamilton R, Phillips S. *Occupational, Industrial, and Environmental Toxicology*. St. Louis: CV Mosby, 1997.

### 1998

- Borron SW, Forman SA, Lockey JE, Lemasters GK, Yee LM. 'Dust and Mirrors' or 'Corruption Is in the Eye of the Beholder' (Letter to the Editor) *American Journal of Industrial Medicine* 1998;34:409-410.
- Buchta TM, Rice CR, Lockey JE, Lemasters GK, Gartside PS. A comparative study of the National Institute for Occupational Safety and Health 7400 "A" and "B" counting rules using refractory ceramic fiber. *Applications of Occupational and Environmental Hygiene* 1998;13(1):58-61.
- Freeman A, Lockey J, Hawley P, Biddinger P, Trout D. Hypersensitivity pneumonitis in a machinist. *Am J Ind Med* 1998;34:387-392.
- Freeman A, Lockey J, Hawley P, Biddinger P, Trout D. Hypersensitivity Pneumonitis in a Machinist. *American Journal of Industrial Medicine* 1998;34:387-392.
- Harber P, Dahlgren J, Bunn W, Lockey J, Chase G. Radiographic and Spirometric Findings in Diatomaceous Earth Workers. *Journal of Occupational and Environmental Medicine* 1998;40(1):22-28.
- Lemasters GK, Lockey JE, Levin LS, McKay RT, Rice CH, Horvath EP, Papes DM, Lu JW, Feldman DJ. An Industry-Wide Pulmonary Study of Men and Women Manufacturing Refractory Ceramic Fiber. *American Journal of Epidemiology* 1998;148(9):910-919.
- Lemasters GK. Chapter Editor, Reproductive System. In: Jeanne Mager Stellman (ed.) *Encyclopaedia of Occupational Health International Labor Organization*. ILO, 1998; Vol. 1, pg. 9.2
- Lemasters GK. Maternal occupational exposures and adverse pregnancy outcome. In: Jeanne Mager Stellman (ed.) *Encyclopaedia of Occupational Health International Labor Organization*. ILO, 1998; Vol. 1, pg. 9.10-9.13.
- Linz, DL, Pinney, SM and Buncher, CR. Cluster analysis applied to building associated illness. *J. Occup. Environ. Med.*40:165-171, 1998.
- Lockey JE, Wiese NK. Man-Made Vitreous Fiber, Vermiculite and Zeolite. In: Rom WN (ed.) Environmental and Occupational Medicine, Third Edition. New York: Little, Brown and Company 1998, pp. 397-412.
- Lockey JE, Ross CS. Health Effects of Man-made fibres. In: Jeanne Mager Stellman (ed.) *Encyclopaedia of Occupational Health International Labor Organization*. ILO, 1998; Vol. 1, pg. 10.74-10.78.
- Lockey JE, Levin LS, Lemasters GK, McKay RT, Rice CH, Hansen KR, Papes DM, Simpson S, Medvedovic M. Longitudinal Estimates of Pulmonary Function in Refractory Ceramic Fiber Manufacturing Workers. *American Journal of Respiratory and Critical Care Medicine* 1998;157:1226-1233
- Lockey JE, Ross CS. Health Effects of Man-made fibres. In: Jeanne Mager Stellman (ed.) *Encyclopaedia of Occupational Health International Labor Organization*. ILO, 1998; Vol. 1, pg. 10.74-10.78.

- Lockey JE, Levin LS, Lemaster GK, McKay RT, Rice CH, Hansen KR, Papes DM, Simpson S, Medvedovic M. Longitudinal estimates of pulmonary function in refractory ceramic fiber manufacturing workers. 1998 ALA/ATS International Conference, April 24-29, 1998, Chicago, Illinois.
- Lummus ZL, Lockey JE, Bernstein IL, Bernstein DI. Microbial Flora of Metalworking Fluids Associated with Occupational Respiratory Disorders. *J Allergy Clin Immunol* 1998;10(1, part 2):S166.
- Raymond LW, Lockey JE, Velez H, Carson AI, Cowl CT, etc. Committee Report: ACOEM Guidelines for Protecting Health Care Workers against Tuberculosis. *J Occup Environ Med* 1998;40(9):765-767.
- Schrader S, Lemasters GK. Male reproductive system and toxicology. In: Jeanne Mager Stellman (ed.) *Encyclopaedia of Occupational Health International Labor Organization*. ILO, 1998; Vol. 1, pg. 9.4-9.7.
- Welch LS, Hunting KL, Balmes J, Bresnitz EA, Guidotti TL, Lockey JE, Myo-Lwin T. Variability in the classification of radiographs using the 1980 International Labor Organization classification for pneumoconiosis. *Chest* 1998;114:1740-1748.

### 1999

- Kirschman JC, Freeman AG, Lockey, JE. ATSDR Case Studies in Environmental Medicine, Environmental Asthma 1999
- Lemasters GK, Lockey JE, Olsen DM, Selevan SG, Tabor MW, Livingston GK, New GR. Comparison of Internal Dose Measures of Solvents in Breath, Blood and Urine and Genotoxic Changes in Aircraft Maintenance Personnel. *Journal of Drug and Chemical Toxicology* 1999;22(1):181-200.
- Lemasters GK, Olsen DM, Yiin JH, Lockey JE, Shukla R, Selevan SG, Schrader SM, Toth GP, Evenson DP, Huszar GB. Male Reproductive Effects of Solvent and Fuel Exposure during Aircraft Maintenance. *Reproductive Toxicology* 1999;13(3):155-166.
- Lemasters GK, Lockey JE, Olsen DM, Selevan SG, Tabor MW, Livingston GK, New GR. Comparison of Internal Dose Measures of Solvents in Breath, Blood and Urine and Genotoxic Changes in Aircraft Maintenance Personnel. *J Drug Chemical Toxicol* 1999;22(1):181-200.
- Lentz TJ, Rice CH, Lockey JE, Succop PA, Lemasters GK. The Potential Significance of Airborne Fiber Dimensions Measured in U.S. Refractory Ceramic Fiber Manufacturing Industry. *Am J Ind Med* 1999;36:286-298.
- McKay RT, Levin LS, Lockey JE, Lemasters GK, Medvedovic M, Papes DM, Simpson SR, Rice CH. Weight Change and Lung Function: Implications for Workplace Surveillance Studies. *J Occupational and Environmental Medicine* 1999;41(7):596-604.
- McKay RT, Freeman Ag, Hall CI, Delaney LJ, Bradley JC. Respiratory user seal checks: use limitations, and defining a standard method. 9th Annual International Respirator Protection Conference, Pittsburgh, PA, October 1999.

### 2000

- Crapo R, Casaburi R, Cotes A, Enright P, Hankinson J, Irvin CG, MacIntyre NR, McKay RT, Wanger J, et. Al. American Thoracic Society: Guidelines for Methacholine and Exercise Challenge Testing – 1999. *Am J Respir Crit Care Med* 161:309-329, 2000.
- Lockey James, Freeman Andrew, Bernstein David, Linz Douglas, Lummus Zana. Metal Working Fluid Associated Hypersensitivity Pneumonitis: A Case Series. 2000 *The J Allergy and Clin Immunol*, Volume 105, Number 1, Part 2, Abstracts S49
- Levin LS, Rice CH, Lemasters, GK, Lockey JE, Medvedovic, Mario. What is the Potential Measurement Error in Occupational Exposure Studies? *Journal of Air & Waste Management Association* 2000;50:941-947.

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- Linz DH, McKay RT, Middaugh DA, Lockey JE. Chronic Hyperventilation Syndrome: An Under-Recognized Cause of Work Disability. *Journal of Disability* (in press)
- Lockey J, Freeman A, Bernstein D, Linz D, Lummus Z. Metal working fluid associated hypersensitivity pneumonitis: A Case Series. *J Allergy and Clin Immunol* 2000, 105(1), part 2, Abstracts S49.
- McKay RT, Davis E. Capability of Respirator Wearers to Detect Aerosolized Qualitative Fit Test Agents (Sweetener and Bitrex) with Known Fixed Leaks. *Applied Occup Env Hygiene*; 15(6): 479-484, 2000.
- Rice CH, Lockey J, Lemasters G, Levin L. Evaluation of Exposures to Refractory Ceramic Fibers in U.S. Manufacturing Facilities. 4th International Scientific Conference of the International Occupational Hygiene Association, Cairns, Australia, July 10-14, 2000.
- Simpson S, Lemasters G, Kesner J, Lockey J, Shukla R, Knecht E, Krieg E. Internal dose of benzene, ethylbenzene, toluene Xylenes & fuel components and effects on reproductive hormones in women. *Am J Epi* 2000;151(11):S70.

### 2001

- L Delaney, R McKay, A Freeman. Determination of Known Exhalation Valve Damage Using a Negative Pressure User Seal Check Method. *Applied Ind Hyg* (accepted) 2001
- Hodges M, McKay RT. A Comparison of Sodium Saccharin versus Controlled Negative Pressure for Detecting Known Leaks in Full Face Respirators. (Manuscript in preparation, 2001)
- Lawson CC, Lemasters MK, Lemasters GK, Reutman SS, Rice CH, Lockey JE. Reliability and Validity of Chest Radiograph Surveillance Programs. *Chest* 2001;120:64-68.
- MacKinnon PA, Lentz TJ, Rice CH, Lockey JE, Lemasters GK, Gartside PS. Electron microscopy study of refractory ceramic fibers. *Applied Occup Env Hyg* 2001;16(10):944-951.

### 2002

- Lockey JE, Lemasters GK, Levin L, Rice C, Yiin J, Reutman S, Papes D, et al. A Longitudinal Study of Chest Radiographic Changes of Workers in the Refractory Ceramic Fiber Industry. *Chest* (in press) 2002.
- Lockey J, Biddinger P, Roggli V, Lemasters G, Rice C. Mineralogic Analyses of Lung Tissue from Participants in a Morbidity Study of Workers in the Refractory Ceramic Fiber Industry (in preparation).
- Reutman SR, LeMasters GK, Knecht EA, Shukla R, Lockey JE, Burroughs GE, Kesner JS. Evidence of reproductive endocrine effects in women with occupational fuel and solvent exposure. *Env Health Perspectives* (in press) 2002.
- Reutman SR, LeMasters GK, Kesner JS, Shukla R, Krieg EF, Knecht EA, Lockey JE. Urinary reproductive hormone level differences between African American and Caucasian women of reproductive age. *Fertility and Sterility*. (in press) 2002.
- Reponen T, Grinshpun SA, Trakumas S, Wang Z-M, LeMasters G, Lockey JE. Concentration Gradient Patterns of Aerosol Particles Near an Interstate Highway in the Greater Cincinnati Airshed. *J Air & Waste Manage. Assoc.* (submitted 2002)
- Jones PE, Case R, Lockey JE, Donovan JR, et al. Occupational Disease. Workers' Compensation in Kentucky, Third Edition 2002. (submitted)

**Attachment D**

Core Courses – Occupational Medicine			
Course Number	Name	Credit Hours	Instructor 2000-2001
26 ENV 701/702/703	Environmental Health Seminar	1	Marshall Anderson, PhD
26 OCCM 786	Basics of Occupational Medicine I	2	Ann Middaugh, MD
26 OCCM 896	Basics of Occupational Medicine II	2	Ann Middaugh, MD
26 BE 975	Design and Management of Field Studies	4	Grace Lemasters, PhD
26 904 748	Occupational Health Management	2	Andrew Freeman, MD
26 BE 787	Introduction to Biostatistics	4	Charles Buncher, ScD
26 904 776	Introduction to Epidemiology	3	Charles Buncher, ScD
26 OCCM 791	Special Topics – Toxicology	2	James Donovan, MD, MS
26 EIH 707	Principles of Occupational Exposure Assessment	3	Glenn Talaska, PhD
26 OCCM 746	Survey of Public Health	3	James Donovan, MD, MS
26 EIH 819, 820, 821	Occupational Health, Hygiene, & Safety Workshop	3	Glenn Talaska, PhD
26 904 792	Principles of Ergonomics	3	Amit Bhattacharya, PhD

## **E. OCCUPATIONAL SAFETY/ERGONOMICS**

### **SIGNIFICANT FINDINGS**

At the present time during the 2002-03 academic year there are four full-time Ph.D. students in the program. Three are supported as NIOSH Trainees. In addition there are four full-time M.S. students in the program, all supported as NIOSH Trainees. There are also six part-time M.S. students in various stages of their program.

Dr. Stephen T. Kowel, Dean of College of Engineering (COE), has recently committed to add a tenure track faculty with safety engineering specialization to the program. A search committee, chaired by Dr. Richard L. Shell, was formed in August 2002. Advertisements for the new position have been released. The anticipated start date for the new faculty is projected to be September 1, 2003. The new faculty will likely teach the graduate course, Safety Engineering Design and Management (20-MINE-778), and develop two new courses. Depending on the individuals' interest and background, the new courses would be Safety Engineering Design, a new required core course that would study selected safety engineering topics in more depth; and another advanced level elective course such as Fire Protection or Emergency Planning for Disasters.

The core curriculum for the MS degree has been redesigned to offer excellent coverage (with minimal overlap) in both safety engineering and ergonomics. The revised core contains a series of 3 safety courses that address fundamentals, system safety, and safety engineering design. In parallel, the core for ergonomics contains a series of 3 courses that address fundamentals, human factors analysis, and human factors design (reference Table 6). Also, the MS student will be able to take electives in advanced topics of safety engineering and/or ergonomics, hence, provide him/her additional depth in areas of particular interest.

In addition to the aforementioned core curriculum, the PhD student is required to take four research oriented courses, and Safety Engineering Design and Management (20-MINE-778) if not previously taken as a MS elective. Also there are several more advanced or specialized courses available to the Ph.D. in the COE or in the College of Medicine (COM).

An OSE Advisory Board is in the process of being formed. It will be comprised of individuals with safety, health, and ergonomic backgrounds. The Board members will be selected from industry, local and federal government, and a local labor union. It is planned to finalize Board membership during the Autumn Quarter 2002.

During the five year period 1997 through 2002, 16 M.S. students graduated along with 6 Ph.D. students. During this time strong emphasis has been placed on research relating to safety, health, and ergonomics. Dissertation topics have included the following:

- Verna M. Fitzsimmons, August 2002. Dissertation title: "The Relationship of Performance Based Financial Incentives to Productivity and Quality of Work Life."
- \*Michael Gressel, June 2001. Dissertation title: "Comparison of Mist Generation of Flood and Mist Application of Metal Working Fluids During Metal Cutting."
- Christin Shoaf, 1999. Dissertation title: "An Integrated Work System Model for Hazard and Risk Assessment of Work System Hazards and Risks."
- \*Fadi El Khatib, 1999. Dissertation title: "Biodynamic Modeling of Motor Vehicle Crash Victims."

- Awwad Dababneh, 1998. Dissertation title: "Temporal Structure of the Work Day: A Study of the Impact of Added Rest Breaks on the Productivity and Well Being of Workers."
- Omar Mohamed, 1997. Dissertation title: "Testing and Assessing the Postural Stresses Associated with Sedentary Work."

Support for students has been provided by NIOSH, the Internal Revenue Service, and several industrial organizations. These have included Tech Solve, General Electric Aircraft Engines, Hudson Foods, The Kroger Company, Ergo Accommodations, Inc., and Fluor Daniel Corp.

The NIOSH supported Pilot Research Project (PRP) program has funded projects. For example, in 2000-01 Nancy Daraiseh a PhD student in OS/E and Mattie Burton a PhD student in OHN received a PRP grant to investigate "Work-Related Musculoskeletal Disorders in Nursing Personnel: An Instrument Validation Study. This project also received continuation funding during 2001-02, -03.

National Science Foundation funding was obtained for a Multi-university Material Handling Research Center, 1991-97. The Center has provided additional on-going opportunities for occupational safety/ergonomics related research investigations in material handling, distribution, and logistics.

In addition, the University has provided full tuition waivers, in the form of University Graduate Scholarships, for all full-time M.S. and Ph.D. students in the program.

Outreach and continuing education efforts have been active during the five year period. Examples of outreach include providing assistance to other universities, e.g., the University of South Florida and the University of Louisville; consulting about safety and ergonomics with industrial firms; presenting seminars and short courses in safety engineering and ergonomics, and teaching the CSP 40 hour review course for safety certification.

## **OCCUPATIONAL SAFETY / ERGONOMICS OVERVIEW**

### **BACKGROUND**

The occupational safety/ergonomics program (OS/E) is made possible through a wide range of University of Cincinnati (UC) courses and faculty, and the NIOSH funding support of the Cincinnati ERC. The majority of courses are taught by faculty from the colleges of Engineering and Medicine through the departments of Mechanical, Industrial and Nuclear Engineering (MINE) and Environmental Health (EH). The major objective of the occupational safety/ergonomics training and research program is to provide graduate engineers with specialized courses and experiences that will enable them to become practicing safety/ergonomics professionals or researchers in the field. A secondary objective is to provide an exposure and awareness of occupational safety/ergonomics to engineers that do not work as safety professionals or researchers but are employed in other engineering capacities and should include safety/ergonomics considerations in those activities. Several key occupational safety/ergonomics courses would not be offered without support from NIOSH.

Safety engineering and ergonomics courses were initially developed at the undergraduate and graduate levels in 1975 coinciding with the beginning of the Industrial Engineering Program in the College of Engineering (COE). Between 1975 and 1986, prior to NIOSH funding, several students completed M.S. degrees with course work that related to occupational safety/ergonomics. Also, during this time period the first Ph.D. with safety/ergonomics specialization was completed in 1987 by Linda Cahill-McQuiston (the first female to complete the Ph.D. in the MINE Department).

## **ACADEMIC TRAINING, MASTERS LEVEL**

### **Program Leadership and Faculty**

Effective May 1, 1999, Dr. Stephen Kowel became Dean of the College and Dr. Frank Gerner replaced Dr. Urmila Ghia as head of MINE. The safety/ergonomics program is administered by Dr. Richard Shell in the MINE Department. As Program Director, he reports to Dr. Scott Clark, ERC Director. Dr. Shell also reports to Dr. Gerner, Head MINE. Dr. Clark reports to Dr. Marshall Anderson, EH Department Director. Dr. Clark schedules ERC directors meetings throughout the year to insure communication among the four core programs (Occupational Medicine, Industrial Hygiene, Occupational Health Nursing, and Occupational Safety/Ergonomics), and Continuing Education. Dr. Genaidy began serving as the Associate Program Director for the safety/ergonomics program July 1, 2000.

The most recent change in faculty has been the hiring of Dr. Kermit Davis in the EH Department. Dr. Davis also holds an appointment in the MINE Department as Assistant Professor of Industrial Engineering. His specialization is occupational ergonomics. Dr. Davis began his assignment June 2001, and will strengthen the ergonomics part of the program, and further enhance the interaction between MINE and EH.

The participating full-time faculty (Drs. Genaidy, Mital, and Shell) supported in part by this grant have diverse backgrounds and experience, and collectively represent a unique human resource for graduate education and research in occupational safety/ergonomics. Their academic majors include industrial engineering, mechanical engineering, and bio-medical engineering. Their academic and professional involvement, research specializations, and consulting represent an even greater professional breadth. The two participating part-time faculty (Drs. T. Huston and Stuebbe) supported by this grant have excellent professional work and consulting experience relating to safety and ergonomics. Dr. T. Huston has taught in the program since 1985, and Dr. Stuebbe since 1995. Both consistently receive outstanding teaching evaluations. Reference Table 5 for summary of core and supporting faculty with their areas of specialization. As previously mentioned, a new faculty specializing in Safety Engineering is projected to start in September 2003.

## **PROGRAM PLAN/CURRICULUM**

The program offers graduate study leading to the M.S. and Ph.D. degrees in Industrial Engineering, Mechanical Engineering or Nuclear Engineering with a specialization in OS/E for both full-time or part-time students. The majority of the students are enrolled in Industrial Engineering. In addition, the program offers safety and ergonomics courses to the engineering student not concentrating in occupational safety/ergonomics but wanting to gain some awareness and insight about this important field. Consequently, several courses of most interest to the working professional are scheduled during late afternoons or early evenings to accommodate the engineer working full-time in the greater Cincinnati area and desiring to pursue an advanced degree on a part-time basis. For example, enrollment in the System Safety I and II courses is typically 20 to 30; no more than 6 or 7 of these students receive NIOSH traineeships.

There have been changes in the curriculum for the safety/ergonomics specialization during 2001-02 as previously mentioned. The required core courses and assigned faculty are outlined in Table 6. Commonly selected electives are listed in Tables 7 and 8. The program of study for the MS degree is shown in Tables 9 and 10. for the thesis and non-thesis options respectively. The non-thesis option does require a Special Topic Project. Applicants lacking a B.S. degree in engineering are required to complete the leveling courses listed in Table 11.

Working with a faculty advisor, the student selects a group of elective courses for the M.S. which will best meet the student's professional goals. Table 7 and 8 lists electives commonly selected by students with interest in OS/E. The departments of EH and MINE collectively offer over 100 graduate courses, of which many are of interest to the occupational safety/ergonomics student.

### **Regional Need**

The demand for graduate engineers with a specialization in safety/ergonomics continues to be strong and comes from a broad spectrum of the economy: industrial companies, government organizations, research laboratories, consulting firms, and academic institutions. Since the establishment of Industrial Engineering at UC in 1975 and the NIOSH supported safety/ergonomics Specialization in 1986, the number of jobs available to graduates has always exceeded the supply. Historically, each graduate receives three or more offers of employment. During the past five years, the program graduates have received numerous offers of employment and have been employed by a wide range of industrial firms including the following: The Kroger Co., General Electric Aircraft Engines, Merck Pharmaceuticals Co., UPS, General Motors, Anderson Consulting, Square D Corporation, Frito-Lay Corporation, Ohmeda Corp., 3M Company, Hamilton Plastics Corporation, Siemens, General Electric Medical Systems, and Procter & Gamble Co. Government/university organizations employing program graduates include: NIOSH, Department of Energy, and Wright-Patterson Air Force Base.

### **Interdisciplinary Experience**

There is a strong interdisciplinary experience for all safety/ergonomics students. Required common courses include Principles of Occupational Exposure Assessment (26-EIH-707), and the Occupational Health, Hygiene and Safety Workshop (20-EIH-819, 820, 821). In addition most of the ERC students include Occupational Safety Engineering (20-INDS-710) and Management of Professionals (20-MINE-640) in their program of study. OS/E students have successfully completed, along with students from other ERC academic core areas, the ERC Pilot Research Project training program.

## **TRAINING CANDIDATES**

Almost all applicants to the M.S. program have an undergraduate degree in engineering. Those individuals that have other undergraduate majors must have completed coursework in mathematics through differential equations, physics, chemistry, the engineering fundamental courses, and four upper level undergraduate IE courses (see Table 11).

All present and past trainees in the M.S. program have had a minimum of one and one-half years of practical experience. The formal admission requirements are outlined below.

- Students graduating from an ABET accredited undergraduate engineering program must have a minimum of a 3.0 QPA, or equivalent, in their undergraduate program to be considered for admission.
- Students graduating from an ABET accredited undergraduate engineering program with a QPA of less than 3.0 or equivalent, are required to take the General Test of the Graduate Record Exam (GRE).
- All students not graduating from an ABET accredited undergraduate engineering program are required to take the General Test of the Graduate Record Exam (GRE).
- All students, originating from countries where English is not one of the official national languages, are required to take the Test of English as a Foreign Language (TOEFL) and the Test of Spoken English (TSE). The minimum acceptable score for admission to the Program is 575 for TOEFL and 250 for TSE.

Other accomplishments, such as work experience, letters of recommendation and reputation of the undergraduate university are considered. All applications are reviewed by the IE Director of Graduate Studies in consultation with the IE program faculty in the student's indicated area of interest.

## **TRAINING FACILITIES AND RESOURCES**

### **Research and Scholarship**

The University of Cincinnati is a Research I institution. In total, UC faculty and staff garner over \$160 million in sponsored programs annually. The Colleges of Medicine and Engineering rank first and second respectively in sponsored research. UC endowment funds exceed \$1 billion. These levels place UC in the top 2% of universities for funding, and provides support for an excellent environment for innovative scholarship and research.

### **Physical Plant**

The EH Department located within the College of Medicine in the Kettering Building has excellent physical facilities including a recent major addition for offices, laboratories, and computer facilities. The MINE Department located within the College of Engineering also has excellent physical facilities including a new Engineering Research Center building for graduate education and research. The departmental laboratories most frequently used by the occupational safety/ergonomics students are the Robotics and Vision Lab (Dr. Hall); the Ergonomics Lab (Dr. Mital); and the Occupational Safety, Health and Ergonomics Engineering (OSHEE) Lab (Dr. Genaidy and Dr. Shell).

### **The University of Cincinnati Libraries**

The 18 libraries of the University of Cincinnati constitute a nationally recognized research center. A charter member of the Association of Research Libraries, this center includes medical, law, departmental and branch campus libraries and one extensive general library. The libraries directly support the university's research and instructional programs by maintaining resources which exceed 2.1 million bound volumes, 3 million microform units and over 19,000 current serial subscriptions. Traditional library materials are significantly enhanced by more than 200 electronic databases including online catalogs, electronic indexes, full-text document delivery and many other networked resources; all are accessible in each library or from home or office computers through modem. Subject specialists in each of the libraries, e.g., Colleges of Medicine and Engineering, provide reference assistance and collection development services.

UC's libraries provide information on most resources through an online catalog, UCLID, which is available at computer terminals located in each library and in most offices. In addition, OhioLINK, a statewide union database, offers information about other library collections across Ohio and facilitates access to a growing number of electronic research databases. Many of the libraries' resources are available via the Web address: <http://www.libraries.uc.edu>.

### **Information Technology Facilities**

The Center for Information Technology Services (CITS) provides diverse information technology (i.e., computing and telecommunications) resources for UC's students, faculty and staff. The organization consists of five main divisions: the CITS Director's Office, Academic Information Technology Services, University Administrative Information Systems, Network Services and Network Operations. Computer systems and services range from supercomputer access and consulting support to the management of six public microcomputer facilities. The CITS also offers software training, hardware maintenance and repair support. CITS operates UCNET, which connects the Bearcat Online (e-mail) servers, the Amdahl mainframe computer, the Student Access Network and hosts of other computers, workstations and peripheral devices. UCNET is connected to OARNET, the Ohio Academic Research Network, which provides access to international networks, including the Internet. By virtue of a broad band connection, UC

researchers enjoy interactive access to the supercomputers at the Ohio Supercomputer Center in Columbus, Ohio.

### **Continuing Education/Outreach**

Drs. Genaidy, Mital, and Shell are active in continuing education and outreach. Outreach efforts have included advising and assisting other universities including the University of South Florida and the University of Louisville, and other programs in the COE concerning safety and health. They have made over 12 presentations to technical societies during the past two years concerning safety/ergonomics, and have served as consultants to industry and government. Also, Dr Shell has a record of serving on numerous NIOSH site visit and special emphasis panels.

### **Research Training, Doctoral Level**

#### **Program Plan**

A Master's degree in engineering is required prior to application for Ph. D. work. Only students who have performed at an above average level in their Master's program will be admitted for further graduate study.

Working with a faculty advisor, the student selects a sequence of courses for the Ph.D., which builds on prior experience and will best meet the student's professional goals. In addition, there are 4 required research related courses and the requirement to take the Safety Engineering Design and Management course (20-MINE-778) (See Table 12). All safety/ergonomic MS core courses must be satisfied. The departments of EH and MINE collectively offer over 100 graduate courses, of which many are of interest to the occupational safety/ergonomics student.

The Ph.D. program in Industrial Engineering requires the following:

1. A minimum of ninety graduate credits beyond the MS degree.
2. A minimum of 18 credits of graduate courses (600 and 700 level courses only) in IE areas. At least 9 graduate credits must be taken at the 700 level.
3. A minimum of 30 credits of graduate courses is required.
4. A minimum of 60 credits will be awarded for the dissertation.
5. Additional fulfillment of IE basic core competency: The student must demonstrate (based on prior work) competency in the following nine IE areas: linear programming, simulation / stochastic models, quality control / probability and statistics, ergonomics, work measurement, safety, facilities design, engineering economics, and manufacturing processes. If any of the nine IE areas is not satisfied, the student will be required to take a course in the designated area. Any courses taken to satisfy the core competency in IE are not counted towards the minimum requirements of 30 credits of graduate work. It is the responsibility of the student advisor to verify and document (in the student's file) the fulfillment of the IE core competency requirements.
6. Satisfactory completion of Parts 1 and 2 of the Doctoral Qualifying Exam: Part I exam consists of an in-class exam consisting of three questions given by an examining committee consisting of at least three members (a minimum of two members must be IE faculty). The exam will expand upon material covered in graduate courses taken by the student; the exam duration is six hours. Part II exam will consist of a research question that will be given to the student by the same examining committee of Part I exam. The student will be given four weeks to prepare a written essay about the research question, and will be required to pass an oral exam one week after submission of the written essay. The student must pass Part I before proceeding to Part II. Both parts are expected to be completed within the first two years of study.

7. Satisfactory completion of doctoral proposal defense after fulfillment of Parts I and II exams. Candidacy must be completed within five years.
8. Completion of the dissertation and Final Oral Exam.
9. Additional fulfillment of 12 credit hours of communication courses.
10. A minimum QPA of 3.0.
11. All requirements must be completed within a nine-year period.

An example second year program of study is shown in Table 12 not including 12 credit hours of foreign language or communication courses.

### **Practical Experience of Trainees**

Students entering the program since the beginning of NIOSH support in 1986 have all had a minimum of one and one-half years of work experience. The Ph.D. students have always exceeded the one and one-half years. For example, the current group of four Ph.D. students average over 10 years of professional level work experience. This adds practical insight to the learning process. In addition, for several of the required OS/E and elective courses, students complete team-based projects interacting with local industry. An example would be the project completed in the Occupational Health, Hygiene, and Safety Workshop.

### **The Industrial Focus**

The program has emphasized occupational safety and health in manufacturing, warehousing, distribution and service organizations. The MINE Center for Robotics and the Ergonomics and Biomechanics laboratories offer highly specialized facilities that enhance the manufacturing and human performance focus of the program. In addition, there is close cooperation with the Institute of Advanced Manufacturing Sciences (Tech Solve) to further develop linkage between student groups and the greater Cincinnati area manufacturing sector. The students have opportunities to work with safety/ergonomics professionals employed by a number of local firms, e.g., General Electric Aircraft Engines, James River Corp., The Procter & Gamble Company, The Kroger Company, Hydro Systems Company and Hudson Foods Corporation.

The program has been designed to produce a safety/ergonomics specialist in addition to comprehensive engineering skills and safety/ergonomics knowledge, that has excellent mathematical/quantitative abilities, and an orientation to manufacturing and warehousing/distribution. The human performance part of the program is a key factor to enhance hazard identification, risk assessment management, and the integration of safety and health considerations into the overall business activity. A strong majority of the graduates accept positions in the industrial sector.

### **TABLE 5. CORE AND SUPPORTING FACULTY**

The following full-time faculty, partially supported on the training grant, are working to administer and facilitate the occupational safety/ergonomics program:

Richard L. Shell, Professor of Industrial Engineering and Professor of Environmental Health  
(Program Director)

University of Iowa, B.S.M.E. (I.E. Option), 1961

University of Kentucky, M.S.M.E., 1963

University of Illinois, Ph.D., 1970

Human performance, occupational safety/management, and manufacturing engineering

Ash M. Genaidy, Associate Professor of Industrial Engineering and Associate Professor of Environmental Health (Associate Program Director)

Cairo University, B.S., 1980

University of Miami, M.S., 1983

University of Miami, Ph.D., 1987

Biological Ergonomics, human factors, and safety and health engineering

Anil Mital, Professor of Industrial Engineering and Professor of Medicine and Rehabilitation

Allahabad University, B.E., 1974

Kansas State University, M.S.I.E., 1976

Texas Technological University, Ph.D., 1980

Ergonomics, manufacturing engineering and occupational safety

In addition to the above MINE faculty several full-time EH and COE faculty hold adjunct appointments in Industrial Engineering and lecture in specific classes and serve on graduate committees. These include:

Dorothy F. Byers, Ph.D., Engineering Librarian and Adjunct Professor of Industrial Engineering

Amit Bhattacharya, Ph.D., Adjunct Professor of Industrial Engineering

Scott Clark, Ph.D., P.E., CIH, Adjunct Professor of Industrial Engineering

Kermit Davis, Ph.D., Adjunct Assistant Professor of Industrial Engineering

Klaus Willeke, Ph.D., CIH, Adjunct Professor of Industrial Engineering

In addition to full-time faculty in MINE and EH, the following off-campus adjuncts have taught courses, served on committees, and/or interfaced with student research in areas relating to the program:

Awwad J. Dababneh, Adjunct Assistant Professor of Industrial Engineering

Yarmouk University (Jordan), BSME, 1987

University of Cincinnati, MSIE, 1995

University of Cincinnati, Ph.D., 1997

Occupational Health and Safety

Janet C. Haartz, Adjunct Professor of Industrial Engineering

University of Michigan, B.S. Chem., 1960

University of Cincinnati, M.S. 1964

University of Cincinnati, Ph.D., 1972

Occupational Safety and Health

Thomas R. Huston, Adjunct Associate Professor of Industrial Engineering

University of Cincinnati, Engineering Science, B.S., 1980

University of Cincinnati, M.S.M.E., 1981

University of Cincinnati, Ph.D., 1985

Statistics, engineering economy, and product liability/safety engineering

Steven L. Sauter, Adjunct Professor of Human Factors

University of Wisconsin-Madison, B.A., 1968

University of Wisconsin-Madison, M.A., 1972

University of Wisconsin-Madison, Ph.D., 1975

Occupational stress, safety, and health

Rodney J. Simmons, Adjunct Associate Professor of Industrial Engineering  
 California State University, B.S., 1975  
 California State University, M.S., 1976  
 Harvard University, S.M., 1978  
 Texas A&M University, Ph.D., 1993  
 System and occupational safety engineering/management

Philip A. Stuebbe, Adjunct Assistant Professor of Industrial Engineering  
 University of Cincinnati, B.S.C.E., 1982  
 Xavier University, M.B.A., 1988  
 University of Cincinnati, M.S.I.E., 1989  
 University of Cincinnati, Ph.D., 1994  
 System safety and occupational safety engineering

Naomi G. Swanson, Adjunct Associate Professor of Industrial Engineering  
 Dakota Wesleyan University, B.A., 1980  
 University of Wisconsin-Madison, M.A., 1983  
 University of Wisconsin-Madison, Ph.D., 1989  
 Ergonomics and psychosocial stressors

Thomas R. Waters, Adjunct Professor of Industrial Engineering  
 University of South Florida, B.A., 1975  
 University of Cincinnati, M.S., 1981  
 University of Cincinnati, Ph.D., 1987  
 Ergonomics and psychophysiology

**TABLE 6. REQUIRED CORE COURSES AND ASSIGNED FACULTY**

<b>Safety Engineering Course</b>	Faculty
Fundamentals of Safety Engineering (20-INDS-620)	Shell
System Safety Engineering I (20-MINE-621)	Stuebbe
Safety Engineering Design (20-INDS-6XX), new course	New Faculty
<b>Ergonomics Courses</b>	
Fundamentals of Ergonomics (20-INDS-638)	Mital
Human Factors Analysis (20-INDS-624)	Genaidy
Human Factors Design (20-INDS-625)	Genaidy
<b>Occupational Health, Hygiene and Safety-Related Courses</b>	
<b>Interdisciplinary Project Courses</b>	
Occupational Health, Hygiene and Safety Workshop (26-EIH-819, 820, 821)	MINE, OHN & EH faculty
<b>Industrial Hygiene Course</b>	
Principles of Occupational Exposure Assessment (26-EIH-707)	Talaska

**Research Courses**

Experimental Design for Thesis Option (26-BE-789 or 22-QA-878  
 or 15-MATH-533)

or

Regression Analysis for Non-Thesis Option (26-BE-788 or 22-QA-876  
 or 15-MATH-532)

Engineering Information Research (20-ENGR-601)

Byers

**TABLE 7. COMMONLY SELECTED ELECTIVE COURSES FOR  
 OCCUPATIONAL SAFETY / ERGONOMICS**

Course Title and Number

**AUTUMN QUARTER**

Systems Modeling and Analysis (20-INDS-671)

Introduction to SAS Programming (26-BE-778)

Advanced Work Measurement (20-INDS-720)

**WINTER QUARTER**

Safety Engineering and Product Liability (20-MINE-779)

Tissue Biomechanics (20-MECH-686)

Introduction into Epidemiology (26-BE-776)

Survey of Environmental Toxicology (26-TOX-782)

Occupational Biomechanics (20-INDS-752)

**SPRING QUARTER**

System Safety Engineering II (20-MINE-622)

Management of Professionals (20-MINE-640)

Human Body Dynamics (20-MINE-687)

Simulation (20-INDS-733)

Probability Risk Assessment (20-NUC-680)

Ergonomics in Design I or II (20-INDS-755, 756)

Biomechanical or Physical Aspects of Muscular Activity (26-OSE-744)

**SUMMER QUARTER**

Safety Engineering Design and Management (20-MINE-780)

**TABLE 8. COURSES FOR OSE MATHEMATICS/RESEARCH ELECTIVES**

<u>Course Title</u>	<u>Course Number</u>	<u>Credit Hours</u>
<b><u>AUTUMN QUARTER</u></b>		
Applied Statistical Inference	15-MATH-531	
Design of Experiments *	20-INDS-613	
Linear Models and Multivariate Analysis	15-MATH-613	4

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Intermediate Analysis of Variance ♦	26-BE-777	3
Introduction to Biostatistics	26-BE-787	4
Rates and Proportions ♦	26-BE-797	3
Applied Multivariate Analysis ♦	26-BE-799	3
Fourier Transform Techniques	20-MECH-660	3

**WINTER QUARTER**

Applied Regression Analysis *	15-MATH-532	
SAS Programming	15-MATH-534	
Regression Analysis*	26-BE-788	
Linear Programming	15-MATH-524	3
Linear Models and Multivariate Analysis	15-MATH-614	4
Regression Analysis*	26-BE-788	4
Statistics of Bioassay ♦	26-BE-793	3
Intro to SAS Programming	26-BE-778	2

**SPRING QUARTER**

Analysis of Variance	15-MATH-533	
Linear Programming	15-MATH-525	3
Nonlinear Optimization	15-MATH-526	3
Linear Models and Multivariate Analysis	15-MATH-615	4
Experimental Design ♦	26-BE-789	4
Survey Sampling ♦	26-BE-794	3
Nonparametric Statistics ♦	26-BE-795	3
Survival Analysis ♦	26-BE-798	3
Logistic Regression	26-BE-871	3

- 
- ♦Course offered alternate years  
 a. May have been taken in the OSE core course requirement

**TABLE 9. PROGRAM OF STUDY, MASTER OF SCIENCE – THESIS OPTION  
 (Occupational Safety / Ergonomics)**

Course Title and Number	Credit Hours
<b>AUTUMN QUARTER</b>	
Fundamentals of Safety Engineering (20-INDS-620)	3
Fundamentals of Ergonomics (20-INDS-638)	3
Occupational Health, Hygiene and Safety Workshop (26-EIH-819)	1
Principles of Occupational Exposure Assessment (26-EIH-707)	3
Mathematics or Technical Elective	3
	ST 13

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<b>WINTER QUARTER</b>		
System Safety Engineering I (20-MINE-621)	3	
Human Factors Analysis (20-INDS-624)	3	
Engineering Information Research (20-ENGR-601)	2	
Occupational Health, Hygiene and Safety Workshop (26-EIH-820)	1	
Thesis (20-MINE-800)	3	
	12	ST
<b>SPRING QUARTER</b>		
Safety Engineering Design (20-INDS-6XX)      new course	3	
Human Factors Design (20-INDS-625)	3	
Occupational Health, Hygiene and Safety Workshop (26-EIH-821)	1	
Experimental Design (26-BE-789) or (22-QA-878) or (15-MATH-533)	3	
Thesis (20-MINE-800)	3	
Mathematics or Technical Elective	3	
	16	ST
<b>SUMMER QUARTER</b>		
Thesis (20-MINE-800)	6	
	6	ST
<b>TOTAL MINIMUM CREDITS</b>		<b>47</b>

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Shaded areas indicate core courses, 29 credit hours

**TABLE 10. PROGRAM OF STUDY, MASTER OF SCIENCE – NON-THESIS OPTION  
 (Occupational Safety / Ergonomics)**

Course Title and Number	Credit Hours
<b>AUTUMN QUARTER</b>	
Fundamentals of Safety Engineering (20-INDS-620)	3
Fundamentals of Ergonomics (20-INDS-638)	3
Occupational Health, Hygiene and Safety Workshop (26-EIH-819)	1
Principles of Occupational Exposure Assessment (26-EIH-707)	3
Mathematics or Technical Elective	3
	13
<b>WINTER QUARTER</b>	
System Safety Engineering I (20-MINE-621)	3
Human Factors Analysis (20-INDS-624)	3
Engineering Information Research (20-ENGR-601)	2
Occupational Health, Hygiene and Safety Workshop (26-EIH-820)	1
Regression Analysis (26-BE-788) or (22-QA-876) or (15-MATH-532)	3
Special Topic-Project (20-MINE-870)	3
	15

<b>SPRING QUARTER</b>	
Safety Engineering Design (20-INDS-6XX) new course	3
Human Factors Design (20-INDS-625)	3
Occupational Health, Hygiene and Safety Workshop (26-EIH-821)	1
Mathematics or Technical Electives	6
	13
<b>SUMMER QUARTER</b>	
Special Topic-Project (20-MINE-870)	6
	6
<b>TOTAL MINIMUM CREDITS</b>	<b>47</b>

Shaded areas indicate core courses, 29 credit hours

**TABLE 11.**  
**REQUIREMENTS FOR ADMISSION INTO THE MASTER OF SCIENCE**  
**PROGRAM FOR THOSE STUDENTS WITHOUT A BS DEGREE IN ENGINEERING**

All applicants must fulfill general University and Departmental admission requirements as specified in "A Manual for the Guidance of Graduate Students." Applicants possessing non-engineering baccalaureate degrees are evaluated on their individual merits. For industrial engineering admission, the non-engineering baccalaureate degree holder will have completed or will complete as make-up requirements the following minimum number of courses or their equivalent:

Course*	Number	Credit Hrs
Mathematics through Differential Equations	20-MATH-273	5
General Physics I, II, III	15-PHYS-201, 202, 203	12
General Physics Lab I, II, III	15-PHYS-211, 212, 213	3
First Year Chemistry	15-CHEM-101, 102	8
Mechanics I, II	20-ENFD-101, 102	6
Computer Language	20-ENFD-111	3
Graphics Fundamentals	20-ENFD-250	3
Basic Electric Circuit Analysis	20-ENFD-371	3
Nature and Properties of Materials	20-ENFD-376	3
Basic Strength of Materials	20-ENFD-375	3
Basic Thermodynamics	20-ENFD-382	3
Basic Fluid Mechanics	20-ENFD-383	3
Basic Heat Transfer	20-ENFD-385	3
Four upper level undergraduate IE courses	TBD	12

\*Equivalent courses are also available in the UC College of Evening and Continuing Education

**TABLE 12.**  
**EXAMPLE PROGRAM OF STUDY FOR DOCTOR OF PHILOSOPHY ASSUMING**  
**COMPLETION OF MASTER OF SCIENCE AS SHOWN IN TABLE 9 OR 10**

NOTE: The minimum second year coursework requirements are 45 hours, of which a minimum of 18 hrs are MINE Department courses. Based upon the student's background and goals, as well as course avail-

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ability, the student and advisor will develop a program of study. Shown below is just one example of a second year program of study for a student who wishes to have a mix of ergonomics / safety, industrial hygiene and environmental courses.

Course Title and Number	Credit Hours
<b>AUTUMN QUARTER</b>	
Categorical Data Analysis (26-BE-797) or Logistic Regression and Log Linear Models (26-BE-871)	3
Introduction into SAS Programming (20-BE-778)	2
Applied Multivariate Analysis (26-BE-799)	3
Organizational Behavior and Theory (22-MGM-711)	4
Environmental Health Seminar (26-ENV-701)	1
	13
	ST
<b>WINTER QUARTER</b>	
Introduction into Epidemiology (26-BE-776)	3
Safety Engineering and Product Liability (20-MINE-779)	3
Occupational Biomechanics (20-INDS-752)	3
Industrial Ventilation (26-EIH-779)	3
Environmental Health Seminar (26-ENV-702)	1
	13
	ST
<b>SPRING QUARTER</b>	
Design and Management of Field Studies (26-BE-975)	3
System Safety Engineering II (20-MINE-622)	3
Management of Professionals (20-MINE-640)	3
Human Body Dynamics (20-MECH-687)	3
Ergonomics in Design I or II (20-INDS-755, 756)	3
Environmental Health Seminar (26-ENV-703)	1
	16
	ST
<b>SUMMER QUARTER</b>	
Critical Appraisal of Epidemiological Studies (26-BE-968)	3
Safety Engineering Design and Management (20-MINE-778)	3
	6
	ST
<b>TOTAL MINIMUM CREDITS</b>	<b>48</b>

Shaded areas indicate additional core courses at the PhD level, 15 credit hours. The third/fourth year of the doctoral program requires completion of the dissertation, and 12 credit hours of communication courses.

## F. HAZARDOUS SUBSTANCES ACADEMIC TRAINING

### BACKGROUND

The Hazardous Substances Academic Training (HSAT) program at the University of Cincinnati is an emphasis area within the Environmental and Industrial Hygiene program. Students selecting the HSAT area have two additional required courses and also attend a 40-hour health and safety class for hazardous waste site workers. Several other industrial hygiene courses have been strengthened in hazardous substance content and additional courses have been developed. The program therefore impacts all students taking industrial hygiene core courses, whether taking courses as part of the Environmental and Industrial Hygiene major or as electives. The HSAT program requires additional training in Biological Monitoring and Risk Assessment for those students pursuing the HSAT program as an area of concentration or who select these courses for other reasons. Although the HSAT program is officially a part of the M.S. degree program, these courses are also taken by the students pursuing the Ph.D. degree in Environmental and Industrial Hygiene. Students in other programs in the Department of Environmental Health, in programs in epidemiology and toxicology, and elsewhere in the University of Cincinnati, particularly the Civil and Environmental Engineering and Mechanical, Industrial and Nuclear Engineering.

The existing required industrial hygiene course in Hazardous Materials Management was strengthened through HSAT funding by the addition of field trips and by incorporation into the class of computer software such as those for the modeling of chemical releases into the air and ground-water and for risk assessment. A special laboratory exercise has been developed for a core industrial hygiene course where students make use of a chemical monitoring data set developed to simulate an actual industrial chemical release incident. Students attend hazardous waste worker training programs and related courses offered through the EPA-supported training center located in Cincinnati or through one of the local programs in the NIEHS-supported hazardous waste worker training centers with which the Department of Environmental Health is involved such as the Midwest Consortium for Hazardous Waste Worker Training and the ICWUC Center for Worker Health and Safety Education.

### ACADEMIC TRAINING

#### Goals and Objectives

The HSAT program is designed to enhance the hazardous substances content of training for all students in the Environmental and Industrial Hygiene program and to provide an option for those students who seek additional training in this area.

#### Graduates

A total of ten (10) M.S. degrees in IH-HSAT have been awarded during this five-year reporting period. The number of each, by year is shown below

#### **HSAT Degrees Awarded 9/1/97 through 8/31/02**

Year	M.S.
1997-1998	2
1998-1999	3
1999-2000	1
2000-2001	2
2001-2002	2

**MS IH-HSAT Graduate 9/1/97 through 8/31/02**

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Andrea M. Armstrong	MS / IH-HSAT
Craig D. Evans	MS / IH-HSAT
Scott Henn	MS / IH-HSAT
Erin Snyder	MS / IH-HSAT
Edward D. Auyang	MS / OS-Ergo., IH-HSAT
Krystyn R. Clark (Nee: Bussa)	MS / IH-HSAT
Kincl, Laurel	MS / IH-HSAT
Joshua Harney	MS / IH-HSAT
Darren Burks	MS / IH-HSAT
Christine Newman	MS / IH-HSAT

**Thesis/Dissertations**

M.S. students complete a research thesis. Ph.D. students complete a dissertation. Titles, student name, degree and placement are shown in Appendix A. Abstracts of dissertations and theses are shown in Appendix B. Students are encouraged to present research findings at national and international meetings. Titles and abstracts of presentations are shown in Appendix C. During 1997-2002, a total of 65 presentations were made. A listing of 130 publications involving students is shown in Appendix D. This listing includes a recent publication by Laurel Kincl, one of the first HSAT students. The work was conducted at local worker training centers.

## G. CONTINUING EDUCATION/OUTREACH

### 1997-2002 Progress Report

#### BACKGROUND

The Office of Continuing Education, Department of Environmental Health, University of Cincinnati College of Medicine continues the tradition begun in 1949 of offering short courses in environmental and occupational health and safety. Established in 1983, the Office of Continuing Education assumed the coordination of the administrative and marketing functions of the program, allowing faculty to concentrate their efforts on course development. Through this cooperative effort the Office of Continuing Education has built a national reputation for offering excellence in environmental/occupational health and safety short courses. Continuing education courses presented through this program are multi-faceted, ranging from one-day seminars on selected topics to four-week intensive training programs. These courses reflect the reputation, strength, and diversity of the ERC faculty.

The Office of Continuing Education offers courses in all four ERC core areas: occupational medicine, occupational health nursing, environmental/industrial hygiene, and occupational safety. The program is interdisciplinary, utilizing faculty from the College of Medicine, the College of Nursing and Health, the College of Engineering (both from the Clifton campus and Section Road facility), the University College Department of Math and Applied Sciences, and the College of Education. The role of the Continuing Education Office includes the development of new short courses, the coordination of interdepartmental continuing education programming, marketing, administration, and program evaluation. The Director of the Office of Continuing Education is Judy L. Jarrell, M.A., Ed.D., Field Service Professor. The Cincinnati NIOSH ERC/CE Office also handles the responsibility of the ERC/CE conference booth, which is displayed at four to five national conferences each year.

Negotiations began in the Spring of 2000 to merge the continuing education program under the Department of Environmental Health into the Continuing Medical Education Office under the Dean of the College of Medicine. This program is overseen by the Assistant Dean for Continuing Medical Education, Dr. John R. Kues. This merger has led to advantages for the ERC Continuing Education Program, as well as for the OSHA Regional Education Center program (which Dr. Jarrell also directs). It was determined that the economies realized by the merger (additional staff and funding opportunities) would bolster the financial position of the merged continuing education programs. The merger has enabled the ERC Continuing Education Program to explore distance-learning opportunities, since the CME program was already involved in these formats of training. It also enabled more interaction with medical and nursing faculty (especially with the Department of Family Medicine—wherein Dr. Kues holds a faculty appointment). Dr. Jarrell has maintained her faculty appointment, and the ERC NIOSH grant funds for continuing education and special projects will remain, in the Department of Environmental Health.

All ERC continuing education courses are developed with the expertise of course directors. Course directors are responsible for the technical content of their short courses and serve as principal instructors. Many of the course directors are members of University faculty; when appropriate, however, experts outside the University are utilized.

A formal ERC/CE Advisory Committee, formed in the Spring of 1996, works with the CE Director in strategic planning for marketing/advertising, course and instructor evaluations, new course development, and innovative directions for the program. Committee meetings are usually held in the form of conference calls. The following persons serve on this committee:

Glenn Markle, PhD, professor, College of Education  
Kay Hayes, MPH, former ERC/CE director  
Robert A. Herrick, PE, DEE, CIH, consultant  
Richard Fulwiler, ScD, CIH, consultant  
Douglas Linz, M.D., M.S., occupational physician  
L. Sue Davis, Ph.D., OHN, occupational health nurse

### **Faculty Commitment/Breadth**

The dedication and commitment of the faculty to continuing education is evidenced by the number of courses offered at least yearly. For example, our "Occupational Ergonomics" course is offered at least once yearly directed by Dr. Amit Bhattacharya of our Environmental & Industrial Hygiene core group. The "Introduction to Industrial Toxicology," course directed by C. Stuart Baxter, PhD, of the Environmental Health Dept. faculty, has missed only one year out of the past six years. Asbestos and lead abatement courses, as well as OSHA safety courses, are offered several times throughout the academic year.

The "Occupational Medicine Training" course continues to provide training for physicians practicing occupational medicine. This program, directed by Vikas Kapil, D.O. and Douglas Linz, M.D., consists of four one-week sessions taken over the span of a year. The course has been averaging about 22 physicians in each weekly session. The occupational medicine training program is nationally recognized for its excellence.

Occupational Health Nursing short courses are offered both in the Department of Environmental Health and the College of Nursing and Health continuing education programs. Lou Ann Emerson, Ph.D., Associate Dean, directs the College of Nursing and Health Continuing Education program. This program has presented nursing continuing education courses for over twenty years but has recently decided to gradually turn these courses over to the Continuing Education office.

The development of new courses is also evidence of faculty commitment. For example, the following are some of the new courses which were developed and offered in the last five academic years:

- ✓ Lead Risk Assessor Refresher
- ✓ Using the Internet to Access Health & Safety Resources
- ✓ Associate Safety Professional Comprehensive Review
- ✓ OSHA #502 – Update for Construction Industry Authorized Trainers
- ✓ Scaffold User Safety
- ✓ OSHA Forklift Safety Train-the-Trainer Workshop
- ✓ OSHA Electrical Standards
- ✓ Psychological & Chemical Stress Factors in the Workplace
- ✓ Trenching & Excavation Safety
- ✓ Revised Occupational Ergonomics (OSHA #225)
- ✓ Forklift Safety Train-the-Trainer
- ✓ OSHA #311 – Fall Arrest Systems Training (Occupational Safety)
- ✓ OHN Certification Review Course (O.H. Nursing)
- ✓ Overview of Occupational Health Nursing (O.H. Nursing)
- ✓ OSHA's Needle Stick Standard—With Ohio Add'l Requirements (Multi-disciplines)
- ✓ Musculoskeletal Exam and Treatments (Occupational Medicine)
- ✓ Medical Center Occupational Health & Safety (Occupational Medicine)

### **Faculty Reputation/Strength**

University Faculty [NOTE: Please refer to individual Program sections for a discussion of the reputation and strength of the University faculty utilized in continuing education short courses.]

In addition to the distinguished faculty listed by the other Program Area Directors, several other University faculty play an integral role in the continuing education program. Judy Jarrell, M.A., Ed.D., in addition to directing the ERC/CE Program, instructs in several of the short courses and developed a train-the-trainer course in which she is the primary instructor. Dr. Jarrell's expertise in program development and evaluation, and regulated mandatory continuing education, is sought by state and national organizations for consultations. She is also active as a presenter at conferences in these topic areas (see "Outreach" section).

Assists Dr. Jarrell with instruction in the "Effective Training Techniques for Lead Abatement Trainers" course.

James Lockey, M.D., M.S., and Donald E. Shrey, Ph.D., Director, Disability Management in the Dept. of Physical Medicine & Rehabilitation, participated in the Cairo Egypt International Conference (March 26-29, 2001) as plenary speakers. Timothy Keener, Ph.D., associate professor of civil & environmental engineering, lectures on air pollution in our "Comprehensive Review for Industrial Hygiene Professionals" and "Industrial Ventilation" courses.

#### **Non-University Faculty**

Besides these outstanding educators, the ERC Continuing Education Program utilizes the expertise of non-University personnel. Involved in the asbestos abatement training courses are: Mark Karaffa, M.S., CIH, and James Romine, M.S., CIH, CHMM (consultants and graduates of our IH program), Larry Wilson (former OSHA compliance officer), Michael W. Hayslip (environmental attorney and safety consultant), D. Wesley Newhouse (environmental attorney), and Kurt Varga, PhD (environmental and educational consultant).

Non-University personnel involved in the lead abatement training courses are: Richard Boehnke of the Dept. of Public Health, City of Toronto, Ontario, Canada; John Pesce (Massachusetts Master Lead Inspector—nationally known lead abatement training instructor and teacher in similar courses throughout the country) of Star Industries, Boston, MA; D. Wesley Newhouse (environmental attorney); Salvatore Cali, M.S. of the University of Illinois, and Barbara Boylan, City of Cincinnati Health Department.

Robert Willson, M.S., CIH is course director of "Industrial Noise Control" and lectures in "Comprehensive Review for Industrial Hygiene Professionals," "Industrial Ventilation," and "Survey of Industrial Hygiene" short courses. Mr. Willson has many years' experience in industrial hygiene and specializes in the control of industrial noise. He has been president of Beta Associates, Inc., an industrial hygiene consulting firm, for over twelve years. Prior to that, he was an industrial hygienist with PEDCo, Inc. and NIOSH.

Charles Nenadic, M.S., J.D., CIH, P.E., is course director of the "Comprehensive Review for Industrial Hygiene Professionals," "Industrial Ventilation," "Indoor Air Quality," and "Survey of Industrial Hygiene." Mr. Nenadic served as a commissioned officer with NIOSH for six years, and is now president of Consolidated Environmental Services, Inc., an industrial hygiene consulting and training company.

Mary Malotke, is course director of our "OSHA #501 and OSHA #503" short courses. Ms. Malotke is owner and president of TENCON Consulting and TechniTrain, Inc. Previous to the establishment of these two firms she was an environmental manager for Procter & Gamble.

James Romine, MS, CIH, CHMM, is director of our "Hazardous Materials Management Review," "Air Sampling for Toxic Substances," "OSHA #521" and "OSHA #201A" courses and instructs in our "Survey of Industrial Hygiene" and "Asbestos Abatement Training" courses. Mr. Romine is a graduate of the industrial hygiene program at the University of Cincinnati.

Howard Etkind, M.S., CSP, REP, (with the U.S. Department of Energy), is co-director, with Mr. James Romine, of our "Certified/Associate Safety Professional Comprehensive Review" courses for safety professionals wishing a review course to prepare for the certification examination.

James McGlothlin, M.P.H., Ph.D., C.P.E. retired as a research occupational ergonomist/hygienist with the Engineering Control Technology Branch of NIOSH to enter an academic career as Associate Professor of Health Sciences at Purdue University in 1999. Dr. McGlothlin is the director for "Ergonomic Control Programs to Prevent Injury in Industry," "Use of Real-Time Instruments to Solve Industrial Hygiene and Ergonomic Problems," and "Office Ergonomics" courses. He also lectures in "Occupational Ergonomics/OSHA #225," "Survey of Industrial Hygiene," and "Comprehensive Review for Industrial Hygiene Professionals" courses.

The proximity of the Cincinnati ERC to NIOSH and EPA research facilities, frequently results in collaboration with NIOSH and EPA scientists as development consultants, instructors, and course directors.

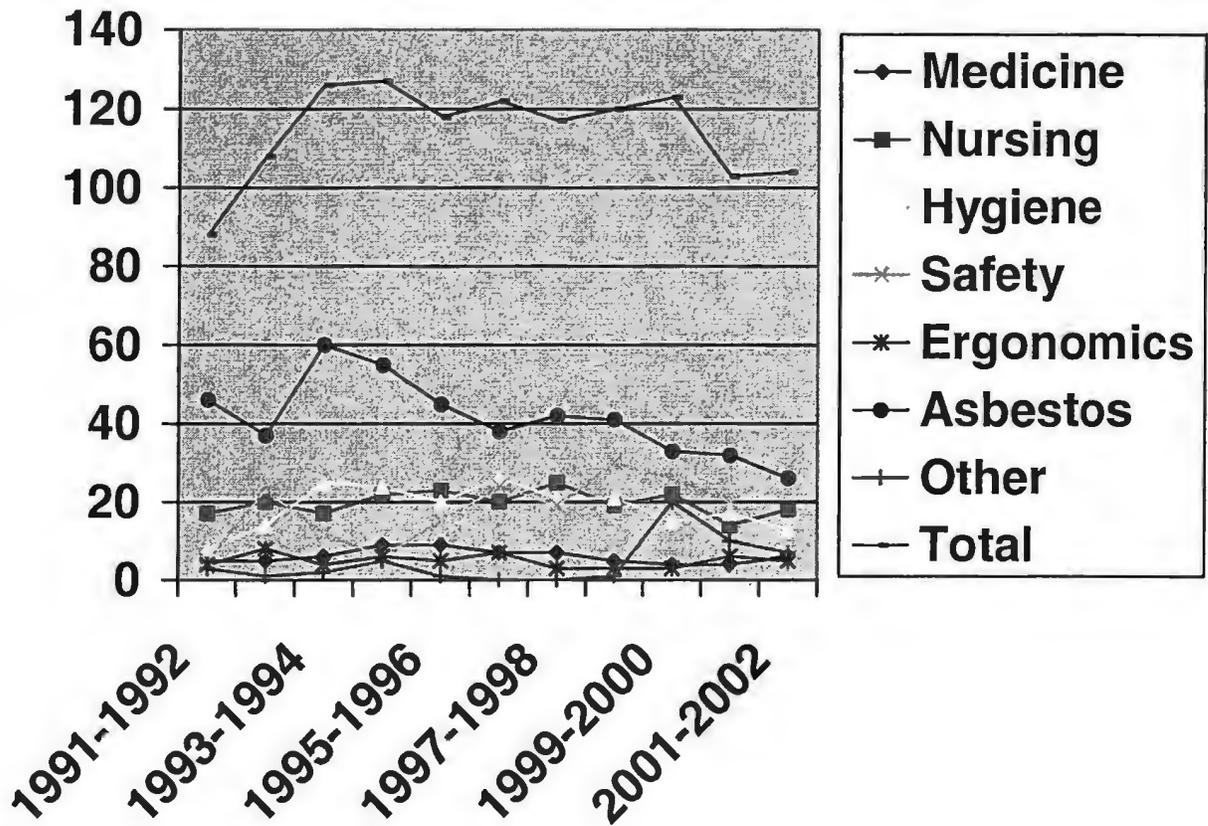
#### **Courses Offered by Specialty Area**

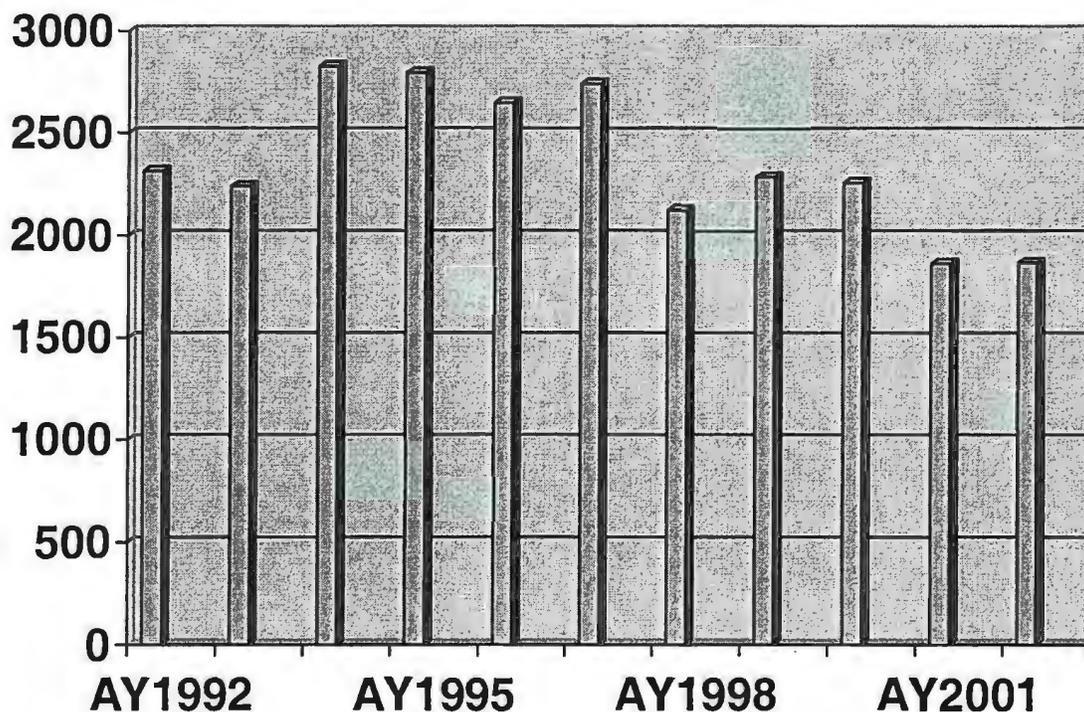
The following table shows the development of continuing education course offerings by program over the past ten years.

<b>Total ERC Continuing Education Course Offerings</b>								
<u>Grant Year</u>	<u>Medicine</u>	<u>Nursing</u>	<u>Hygiene</u>	<u>Safety</u>	<u>Erqo</u>	<u>Asbestos</u>	<u>Other</u>	<u>Total</u>
1997-1998	7	25	21	19	3	42	0	117
1998-1999	5	19	21	30	3	41	1	120
1999-2000	4	22	15	26	3	33	20	123
2000-2001	4*	14**	17	20	6	32	10	103
2001-2002	6	18	13	29	5	26	7	104

\*The 2000-2001 academic year is the first to have the Occupational Medicine Training courses offered four times (four one-week courses, instead of three [two one-week courses and one two-week course] per year, this rearrangement resulted in one course going into the next academic year.

\*\*The nursing continuing education program is undergoing many changes that have resulted in a significant decrease in number of courses offered. The ERC CE office developed and offered additional courses out of its office beginning in AY2001-2002.





**Total Number of Trainees in Courses AY1992-2002**

AY1992	2,312
AY1993	2,239
AY1994	2,826
AY1995	2,795
AY1996	2,646
AY1997	2,741
AY1998	2,124
AY1999	2,283
AY2000	2,256
AY2001	1,861
AY2002	2,889

**Outreach Activities**

The faculty of all four core programs as well as the director of the continuing education program participated in all aspects of outreach activities: educational development; presentation / lectures / awareness seminars; consultations; and miscellaneous other activities. This Center continues to be an appreciated resource to Cincinnati, Ohio, the region, the U.S., and the international arena of environmental and occupational health and safety.

## H. PILOT RESEARCH PROJECT TRAINING PROGRAM

### Background

Pilot Research Project Training Program at the University of Cincinnati was established on July 1, 1999. Students and faculty at collaborating institutions in programs that do not currently have NIOSH training grant support are also eligible for the pilot project grants.

### Operation of Program

As initially established, the University of Cincinnati PRP included three other universities in the region: Purdue University, University of Kentucky and Western Kentucky University. Dr. Bhattacharya heads the UC PRP program. For the five-year competitive renewal of the PRP for July 1, 2001 to June 30, 2006, the program was expanded to include four other institutions: Central State University, Eastern Kentucky University, Murray State University and Western Kentucky University. Pilot projects are intended to enable the following:

- Develop research expertise, capacity, and understanding in Education and Research Center research trainees and new investigators and within regional occupational safety and health research training programs.
- Provide initial support for new occupational safety and health investigators to establish new areas of research that address NORA topics.

Encourage investigators from other relevant research areas to apply their expertise to NORA topics.

Guidelines for the operation of the Pilot Research Project Training Program (including guidelines for proposals, review process, dissemination of information on the program and on its accomplishments and evaluation) were developed through a Steering Committee consisting of representatives of participating institutions. Current members of the PRP Steering Committee are listed in Table 13.

**Table 13**

Amit Bhattacharya, Ph.D., CPE	University of Cincinnati
Scott Clark, Ph.D., PE, CIH	University of Cincinnati
Omokere Odje, Ph.D.	Central State University
Steven Konkel, Ph.D.	Eastern Kentucky University
Deborah Whitehouse, DSN	Eastern Kentucky University
Kazi Javed, Ph.D.	Kentucky State University
David G. Kraemer, Ph.D.	Murray State University
Frank Rosenthal, Ph.D., CIH	Purdue University
Neil Zimmerman, Ph.D., CIH	Purdue University
T. Scott Prince, M.D.	University of Kentucky
Dennis George, Ph.D., CIH	Western Kentucky University

### Accomplishments

During the first three years of its operation, the PRP program has funded 48 projects from six of the participating institutions. A listing of these projects, the investigators and their mentors, the institutions and the project period is presented in Attachment E

An annual Pilot Research Project Symposium was initiated in the fall of 2000 to provide an opportunity for investigators from completed projects to present their results and those of newly funded pro-

jects to present their plans and initial findings, if available. A major objective of the annual symposium is to provide a forum for interchange among investigators and others at the participating institutions.

A listing of the programs for the first two annual symposia are included in Attachment F.

Measures of the outcome of the PRP program that are used in its evaluation include: new grants developed using pilot research results, publications, new research careers established or stimulated by the pilot project experience and career shifts by investigators in related fields.

A list of Pilot Research Project Presentations and Manuscripts that have thus far resulted from pilot research project research is contained in Table 14. Fifty-nine (59) research proposals have thus far been submitted based on pilot research findings, forty-nine (49) of which have been funded.

<b>Table 14</b>	
<b>Pilot Research Project Presentations and Manuscripts</b>	
<b>Name</b>	<b>Presentation or Manuscript</b>
Kyoo T. Choe	“Relationship Between Lead Levels on Painted Surfaces and Percent Lead in the Particles Aerosolized During Lead Abatement” Applied Occupational and Environmental Hygiene, V17(8):573-579, 2002
Nancy Daraiseh	“The Nursing Shortage: A Method of Analysis” (manuscript in progress—will be submitted to <i>Nursing Administration</i> )
Rado Gazo	“Ergonomic Solutions for the Wood Industry” 1. \$80,000 USDA Forest Service grant 2. Ergonomics briefing. Presentation to David R. Webb, Inc. Ergonomics task force. 9/18/2000 3. Ergonomics briefing. Presentation to Koetter Woodworking, Inc. Ergonomics task force. 9/19/2000 4. Ergonomics program, training. Presentation to Koetter Woodworking, Inc. Management team. 1/30/2001
Shawn Gibbs	“Antibiotic Resistant Bacteria Isolated from the Air of Swine Confinement Operations” (publication in preparation)
Ginger Hepler	“Genetic Counseling for Occupational Exposures” (submitted during 2001 to <i>Journal of Genetic Counseling</i> )
Susan Jones	1. “Assessing Factors Contributing to the Use of Respiratory Protection of Workers in Swine Confinement Buildings” presented at Kentucky Nurses Association Research Poster Session in Louisville, Ky , October 17, 2001. 2. “Assessing Factors Contributing to the Use of Respiratory Protection of Workers in Swine Confinement Buildings” presented at the Agromedicine Conference, Charleston, SC, November 4, 2001.
Cynthia Kelly	“Measuring Behavior Change” Presentation at the International Conference of Objective Measurement at University of Illinois, Chicago on October 19, 2001. Manuscript in progress.
Laurel Kincl	3. “Injury Trends for Adolescents with Perinatal and Early Childhood Lead Exposure” presented the Suskind Symposium, 9/8/01 (manuscript in progress) 4. “Postural Sway Measurements: A Potential Safety Monitoring Technique for Workers Wearing Personal Protective Equipment”, Applied Occupational and Environ-

**Table 14**  
**Pilot Research Project Presentations and Manuscripts**

Name	Presentation or Manuscript
	mental Hygiene, V17(4), 256-266, 2002
Laurel Kincl and Ming-Lun Lu	“Assessment of Risk Factors Associated with Work on Slippery Surfaces at an Automobile Parts Manufacturing Facility” Abstract to AIHCE 2000, and Presentation at NIOSH
Jeffrey Lodwick	“Evaluation of Positional Dependence on the Leg Associated with In Vivo x-ray Fluorescence Measurements of Stable Lead in the Tibia” Poster Presentation at University of Cincinnati Graduate Research Forum, March 2001
Gediman Mainelis	“Counting of Water-borne Microorganisms by Light-scattering Spectrometry” to be submitted to the <i>Journal of Microbiological Methods</i>
Preethi Rao	<ol style="list-style-type: none"> <li>1. “Pesticide use Work Practice Observations and Residual Pesticides in Soil/Dust Samples from Homes of Farm-workers in Gujarat, India” presented at AIHCE 2001, New Orleans, LA 6/4/01.</li> <li>2. “Surveillance of Pesticide Poisonings and Pesticide use Work Practices in Rural Farms of Gujarat, India” Abstract submitted for the Society for Occupational and Environmental Health (SOEH) Conference July 2002, Bethesda (accepted)</li> <li>3. “Pesticide Poisonings and Pesticide use Work Practices in Gujarat, India” Abstract submitted for the International Roundtable for IAC and Ag. H&amp;S (AIHCE 2002, San Diego) conference, June 2002, San Diego, CA*</li> </ol>
Deborah Reed	<p><u>Publications in progress:</u></p> <ol style="list-style-type: none"> <li>1. Access to health care on the road <i>Journal Women’s Health Issues</i></li> <li>2. Health issues and access to care <i>American Journal Of Public Health</i></li> <li>3. Living in a man’s world: Stress at the wheel <i>Women Truckers</i> (popular press)</li> </ol> <p><u>Presentations:</u></p> <ol style="list-style-type: none"> <li>1. “Health issues and concerns of female long-haul truck drivers” Faculty presentation. University of Kentucky College of Nursing. 12/18/00</li> <li>2. “ Women long-haul truck drivers, health, and access to health care” Presented at the Southern Nursing Research Conference, Baltimore, MD. February, 2001</li> <li>3. “Occupational Health Issues of Female Long Haul Truck Drivers” Submitted to The International Women, Work and health Conference, for June, 2002</li> </ol>
Mikhaylo Trunov	<ol style="list-style-type: none"> <li>1. “Personal Lead Exposure During Indoor Lead-based Paint Abatement” (AIHCE 2002 Presentation).</li> <li>2. “Relationship Between Lead Levels on Painted Surfaces and Percent Lead in the Particles Aerosolized During Lead Abatement”, <i>Applied Occupational and Environmental Hygiene V17(8): 573 – 579, 2002</i></li> </ol>
*Received Best of Session and Best Occupational Epidemiology awards.	

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**Attachment E Pilot Project Awards, Investigators and Institutions**

Project #	Project Title	Principal Investigator (Mentor)	Institution	Project Period
1	Development of Quantitative PCR to Measure Metal Working Fluid Aerosols Implicated in Occupational Respiratory Illness	Jagjit Yadav, PhD – Faculty	U. of Cincinnati	2-1-00 / 6-30-00
2	The Development, Assembly, and Pilot Testing of Video Exposure Assessment System	John Vosicky – MS Student, Industrial Hygiene (James D. McGlothlin, PhD)	Purdue U.	2-1-00 / 6-30-00
3	Residual Pesticides in Soil/Dust Samples from the Homes of Farm Workers in Gujarat, India: Observation of Worker Practices, Preliminary Assessment of Pesticide Levels in Home Soil/Dust and Methods of Analysis for Future Monitoring	Preethi Rao – PhD Student, Industrial Hygiene (Glenn Talaska, PhD)	U. of Cincinnati	2-1-00 / 6-30-00
4	Injury Trends for Adolescents with Childhood Lead Exposure	Laurel Kincl – PhD Student, Industrial Hygiene (OSE) (Kim N. Dietrich, PhD)	U. of Cincinnati	2-1-00 / 6-30-00
5	Health Care Access of Female Truckers: Pilot Study	Deborah Reed, PhD – Faculty	U. of Kentucky	2-1-00 / 6-30-00
6	Development of a Model for Determining the Linkage between Productivity Thresholds and Adverse Musculoskeletal Outcomes in Masonry Operations	R. Wirahadikusumah – Post Doctoral Student, Industrial Hygiene John Vosicky – MS Student, Industrial Hygiene (James D. McGlothlin, PhD)	Purdue U.	2-1-00 / 6-30-00
7	Assessment of Endotoxin, Dust and Fungal Exposures in a Horse Containment Room	Michael Hunt – MS Student, Industrial Hygiene (Frank S. Rosenthal, PhD)	Purdue U.	2-1-00 / 6-30-00

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**Attachment E Pilot Project Awards, Investigators and Institutions**

Project #	Project Title	Principal Investigator (Mentor)	Institution	Project Period
8	Development of an Instrument to Access Factors Contributing to the use of Respiratory Protection of Workers in Swine Confinement Buildings	Susan Jones – PhD Student, Occupational Health Nursing (L. Sue Davis, PhD)	U. of Cincinnati	2-1-00 / 6-30-00
9	Cardiovascular Health Rating Scale Development	Cynthia Kelly – PhD Student, Occupational Health Nursing (Elizabeth Betemps, PhD)	U. of Cincinnati	2-1-00 / 6-30-00
10	Evaluation of Positional Dependence on the Leg Associated with in vivo X-ray Fluorescence Measurement of Stable Lead in Tibia	Jeffrey Lodwick - PhD Student, Industrial Hygiene (Henry B. Spitz, PhD)	U. of Cincinnati	2-1-00 / 6-30-00
11	Genetic Counseling for Occupational Exposures	Ginger Hepler – MS Student, College of Allied Health (Nancy S. Warren, MS & Carol Rice, PhD)	U. of Cincinnati	2-1-00 / 6-30-00
12	Assessment of Risk Factors Associated with Work on Slippery Surfaces at an Automobile Parts Manufacturing Facility	MingLun Lu- PhD Student, Industrial Hygiene (C. Scott Clark, PhD)	U. of Cincinnati	2-1-00 / 6-30-00
13	Work-related Musculoskeletal Disorders in Nursing Personnel: An Instrument Validation	Nancy Darariseh – PhD Student, Industrial Engineering Mattie Burton – PhD Student, Occupational Health Nursing (Ashraf Genaidy, PhD)	U. of Cincinnati	7-10-00 / 6/30/01
14	Ergonomic Solutions for the Wood Industry	Rado Gazo, PhD – Faculty	Purdue U.	7-10-00 / 6/30/01
15	The Efficacy of Natural Products as Antifungal Agents in Building Materials	Chie Inumaru - PhD Student, Industrial Hygiene (Neil J. Zimmerman, PhD)	Purdue U.	7-10-00 / 6/30/01
16	Development of a New Method for Enumerating Airborne Microorganisms Sampled in Occupational Environments	Gediminas Mainelis - PhD Student, Industrial Hygiene (Tiina Reponen, PhD)	U. of Cincinnati	7-10-00 / 6/30/01

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**Attachment E Pilot Project Awards, Investigators and Institutions**

Project #	Project Title	Principal Investigator (Mentor)	Institution	Project Period
17	Investigations of Bioaerosols in and around Swine Containment Operations	Shawn Gibbs – MS Student, Environmental Science, Microbiology (Pasquale Scarpino, PhD)	U. of Cincinnati	7-10-00 / 6/30/01
18	Evaluation of Feasibility of the use of a Uniform Pesticide Poisoning Reporting Form for an Agricultural Area in Gujarat, India and Determination of the Changes in Pesticide Levels in Soil/Dust Samples, Before, During, and After Use of Pesticides in the Homes of Farm-workers in the Agricultural Area	Preethi Rao -- PhD Student, Industrial Hygiene (C. Scott Clark, PhD)	U. of Cincinnati	7-10-00 / 6/30/01
19	Ultrafine Particulate Monitoring in Rubber Processing	Leslie Reed – PhD Student, Industrial Hygiene (Neil J. Zimmerman, PhD)	Purdue U.	7-10-00 / 6/30/01
20	The Effects of JP-8 Jet Fuel on the Immune System of Tank Entry Workers	Audrey Rhodes, MD, MS Student, Occupational Medicine (Grace LeMasters, PhD)	U. of Cincinnati	7-10-00 / 6/30/01
21	A Study of Occupational Injuries in EMS Workers in Kentucky	Michael K. Rush – Jr. Faculty & EdD Student, Lee Brown – RN, Dir. Ky. EMS Academy	W. Kentucky U.	7-10-00 / 6/30/01
22	Assessment of Workers' Exposure to Lead during Lead Abatement in Indoor Environments	Mikhailo Trunov – Visiting Scholar & PhD Student, Industrial Hygiene (Sergey Grinshpun, PhD)	U. of Cincinnati	7-10-00 / 6/30/01
23	DNA Fingerprinting for Strain-specific Identification of Mycobacteria in Metalworking Fluids Implicated in Occupational Hypersensitivity Pneumonitis	Jagjit Yadav, PhD – Faculty	U. of Cincinnati	7-10-00 / 6/30/01
24	Occupational Exposure to Particulate Matter and Heart Rate Variability	Robert Eninger – MS Student, Industrial Hygiene (Frank S. Rosenthal, PhD)	Purdue U.	9-1-01 / 6-30-02
25	Antibiotic Feeding of Animals (Pigs) and Antibiotic Resistance of Farm Personnel	Darryl Ragland, DVM, PhD – Faculty	Purdue U.	9-1-01 / 6-30-02

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**Attachment E Pilot Project Awards, Investigators and Institutions**

Project #	Project Title	Principal Investigator (Mentor)	Institution	Project Period
26	Investigation of Cellulose Polymer as an Extender of Natural Antifungal Agents in Building Materials	Chie Inumaru –PhD Student, Industrial Hygiene (Neil J. Zimmerman, PhD)	Purdue U.	9-1-01 / 6-30-02
27	Development and Use of a Real-time Video Exposure Monitoring System to Train Workers How to Prevent Excessive Occupational Radiation Exposure	Wei-Hsung Wang, PhD – Faculty	Purdue U.	9-1-01 / 6-30-02
28	Impact of Organization of Work Factors on Work-related Injuries at Eating and Drinking Places	Douglas C. Nelson, PhD – Faculty	Purdue U.	9-1-01 / 6-30-02
29	Impact of Non-low Back Injuries on Low Back Biomechanics	Kermit G Davis, PhD – Faculty	U. of Cincinnati	9-1-01 / 6-30-02
30	Work-related Musculoskeletal Disorders in Nursing Personnel: An Instrument Validation Study	Nancy Darariseh – PhD Student, Industrial Engineering Mattie Burton – PhD Student, Occupational Health Nursing (Ashraf Genaidy, PhD)	U. of Cincinnati	9-1-01 / 6-30-02
31	Violence and Stress Experienced by Female Long-Haul Truckers	Debra G Anderson, PhD – Faculty	U. of Kentucky	1-1-02 / 6-30-02
32	Pilot Study- Evaluation of Occupational Particle Exposure and IPF	Edward B. Balsink, Jr., MD – MS Student, Occupational Medicine (James Lockey, MD)	U. of Cincinnati	1-1-02 / 6-30-02
33	Pilot Study on Fungal Fragments as Indoor Biocontaminants	Seung-Hyun Cho, PhD Student, Industrial Hygiene (Tiina Reponen, PhD)	U. of Cincinnati	1-1-02 / 6-30-02
34	Impact of Arsenic on Benzo[a]pyrene DNA Adduct Levels	Craig D. Evans – MS Student, Industrial Hygiene (Glenn Talaska, PhD, CIH)	U. of Cincinnati	1-1-02 / 6-30-02
35	Assessing Personal Factors Contributing to Safe Performance in Paid and Volunteer Fire Departments	David L. Fender, EdD – Faculty	Murray State U	1-1-02 / 6-30-02

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**Attachment E Pilot Project Awards, Investigators and Institutions**

Project #	Project Title	Principal Investigator (Mentor)	Institution	Project Period
36	Enumeration Study of Migrant & Seasonal Farm Workers in Central Kentucky	Susan G. Fister, PhD – Faculty	Eastern Ky U	1-1-02 / 6-30-02
37	EMS Turnover: Determinants & Predictors	Marilyn M. Gardner, PhD – Faculty	Western Ky U	1-1-02 / 6-30-02
38	Musculoskeletal Injuries Associated with Selected University Staff & Faculty in an Office environment	R. Steven Konkkel, PhD – Faculty	Eastern Ky U	1-1-02 / 6-30-02
39	A Hypermedia Web-based Simulation that Teaches Defensive Driving Skills to Prevent Motor Vehicle and Farm Equipment Collisions	Bor Chyi Lin, PhD Student, Preventive Medicine & Environmental Health (Henry P. Cole, EdD)	U. of Kentucky	1-1-02 / 6-30-02
40	Pilot Study of On-farm Manure Storage-Related Entrapments and Fatalities	Jiqin Ni, PhD – Faculty Randy L. Beaver – MS Student, Agri. (Wm. E. Field, EdD)	Purdue U.	8-1-02 / 6-30-03
41	Ablation of Blood Lipid's Effect on Solvent Absorption	MaryBeth Genter, PhD – Faculty Brent Edwards – MS Student, Industrial Hygiene (Glenn Talaska, PhD)	U. of Cincinnati	8-1-02 / 6-30-03
42	A Supportive Nursing Care Unit for Registered Nurses	Debra S. Hall – PhD Student, Nursing (Juliann Sebastian, PhD)	U. of Kentucky	8-1-02 / 6-30-03
43	How is Postural Stability Affected by Age and Manual Materials Handling in the Occupational Environment	Shirley Rietdyk, PhD – Faculty	Purdue U.	8-1-02 / 6-30-03
44	Determination of the Attenuation Properties of Laboratory Gloves Exposed to Ultraviolet Transilluminators	Wei-Hsung Wang, PhD – Faculty Edward Gazdik – MS Student, Industrial Hygiene (Frank Rosenthal, PhD)	Purdue U.	8-1-02 / 6-30-03

**Attachment E Pilot Project Awards, Investigators and Institutions**

<b>Project #</b>	<b>Project Title</b>	<b>Principal Investigator (Mentor)</b>	<b>Institution</b>	<b>Project Period</b>
45	Postural Sway Measurements Among Firefighters	Tarek Sobeih, MD – PhD Student, Industrial Hygiene (OSE) (Kermit Davis, PhD)	U. of Cincinnati	8-1-02 / 6-30-03
46	Validation of a Method to Qualify Fungi on Heating Ventilation and Air Conditioning System Filters	Hernando R. Perez – PhD Student, Industrial Hygiene (Neil Zimmerman, PhD)	Purdue U.	8-1-02 / 6-30-03
47	Screening for Early Asthma Symptoms in Healthy Workers	Nancy E. Johnson – PhD Student, Environmental Health (T. Scott Prince, M.D.)	U. of Kentucky	8-1-02 / 6-30-03
48	Perceived Risk as a Predictor of WMSDs	Christian Shoaf, PhD – Faculty	U. of Cincinnati	8-1-02 / 6-30-03

**University of Cincinnati**  
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**Symposium**

**Kehoe Auditorium – Kettering Laboratory Building**

**University of Cincinnati**

<b>10/12/00 Presentations 2:00 PM – 5:00 PM</b>					
	Time	Name	Title	Univ	
	2:00	2:15	Opening Remarks		
	2:15	2:34	Hepler, Ginger (1)	Genetic Counseling For Occupational Exposures	UC
	2:34	2:53	Reed, Deborah (1)	Occupational Health Issues of Female Long Haul Truck Drivers	UK
	2:53	3:12	Kelly, Cynthia (1)	Psychometric Instrument Development: Using Rasch Rating Scale Method to Develop a Cognitive Measure for Cardiovascular Health	UC
	3:12	3:19	Gazo, Rado (2)	Ergonomic Solutions for the Wood Industry	PU
	3:19	3:26	Reed, Leslie (2)	Ultrafine Particulate Monitoring in Rubber Processing	PU
	3:26	3:46	Break = lobby		
	3:46	3:53	Daraiseh & Burton (2)	Work-Related Musculoskeletal Disorders in Nursing Personnel: An Instrument Validation	UC
	3:53	4:12	Vosicky, John (1)	The Development, Assembly, and Pilot Testing of a Video Exposure Assessment System	PU
	4:12	4:31	Kincl, Laurel (1)	Injury Trends for Adolescents with Childhood Lead Exposure	UC
	4:31	4:50	Hunt, Michael (1)	Assessment of Endotoxin, Dust and Fungal Exposures in a Horse Containment Room	PU
<b>10/13/00 Presentations 8:30 AM – 11:30 AM</b>					
	8:30	8:35	Opening Remarks		
	8:35	8:42	Mainelis, Gediminas (2)	Development of a New Method for Enumerating Airborne Microorganisms Sampled in Occupational Environments	UC
	8:42	9:01	Lodwick, Jeff (1)	Evaluation of the Positional Effects of the Leg on In Vivo X-ray Fluorescence Measurements of Stable Lead in the Tibia	UC
	9:01	9:08	Inumaru, Chie (2)	The Efficacy of Natural Products as Antifungal Agents in Building Materials	PU
	9:08	9:27	Lu, Ming-Lun (1)	Assessment of Risk Factors Associated with Work on Slippery Surfaces at an Automobile Parts Manufacturing Facility	UC
	9:27	9:34	Rhodes, Audry (2)	The Effects of JP-8 Jet Fuel on the Immune System of Tank Entry Workers	UC
	9:34	9:53	Rao, Preethi (1)	Residual Pesticides in Soil/Dust Samples from the Homes of Farm Workers in Gujarat, India: Observation of Worker Practices, Preliminary Assessment of Pesticide Levels in Home Soil/Dust and Methods of Analysis for Future Monitoring.	UC
	9:53	10:00	Rush, Michael (2)	A Study of Occupational Injuries of EMS Workers in Kentucky	WKU
	10:00	10:07	Rao, Preethi (2)	Evaluation of Feasibility of the Use of a Uniform Pesticide Poisoning Reporting Form for an Agricultural Area in Gujarat, India and Determination of the Changes in Pesticide Levels in Soil/Dust Samples, Before, During and After Use of Pesticides, in the Homes of Farm-workers in the Agricultural Area	UC
	10:07	10:30	Break = lobby		
	10:30	10:49	Yadav, Jagjit (1)	Development of Quantitative PCR to Measure Microorganisms in Metal Working Fluid Aerosols Implicated in Occupational Respiratory Illness	UC
	10:49	11:08	Jones, Susan (1)	Assessing Factors Contributing to the Use of Respiratory Protection of Workers in Swine Confinement Buildings	UC
	11:08	11:15	Gibbs, Shawn (2)	Investigations of Bioaerosols in and Around Swine Containment Operations	UC
	11:15	11:22	Trunov, Mikhaylo (2)	Assessment of Workers' Exposure to Lead During Lead Abatement in Indoor Environments	UC
	11:22	11:29	Yadav, Jagjit (2)	DNA Fingerprinting for Strain-specific Identification of Mycobacteria in Metalworking Fluids Implicated in Occupational Hypersensitivity Pneumonitis	UC
PU = Purdue University, UC = University of Cincinnati, UK = University of Kentucky, WKU = Western Kentucky University (1) = Round 1- 1999, (2) = Round 2- 2000					

**NIOSH-supported Education and Research Center Pilot Research Project  
 Symposium**

**Kehoe Auditorium – Kettering Laboratory Building**

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**10/11/01 Presentations 2:00 PM – 4:30**

Time	Name	Title	Univ
2:00 – 2:15	<b>Opening Remarks by John T. Taity, NIOSH Representative</b>		
2:15 - 2:35	Preethi Rao (2)	Evaluation of Feasibility of the Use of a Uniform Pesticide Poisoning Reporting Form for an Agricultural Area in Gujarat, India and Determination of the Changes in Pesticide Levels in Soil/Dust Samples, Before, During and After Use of Pesticides, in the Homes of Farm-workers in the Agricultural Area	UC
2:35 - 2:45	Robert Eninger (3)	Occupational Exposure to Particulate Matter and Heart Rate Variability	PU
2:45 - 3:05	Leslie Recd (2)	Ultrafine Particulate Monitoring in Rubber Processing	PU
3:05 - 3:15	Darryl Ragland, DVM, Ph.D.(3)	Antibiotic Feeding of Animals (Pigs) and Antibiotic Resistance of Farm Personnel	PU
3:15 - 3:35	<b>BREAK = Lobby</b>		
3:35 - 3:55	Audry Rhodes, M.D. (2)	The effects of JP-8 Jet Fuel on the Immune System of Tank Entry Workers	UC
3:55 - 4:15	Chic Inumaru (2)	The Efficacy of Natural Products as Antifungal Agents in Building Materials	PU
4:15 - 4:25	Chic Inumaru (3)	Investigation of Cellulose Polymer as an Extender of Natural Antifungal Agents in Building Materials	PU

**10/12/01 Presentations 8:30 AM – 12:00 Noon**

8:30 - 8:35	<b>Opening Remarks</b>		
8:35 - 8:55	Shawn Gibbs (2)	Investigations of Bioaerosols in and Around Swine Containment Operations	UC
8:55 - 9:05	Douglas Nelson, Ph.D. (3)	Impact of Organization of Work Factors on Work-related Injuries at Eating and Drinking Places	PU
9:05 - 9:25	Rado Gazo, Ph.D. (2)	Ergonomic Solutions for the Wood Industry	PU
9:25 - 9:35	Kermit Davis, Ph.D.(3)	Impact of Non-low Back Injuries on Low Back Biomechanics	UC
9:35 - 9:55	Nancy Daraiseh & Mattie Burton (2)	Work-related Musculoskeletal Disorders in Nursing Personnel: An Instrument Validation	UC
9:55 - 10:05	Nancy Daraiseh & Mattie Burton (3)	Work-related Musculoskeletal Disorders in Nursing Personnel: An Instrument Validation	UC
10:05 - 10:25	<b>BREAK – Lobby</b>		
10:25 - 10:45	Mikhailo Trunov (2)	Assessment of Workers' Exposure to Lead During Lead Abatement in Indoor Environments	UC
10:45 - 11:05	Gediminas Mainelis, Ph.D. (2)	Development of a New Method for Enumerating Airborne Microorganisms Sampled in Occupational Environments	UC
11:05 - 11:25	Jagjit Yadav, Ph.D. (2)	DNA Fingerprinting for Strain-specific Identification of Mycobacteria in Metalworking Fluids Implicated in Occupational Hypersensitivity Pneumonitis	UC
11:25 - 11:35	Wei-Hsung Wang, Ph.D. (3)	Development and Use of a Real-time Video Exposure Monitoring System to Train Workers How to Prevent Excessive Occupational Radiation Exposure	PU
11:35 - 11:55	Michael Rush (2)	A Study of Occupational Injuries of EMS Workers in Kentucky	WKU

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**Kehoe Auditorium – Kettering Laboratory Building**

THE EXACT TIMES ARE SUBJECT TO CHANGE

<b>Thursday – 10/10/02 Presentations 1:00 PM – 5:00 PM</b>			
Time	Name	Title	Univ
1:00 – 1:15	Opening Remarks by Leslie J. Ungers, MS, CIH, President, Academy of Kettering Fellows and Bernadine Kuchinski, PhD, NIOSH Representative		
1:15 – 1:35	Seung-Hyun Cho (2) Tiina Reponen, Ph.D.	Pilot Study on Fungal Fragments as Indoor Biocontaminants	UC
1:35 – 1:55	Douglas Nelson, Ph.D. (1)	Impact of Organization of Work Factors on Work-related Injuries at Eating and Drinking Places	PU
1:55 – 2:15	Debra G. Anderson, PhD (2)	Violence and Stress Experienced by Female Long-Haul Truckers	UK
2:15 – 2:35	Darryl Ragland, DVM, Ph.D.(1)	Antibiotic Feeding of Animals (Pigs) and Antibiotic Resistance of Farm Personnel	PU
2:40 – 3:32	Poster Sessions and Refreshments		
3:40 – 4:00	Edward B. Balsink, Jr., MD (2)	Pilot Study - Evaluation of Occupational Particle Exposure and IPF	UC
4:00 – 4:20	R. Steven Konkel, PhD (2)	Musculoskeletal Injuries Associated with Selected University Staff & Faculty in an Office Environment	EKU
4:20 – 4:40	Craig D. Evans (2) Glenn Talaska, PhD	Impact of Arsenic on Benzo[a]pyrene DNA Adduct Levels	UC
4:40 – 5:00	Chic Inumaru (1) Neil Zimmerman, PhD	Investigation of Cellulose Polymer as an Extender of Natural Antifungal Agents in Building Materials	PU
<b>Friday – 10/11/02 Presentations 8:30 AM – 12:30 PM</b>			
8:30 – 8:35	Opening Remarks		
8:35 – 8:55	David L. Fendcr, EdD (2)	Assessing Personal Factors Contributing to Safe Performance in Paid & Volunteer Fire Departments	MSU
8:55 – 9:15	Kermit Davis, Ph.D.(1)	Impact of Non-low Back Injuries on Low Back Biomechanics	UC
9:15 – 9:35	Susan G. Fister, PhD, RN (2)	Enumeration Study of Migrant & Seasonal Farm Workers in Central Kentucky	EKU
9:35 – 9:55	Marilyn M. Gardner, PhD (2)	EMS Turnover: Determinants and Predictors	WKU
10:00 – 11:00	<b>Poster Sessions and Refreshments</b>		
11:05 – 11:25	Bor Chyi Lin (2) Henry P. Cole, Ed.D	A Hypermedia Web-based Simulation that Teaches Defensive Driving Skills to Prevent Motor Vehicle and Farm Equipment Collisions	UK
11:25 – 11:45	Robert Eninger (1) Frank Rosenthal, PhD	Occupational Exposure to Particulate Matter and Heart Rate Variability	PU
11:45 – 12:05	Wei-Hsung Wang, Ph.D. (1) James D. McGlothlin, Ph.D.	Development and Use of a Real-time Video Exposure Monitoring System to Train Workers How to Prevent Excessive Occupational Radiation Exposure	PU
12:05 – 12:25	Nancy Daraiseh & Mattie Burton (1)	Work-related Musculoskeletal Disorders in Nursing Personnel: An Instrument Validation	UC

EKU = Eastern Kentucky University  
 MSU = Murray State University  
 PU = Purdue University

UC = University of Cincinnati  
 UK = University of Kentucky  
 WKU = Western Kentucky University

(1) = Funding Period 9/1/01 – 6/30/02  
 (2) = Funding Period 1/1/02 – 6/30/02  
 (3) = Funding Period 8/15/02 – 6/30/03

## Poster Presentations

### The Atrium – Kettering Laboratory Building

THE EXACT TIMES ARE SUBJECT TO CHANGE

<b>Thursday – 10/10/02 Poster Presentations 2:40 PM – 3:30 PM</b>			
Time	Name	Title	Univ
2:40 – 2:49	Jiqin Ni, PhD Randy L. Beaver Wm. E. Field, EdD	Pilot Study of On-Farm Manure Storage-Related Entrapments and Fatalities	PU
2:49 – 2:58	Tarek Sobeih, MD Kermit Davis, PhD	Postural Sway Measurements Among Firefighters	UC
2:58 – 3:07	Debra S. Hall Juliann Sebastian, PhD	A Supportive Nursing Care Unit for Registered Nurses	UK
3:07 – 3:16	Hernando R. Perez Neil Zimmerman, PhD	Validation of a Method to Qualify Fungi on Heating Ventilation and Air Conditioning System Filters	PU
3:16 – 3:25	Christian Shoaf, PhD	Perceived Risk as a Predictor of WMSDs	UC
<b>Friday – 10/11/02 Poster Presentations 10:00 AM – 11:00 PM</b>			
10:00 – 10:09	Wei-Hsung Wang, PhD Edward Gazdik Frank Rosenthal, PhD	Determination of the Attenuation Properties of Laboratory Gloves Exposed to Ultraviolet Transilluminators	PU
10:09 – 10:18	MaryBeth Genter, PhD Brent Edwards Glenn Talaska, PhD	Ablation of Blood Lipid's Effect on Solvent Absorption	UC
10:18 – 10:27	Shirley Rietdyk, PhD James McGlothlin, PhD	How is Postural Stability Affected by Age and Manual Materials Handling in the Occupational Environment?	PU
10:27 – 10:36	Nancy E. Johnson T. Scott Prince, M.D.	Screening for Early Asthma Symptoms in Healthy Workers	UK

Authors will make 5 minute oral presentations at their posters at the indicated time followed by questions. Posters remain on display throughout the symposium.

EKU = Eastern Kentucky University  
 MSU = Murray State University  
 PU = Purdue University

UC = University of Cincinnati  
 UK = University of Kentucky  
 WKU = Western Kentucky University

(1) = Funding Period 9/1/01 — 6/30/02  
 (2) = Funding Period 1/1/02 — 6/30/02  
 (3) = Funding Period 8/15/02 — 6/30/03

**Appendix A**

<b>Graduates</b> <b>September 1, 1997 – August 31, 2002</b> <b>Industrial Hygiene</b>				
<b>Year</b>	<b>Name</b>	<b>Degree / Program</b>	<b>Thesis/Dissertation Title</b>	<b>Placement</b>
12/02	Jessica A. Gordon	MS / IH HSAT 98/00	Ergonomic Risk Factors of Residential Lead Abatement Workers and Risk Assessors	Doctoral Student - IH University of Cincinnati Cincinnati, OH
6/02	Andrea M. Armstrong	MS / IH HSAT 00/02	Determination of the Feasibility of Using the Portable X-Ray Fluorescence (XRF) Analyzer in the Field for Measuring the Lead Content of Sieved Soil	NIOSH Cincinnati, OH
6/02	Edward L. Bock III	MS / IH	Practicality of Using Air Lead Measurements by Portable X-Ray Fluorescence to Manage Worker Protection Programs	United States Coast Guard Miami Beach, FL
6/02	Craig D. Evans	MS / IH HSAT 00/02	Impact of Arsenic on Benzo[a]pyrene DNA Adduct Levels in Skin and Lung in the Mouse	Schering-Plough Research Institute Westfield, NJ
6/02	Laurel Kincl	Ph.D. / OS- Ergo	The Effect of Challenging Somatosensory Inputs on the Relationship of Eye Movement and Postural Sway Patterns of Experienced and Inexperienced Workers	University of Oregon Eugene, OR
3/02	Teo Keong Kok	MS/ IH	Comparison of Two Aerial Dispersion Models for the Prediction of Chemical Release Associated with Maritime Accidents Near Coastal Areas	Singapore Polytechnic Singapore
12/01	Mei Juan Chen	Ph.D. / IH	Development of Beryllium Exposure Matrices for Workers in a Former Beryllium Manufacturing Plant	University of Cincinnati Cincinnati, OH
12/01	Kyoo-Tae Choe	Ph.D. / IH	Aerosolization During Indoor Lead Abatement Characterization of Released Particles and Evaluation of Lead Hazard Control Procedures	NIOSH Morgantown, WV
12/01	Ming-Lun Lu	Ph.D. / OS- Ergo	The Effect of Fatigue on Electromyography Activity Patterns while Performing Tasks on Inclined Surfaces	NIOSH Cincinnati, OH
6/01	Linda Faye Grimsley	Ph.D. / IH	Evaluation of Silicosis in Response To the Estimated Silica Exposure From the Highest Task	Faculty-Tulane University New Orleans, LA
6/01	Scott Henn	MS / IH HSAT 99/01	The Relationship Of Urinary 1-Hydroxypyrene and DNA Adduct Levels from Environmental Tobacco Smoke Exposure	EPI Assistant-Contractor NIOSH Cincinnati, OH
6/01	Erin Snyder	MS / IH HSAT 99/01	Determination of Known Exhalation Valve Leakage Using the RespiFit™ Irritant Smoke Test Kit	Industrial Hygienist NIOSH Cincinnati, OH
12/00	Chwan-Fu Lai	Ph.D. / OS- Ergo	The Effects of Environmental Lighting, Shoe Wear/Tear and Load Carriage During Dynamic Task Performance on Slippery Surfaces	FedEx Pittsburgh, PA
12/00	Timothy Rittgers	MS / IH	The Correlation Between Quartz Measurements Based on Location and Type of Samples For Several Dusty Trades Industries In North Carolina	The Industrial Commission of Ohio Columbus, OH
8/00	Vitaly Aizenburg	Ph.D. / IH	Evaluation of Personal Aerosol Samplers	Exxon Mobil Biomedical Sciences

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**Appendix A**

<b>Graduates</b>				
<b>September 1, 1997 – August 31, 2002</b>				
<b>Industrial Hygiene</b>				
<b>Year</b>	<b>Name</b>	<b>Degree / Program</b>	<b>Thesis/Dissertation Title</b>	<b>Placement</b>
				Annandale, NJ
8/00	Terry Bliss	MS / IH	Evaluation of House Dust From Bedding and Floors To Determine Potential Pesticide Exposures at a Migrant Labor Camp In North Western Ohio	Exxon Houston, TX
8/00	Gediminas Mainelis	Ph.D. / IH	Electrostatic Collection of Airborne Microorganisms	University of Cincinnati Cincinnati, OH
6/00	Edward D. Auyang	MS / OS-Ergo HSAT 97/99	Functional Locomotion and Gross and Fine Neuromotor Performance in Children with Chronic Lead Exposure	Ohio State University – student Columbus, OH
6/00	John Cardarelli	Ph.D. / IH	A Potential Consequence of Excluding Work-Related X-Ray Exposures When Computing Cumulative Occupational Radiation Dose at a Uranium Enrichment Plant	NIOSH Cincinnati, OH
3/00	Ruohong Liang	MS / IH	Evaluating the Risk Factors Leading to Loss of Balance during Task Performance on Elevated/Inclined Surfaces	Insurance Company Dayton, OH
12/99	Lisa DeLaney	MS / IH	Determination of Known Exhalation Value Damage Using Negative Pressure User Seal Check Methods on Full Face Respirator	NIOSH Atlanta, GA
12/99	Zheng Wang	MS / IH	Effect of Sampling Time and Relative Humidity on Bioefficiency of Filter Samplers Collecting Bioaerosols	Doctoral Program (Engineering) – UC Cincinnati, OH
12/99	Steven Wurzelbacher	MS / OS-Ergo	The Effect of Weld Process and Ventilation Method on Physical Workload, Weld Fume Exposure, and Weld Performances in a Confined-Space Welding Task	NIOSH Cincinnati, OH
6/99	Tonya Solomon	MS / IH	Residual Pesticides In Housing and Bedding At Migrant Labor Camps In Northwestern Ohio: A Follow-up Investigation	Ford Motor Company Romulus, MI
3/99	Daniel Woody	MS / IH	Evaluation of a Portable Prototype X-Ray Fluorescence Instrument for the Measurement of Lead in Dust Wipe Samples	Payne Consulting Blue Ash, OH
12/98	Krystyn R. Clark (Nee: Bussa)	MS / IH HSAT 96/98	Ntrol of Waste Nitrous Oxide from Anesthesia Delivery Units in Dental Operatories	Industrial Hygienist Bioenvironmental Engineering Flight Wright Patterson AFB, OH
12/98	Xuejun Lin	Ph.D. / IH	Sampling of Airborne Dust and Microorganisms by Aerosol Injection into a Swirling Air Flow	Cincinnati Milacron Cincinnati, OH
9/98	Ming Lun Lu	MS / IH	Measurement of Body Center of Gravity and Center of Pressure when Walking Under Two Different Environmental Conditions	Doctoral Program – UC Cincinnati, OH
9/98	Kincl, Laurel	MS / IH HSAT 95/97	The Use of Postural Sway Measurements as a Safety Monitoring Technique for Workers Wearing Personal Protective Equipment	Doctoral Program – UC Cincinnati, OH
9/98	Javier Ortega-Cesena	MS / IH	Biotic Stability of Metal-Complex Dyes	Environmental Sampling Cincinnati, OH
9/98	Edward Burroughs	Ph.D. / IH	Bioavailability of Arsenic in Environmental and Occupational Bulk Matrices	NIOSH Cincinnati, OH

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**Appendix A**

<b>Graduates</b>				
<b>September 1, 1997 – August 31, 2002</b>				
<b>Industrial Hygiene</b>				
<b>Year</b>	<b>Name</b>	<b>Degree / Program</b>	<b>Thesis/Dissertation Title</b>	<b>Placement</b>
9/98	Harney, Joshua	MS / IH HSAT 95/97	Release of Lead Containing Particles From A Wall Enclosure Model	Industrial Hygienist NIOSH Cincinnati, OH
6/98	Lynn Borland	MS / IH	Evaluation of Job Changes Within the Refractory Ceramic Fiber Industry and How They Affect an Employee's Occupational Exposures	United States Air Force - Tyndall Florida
6/98	Jean Mangharam	MS / OS	The Effect of Muscular Fatigue on Dynamic Motion of Whole Body Center of Gravity	Private Consultant United Kingdom
6/98	Laura Stambaugh	MS / IH	Investigation of Environmental Contamination in Watershed as Basis for Human Exposure Assessment	Good Samaritan Hospital Cincinnati, OH
6/98	Xiaojie Xu Zavon	MS / IH	The Abiotic Degradation of Representative Azo Dyes Under Reducing Conditions	NIOSH Cincinnati, OH
6/98	Yingie Qian	Ph.D. / IH	Behavior of Inert and Biological Particles in a Respirator Filter Medium: Filtration and Reentrainment	Pak/Team Inc. Cincinnati, OH
12/97	Darren Burks	MS / IH HSAT 94/96	An evaluation of the effects of abrasive hand cleaners on the epidermal layer with respect to dermal carcinogen absorption from used gasoline engine oils	Health & Safety Manager IT Corporation Anchorage, Alaska
12/97	Guo-Hua Liu	MS / IH	Assessment of the Association Between Development of Silicosis and the Highest Silica Exposure Tasks	Schlumberger Ltd Houston, TX
9/97	Clinton Morley	MS / IH	Evaluation of A Portable X-Ray Fluorescence Instrument For The Determination of Lead In Workplace Air Samples	General Electric Cincinnati, OH
9/97	Christine Newman	MS / IH HSAT 94/96	Development of a Highly-Sensitive Transportable Method for On-Site Analysis of Benzene in Exhaled Air	Risk Manager Procter & Gamble Mason, OH
6/97	Mei-Juan Chen	MS / IH	The evaluation of the Relationship between children's blood lead and environmental lead in the HUD Lead-Based Paint Hazard Control Grant Program	Doctoral Program – IH UC Cincinnati, OH
6/97	Emily Gorsuch	MS / IH	Method for Evaluation of Inactivation of Biocontaminated Surfaces	Masco Corp. Youngstown, OH
6/97	Thomas Lentz	Ph.D. / IH	The Potential Significance of Airborne Fiber Size Parameters to The Development of Pleural Plaques in Workers Who Manufacture Refractory Ceramic Fibers	NIOSH Cincinnati, OH
6/97	Mark Jenkins	Ph.D. / IH	Production of Anthropometric Bone and Tissue Lead X-Ray Fluorescence Phantoms Using A Polyurethane and Calcium Carbonate Matrix	Feed Materials Facility Cincinnati, OH

**APPENDIX B**  
**ABSTRACTS OF DOCTORAL DISSERTATIONS**  
**INDUSTRIAL HYGIENE**

**BAHVIOR OF INERT AND BIOLOGICAL PARTICLES IN A RESPIRATOR FILTER MEDIUM:  
FILTRATION AND REENTRAINMENT**

By: Yinge Qian  
1997 Ph.D.

Airborne particles, including airborne microorganisms, are a concern in many industries, such as health care, food and agriculture industries. This concern has recently gained special attention because of the increase in TB cases among health care employees. In order to protect workers from airborne particles exposure, respirators are recommended as protective means. In 1995, the National Institute for Occupational Safety and Health issued new regulations for non-powered particulate respirators (42 CFR Part 84). These regulations require a minimum efficiency of 95% against NaCl particles with the mean size of about 0.2 $\mu$ m. The N95 respirators are the most common in use. With highly efficient particulate respirators, another concern is the reentrainment of collected airborne microorganisms from the respirators filter media during exhalation, i.e., the potential for respirators becoming secondary exposure sources for unprotected persons. To investigate airborne particle and microorganism penetration through and reentrainment from the fibrous filter media of respirators, five types of respirators with different efficiencies were tested with polydisperse spherical corn oil particles, polydisperse NaCl particles, and standard monodisperse polydisperse latex particles and bacteria with different aspect ratios. The concentrations of corn oil particles, PSL particles and bacteria upstream and downstream of the test respirator filters were measured with an aerodynamic size spectrometer.

The penetration test results indicate that the spherical corn oil particles and the spherical *Streptococcus salivarius* bacteria have the same penetration in the size range from 0.9 to 1.7 $\mu$ m. It has been found that rod-shaped bacteria penetrate less than the spherical particles/bacteria. The penetration differences between the spherical and rod-shaped bacteria depend on the aspect ratio of the bacteria. For an aspect ratio of 4, the penetration of rod-shaped bacteria is about half that of spherical ones. Thus, it is projected that a respirator with 90% efficiency against spherical microorganisms or test particles (10% penetration) will be 95% efficient against rod-shaped microorganisms of the same aerodynamic equivalent diameter with an aspect ratio of 3 to 4, such as *Mycobacterium tuberculosis* (5% penetration).

The new N95 respirators were found to have higher filtration efficiencies than the previously certified dust/mist (DM) and dust/fume/mist (DFM) respirators and the non-certified surgical masks. N95 respirators made by different companies were found to have different filtration efficiencies for the most penetrating particles of about 0.1 to 0.3 $\mu$ m, but all were at least 95% efficient at the size for NaCl particles. Above the most penetrating particle size, the filtration efficiency increases with size and shape similar to *Mycobacterium tuberculosis* also shown filtration efficiencies of 99.5% or higher. The experimental data have been used to calculate the aerosol mass concentration inside the respirator when worn in representative work environments. The penetrated mass fractions, in the absence of face leakage, range from 0.02% for large particles distributions to 1.8% for submicrometer-size welding fumes. Thus, N95 respirators provide excellent protection against airborne particles when there is a good face seal.

During particle reentrainment tests, the maximum air velocity reached 500 cm/s, almost one hundred times the 6.6cm/s filtration velocity during particle loading, which is typical for inhalation through a half-mask respirator at medium work load. For the test conditions, the reentrainment of 0.6 to 5.1 $\mu$ m particles increase approximately with the square of particle size and reentrainment velocity, and decrease with increasing relative humidity. The minimum reentrainment velocity decreases with increasing parti-

cle size. Experiments at low relative humidity have shown that the reentrainment of particle size. Experiments at low relative humidity have shown that the reentrainment of particles below 1 $\mu$ m, including bacteria of size and shape similar to *Mycobacterium tuberculosis*, does not exceed 0.025% at 300 cm/s in air velocity that simulates violent sneezing or coughing. The reentrainment of larger particles into dry air was significant at this air velocity of 300 cm/s: 1% for 3 $\mu$ m and ca. 6% for 5 $\mu$ m test particles. No reentrainment was detected at relative humidity level exceeding 35% at these conditions. The rise time in reaching the reentrainment air velocity has negligible influence on the degree of reentrainment. Particle and filter type were found to significantly affect particle reentrainment. Electrical charges on the filter fibers significantly increase the collection of submicrometer particles, but their reentrainment is only slightly impeded by the embedded charges.

#### SAMPLING OF AIRBORNE DUST AND MICROORGANISMS BY AEROSOL INJECTION INTO A SWIRLING AIR FLOW

By: Xuejan Lin  
1998 Ph.D

Exposure to airborne particles, especially pathogenic microorganisms, may cause a wide variety of respiratory and other health disorders in general and occupational populations. In order to provide health protection, advanced methods for stationary and personal sampling need to be developed for occupational and environmental exposure assessment.

A prominent method of collection is to draw the airborne particles through a nozzle and impinge the aerosol into a liquid. The changes in the physical collection efficiencies of widely used impinger, such as the all-glass impingers AGI-30 and AGI-4, were studied experimentally with an aerodynamic particle sizer by dynamically measuring the particle concentrations upstream and downstream of the impingers. Monodisperse PSL particles of aerodynamic sizes ranging from 0.3  $\mu$ m to 2.0  $\mu$ m were used in the tests. The inner diameter of the important nozzle was found to be the most critical dimension affecting the collection efficiency. Significant variations were found in the performance of individual impingers due to the variations in the critical dimensions of the impingers tested. About 1% of the initial amount of impingers liquid is evaporated per minute of normal operation. Upon depletion to a critical minimum volume, the collection efficiency decreases drastically due to insufficient impingement into the liquid and particle bounce from the bottom surface. Already collected particles may be entrained by the air bubbles passing through the liquid and be re-aerosolized particles increases with sampling time, but is less than 10% within the first hour of sampling with either the AGI-4 or the AGI-30. A graph has been for selecting the maximum sampling time for a given initial liquid volume so that the collection efficiency is approximately constant throughout the entire sampling period. The graph also indicates the limits where significant particle-bounce, re-aerosolization or liquid splashing occurs. The AGI-4 was found to be more efficient in collecting sub-micrometer particles and to be less particle-size dependent than the AGI-30.

A new principle for collecting airborne particles, including microorganisms, has been introduced by injecting the particles into a swirling airflow from where they are removed onto a collection surface. A dry surface, a surface coated with an adhesive substance or a surface wetted by a liquid swirled onto the collection surface from a reservoir below can be used in the new collection method. The swirling air motion and aerosol injection into it are achieved by drawing the airborne particles through nozzles that are directed at an angle toward the collection surface. This principle has been evaluated against the AGI-30 impinger. Tests with monodisperse PSL particles in the bacterial size ranges have shown that the SAC has better collection efficiency than the AGI-30 for submicrometer particles when the same collection liquid is used. A conventional impinger maintains constant collection efficiency for a relatively short

sampling period, as the liquid evaporates quickly due to the violent bubbling of the liquid. In contrast to conventional impingers, the SAC can be used with non-evaporating liquids that are considerably more viscous than the liquids used in the impingers. Thus, the SAC can sample over a long period of time. The new aerosol sampler produces minimal or no reaerosolization of particles collected in the liquid in contrast to significant reaerosolization in the AGI-30. Since the SAC projects the aerosol particles towards the collection surface where they are removed from the swirling flow, it avoids or significantly reduces particles bounce from the collection surface even when the surface is dry.

In side-by-side comparisons with the AGI-30 impinger in the laboratory setting or in indoor air environment over short time periods, the BioSampler yielded equivalent or higher culturable counts for bacteria and/or fungi than the AGI-30 when the conventional fluid, phosphate buffer, was used as the collection medium. The bio-efficiency of the AGI-30 decreased rapidly with sampling time until the liquid had evaporated after about 1½hrs.

The study has shown that heavy white mineral oil provides a relatively constant culturability for both stress-sensitive and stress-resistant cells. Thus, it is a suitable non-evaporating liquid for sampling viable microorganisms.

When the BioSampler was operated for 4 hrs with non-evaporating heavy white mineral oil, the collection efficiency decreased only moderately due to mineral reaerosolization of collected particles and gentle collection of the variable microorganisms. Samples obtained through long-term sampling with the BioSampler may detect culturable bacteria and fungi at lower ambient concentration levels than is possible through traditional liquid impingement sampling over short time periods.

#### THE EFFECTS OF ENVIRONMENTAL LIGHTING, SHOE WEAR/TEAR AND LOAD CARRIAGE DURING DYNAMIC TASK PERFORMANCE ON SLIPPERY SURFACES

By: Chwan-Fu Lai  
2000 Ph.D

Accidents associated with slips and falls have been recognized as one of the major causes of injuries in the workplace. The purpose of this study was to investigate the kinetic and kinematics aspects of slips associated with tasks performed while walking on a slippery surface under different environmental lighting and shoe wear/tear conditions, and the effect of job-task, shoe wear/tear and environmental lighting on the required coefficient of friction (RCOF) to perform a job safely without slipping was researched. The sliding distance, slipping velocity, the heel contact angle, which are important characteristics of a slipping event, were investigated.

Forty healthy industrial workers were recruited for this study. There were five experimental conditions - surface slipperiness, lighting, shoe type, weight carriage, and walking path. Kinetic measurement that included the Maximum Required Coefficient of Friction ( $RCOF_{max}$ ), and Coefficient of Friction provided by the shoe ( $COF_{shoe}$ ), x-excursion, y-excursion, and cycle time were collected using a strain-gauge type force platform. Using a video-based motion analysis system, the kinematics measurements of incoming velocity, sliding distance, sliding velocity, and heel contact angle were calculated by placing three reflective markers on the heel, ankle joint, and 5<sup>th</sup> metatarsal point. In addition, a subjective rating scale, Perceived Sense of Slip (PSOS), was administered immediately after each gait test to determine the subjective perception of slip during task performance.

Test results indicated that the % of slip occurrence for walking on a turning path (63.7%) was greater than that of a straight path (56.3%). Slip occurrence also increased with the PSOS score. Results from the kinematics analysis indicated that there were behavioral changes associated with the slipperiness of the walking surfaces. The mean incoming velocity at heel strike was smaller (0.98 m/sec) in poor lighting conditions than that in good lighting condition (1.06 m/sec). The mean sliding distance for a very oily surface was 3.4cm, which was significantly longer than that for slightly oily (0.9 cm) or medium oily surface (1.9 cm). The sliding velocity was highest for very oily surfaces (0.15 m/sec) compared to medium (0.09 m/sec) or slightly oily (0.04 m/sec) surfaces. Results from this study indicate that slippery surfaces affect the kinematics of gait, while the effects of surface and path had detrimental impact on the kinetics of gait. Subjects modified their gait patterns while walking on the slippery surfaces and turning paths. However, recognizing an impending danger of slipping and engaging appropriate strategies is not always possible. However, reducing the sliding distance and velocity, once a slip is initiated, by better footwear and floor design may reduce the likelihood of a slip or fall incident.

#### ELECTROSTATIC COLLECTION OF AIRBORNE MICROORGANISMS

By: Gediminas Mainelis  
2000 Ph.D.

Exposure to bioaerosols, especially to pathogenic or allergenic microorganisms, may cause a wide range of respiratory and other health disorders in occupational and general populations. Methods commonly used to monitor exposure to airborne microorganisms, such as impaction and impingement, are known to affect the viability of sensitive microorganisms, which, in turn, leads to underestimations of bioaerosol exposure levels. This research was undertaken to investigate the hypothesis that airborne biological particles can be efficiently collected by electrostatic means without being inactivated. In this method, the airborne particles are electrically charged and then deposited on a collection substrate by electrostatic forces.

This study has shown that collection of airborne microorganisms by electrostatic means is feasible, if electrical charging by corona discharge is avoided and the charge levels do not exceed certain positive or negative charge limits. The levels of electric charges on airborne microorganisms and their effect on microorganisms' viability and injury were studied using a newly designed and built experimental setup. In this setup, electric charges onto airborne microorganisms are imposed by means of induction charging. Microorganisms' fractions carrying electric charges of specific magnitude and polarity are extracted by an electrical mobility analyzer and collected by a microbial sampler.

It was found that electric charging by means of induction does not affect the bacterial viability. This study also found that microorganisms in the airborne state might carry more than 10,000 elementary electric charges, in which case their collection by electrostatics is possible without additional charging. It was determined, however, that very high electric charges inactivate sensitive bacteria, such as *Pseudomonas fluorescens*, while the viability of bacterial spores, such as *Bacillus subtilis* var. *niger*, carrying the same amount of electric charge, is not affected. It was also determined and that electric fields of up to 2,000 V/cm efficiency collect airborne microorganisms without affecting their viability.

The findings of this study have shown that collection of viable airborne microorganisms by electrostatic means has the potential for being an efficient and accurate collection method. Such a method may lead to more accurate exposure monitoring.

#### EVALUATION OF PERSONAL AEROSOL SAMPLERS

By: Vitaly Aizenberg

2000 Ph.D.

The first goal of this dissertation was the development, evaluation and validation of the Simplified Protocol for testing of personal inhalable aerosol samplers. Traditionally, personal inhalable aerosol samplers are evaluated in large wind tunnels. This is very time consuming and involves significant operational expenses. A Simplified Test Protocol is described and evaluated here. It was tested in a large conventional and a specially designed small wind tunnels. The sampling efficiencies of four personal aerosol samplers measured at a variety of sampling conditions according to the conventional approach and the Simplified Protocol in the large and small wind tunnels demonstrated no statistically significant difference. Thus, the Simplified Test Protocol was shown to be suitable for the performance evaluation of personal inhalable aerosol samplers. The Simplified Test Protocol was utilized to measure the sampling efficiencies of the IOM, GSP, and Button Samplers challenged with large (up to 250 pm) particles in the small wind tunnel. The sampling efficiency of the IOM increased with the particles aerodynamic diameter, while that of the GSP and the Button Sampler did not change.

The second goal of this dissertation was the laboratory and field evaluation of the Button Sampler as compared to other commercially available aerosol samplers. First, the airflow patterns near the sampler's inlet were studied using the Laser-Doppler Velocimetry. They were found to be similar regardless of the wind velocity and the presence of a stagnation plate simulating a human torso for the sampler facing the wind. The effect of the wind velocity on the Button Sampler's sampling efficiency was found to be statistically significant, while the wind and direction non-significant factor.

The heavy metal exposure of workers performing abrasive blasting operations was evaluated based on the personal sampling data obtained with the Button Samplers. The respiratory protection used was found to adequately protect against lead exposure. However, the workers were not adequately protected against cadmium and chromium.

A novel application of the Button Sampler, the total enumeration of airborne microorganisms, was investigated. The Button Sampler demonstrated the highest physical collection efficiency, total microbial counts and particle surface density when compared to two commercially available impactor devices. Thus, the Button Sampler is suitable for the enumeration of total airborne spores.

#### A POTENTIAL CONSEQUENCE OF EXCLUDING WORK-RELATED X-RAY EXPOSURES WHEN COMPUTING CUMULATIVE OCCUPATIONAL RADIATION DOSE AT A URANIUM ENRICHMENT PLANT

By: John J. Cardarelli II

2000 Ph.D.

The risks from exposure to ionizing radiation and corresponding regulatory limits were derived primarily from populations that experiences acute high doses of radiation from atomic bomb explosions, medical treatments, or industrial accidents. Studies of workers chronically exposed to ionizing radiation have been conducted to improve understanding of the relationship between acute high doses and chronic low doses, and to assess the adequacy of the regulatory limits. Historical and current regulations require that workers potentially exposed to ionizing radiation beyond a stated value be monitored. These exposures have been recorded for each person monitored while other potential sources of ionizing radiation were generally ignored (e.g., medical X-rays).

The purpose of this study was to evaluate the importance of work-required medical X-ray (WRX) exposures in overall dose in a facility where cumulative exposures are known to be low. Data collected as part

of a case-control study of 364 workers exposed to chronic low-levels of ionizing radiation were used to determine a worker's cumulative bone marrow dose from WRX and occupational data were used to evaluate the relationship between the two sources. Neither type of data were available for the other 67 study subjects.

The average bone marrow dose from WRX examinations exceeded the average bone marrow dose from occupational sources by a factor of 48. This was primarily due to miniature 4"x5" stereoscopic chest X-ray examinations routinely conducted between 1943 through 1956 which accounted for 98 percent of all medically-related bone marrow doses. No statistically significant relationship was observed between the two sources of exposure, although this result was apparently due to the limited number of study subjects. Based on these results, future exposed facilities should include the doses from WRX into the cumulative dose estimates. Failure to do so may result in a substantial underestimation of dose. Further research is needed on more complete data sets to better describe the extent and direction of any errors in dose estimation which may result when the employer has required X-ray procedures.

#### DEVELOPMENT OF BERYLLIUM EXPOSURE MATRICES FOR WORKERS IN A FORMER BERYLLIUM MANUFACTURING PLANT

By: Mei J. Chen  
2001 Ph.D.

Beryllium can cause both acute pulmonary disease and chronic granulomatous lung disease. The purpose of this dissertation is to describe the development of beryllium exposure estimates for the Hazleton (PA) plant for its years of operation (1957-1981). The quantitative historical exposure estimates can then be related to health outcomes to assess exposure-response relationships.

This study describes methods to measure airborne beryllium concentrations. Strategies to reconstruct quantitative estimates from the daily Weighted Average (DWA) and task-specific exposure are presented. The general approach was to identify the sources of industrial hygiene data and make estimates of historical exposures from existing data. Over 2000 DWA historical exposure measurements and 5,000 task-specific measurements collected by the Atomic Energy Commission (EC and Hazleton plant personnel) were available to estimate beryllium exposures of worker over time. Job histories were abstracted from microfilm. The abstracted job titles from the abstracts were standardized and aggregated, reducing the number from 418 to 130. Worker interviews were conducted to gather information on production processes and changes over time.

Beryllium exposure was characterized and exposure matrices were constructed for daily weighted average and task exposure, respectively. For all tasks and jobs throughout the years of production, exposure estimates had to be extrapolated from the existing measurements overtime and across tasks and jobs. The task and DWA matrices were reviewed by long-term employees for accuracy and completeness.

The magnitude of task and DWA exposures were characterized. Exposures between tasks and jobs varied considerably. Exposure estimates for both the tasks and jobs were highest in the early years of plant operation and decreased after 1970. The task exposures ranged from 0.01 to 519.1  $\mu\text{g}/\text{m}^3$ , with "removing billit from billet dolly" having the highest exposure. The overall geometric means of all tasks was 3.4, 2.5, and 0.9  $\mu\text{g}/\text{m}^3$  for the pre-1960s, during the 1960's and after the 1960s respectively. The DWA ranged from 0.04 to 34.8  $\mu\text{g}/\text{m}^3$ , with Attrition Mill Helper having the highest geometric mean DWA estimates at 3.2  $\mu\text{g}/\text{m}^3$ . The geometric mean of all DWA estimates was 0.9  $\mu\text{g}/\text{m}^3$ , with a geometric standard deviation of 2.6  $\mu\text{g}/\text{m}^3$ . The overall mean of peak estimates is three times higher than that of the DWAs. The DWA estimates were correlated with the peak task estimates ( $R^2=0.62$ ).

The availability of task-specific exposure measurements use in the calculation of the DWA in the beryllium industry offers and opportunity to to describe exposure by tasks. The effect of high short-term exposures may not be reflected when only DWA estimates are used exposure evaluation over time. This is especially relevant when the job is composed of many tasks with high variability in exposure among tasks. The focus of this study was to develop not only a job exposure matrix of DWAs, but also a task exposure matrix which can the be used to assign the highest exposure for a worker. Evaluation of the relationship between task-specific exposure estimates and risk of disease might be useful for the purpose of prioritizing activities for control and subsequent reduction in disease. If a job consists of different tasks, it would be most cost-effective to control the tasks that contribute most to the exposure.

#### EVALUATION OF SILICOSIS IN RESPONSE TO THE ESTIMATED SILICA EXPOSURE FROM THE HIGHEST TASK

By: Linda Faye Grimsley  
2001 Ph.D.

More than 1 million workers in the United States are exposed to silica and approximately 100,000 will develop lung diseases. Despite efforts to decrease silica exposure in the workplace, overexposures and deaths from silicosis continue in certain operations and industries.

The purpose of the study was to investigate ways to estimate silica exposure in unsampled tasks and to evaluate the relationship between highest task silica exposure and the development of silicosis. Data from the North Carolina Dusty Trades, a unique resource for exposure-response studies of the effects of silica exposure is the basis for the study. Three methods of imputation were used. The methods included estimating exposures based on the geometric mean exposure at sampled commodity-specific tasks, the median exposure of commodity-specific tasks, and a maximum likelihood estimation statistical model. A case-control study design was used to evaluate the effect that estimated silica exposure from the highest task had on the development of silicosis.

The results indicate that the highest task silica exposure is related to the development of silicosis. Exposure estimates including values imputed using the geometric mean resulted in an overall odds ratio and (95% CI of 2.27 (1.49, 3.44); and overall odds ratio of 2.14 (1.47, 3.11) for the statistical model. these odds ratio results were not significantly different from overall odds ratio of 2.22 (q.52, 3.26) that was calculated using zero for missing data in the highest task.

These results show that the exposure-response relation based on the highest task exposure metric did not increase when non-zero values were imputed using three methods for tasks never sampled. The results are consistent, however, suggesting that peak exposures may b important in the development of silicosis. Further work is needed to better understand the relation between peak exposure and the development of silicosis.

#### THE EFFECT OF FATIGUE ON ELECTROMYOGRAPHY ACTIVITY PATTERNS WHILE PERFORMING TASKS ON INCLINED SURFACES

By: Ming-Lun Lu  
2001 Ph.D

Fall-related fatal injuries remain a major safety problem in the workplace. This study investigated the effects of visual cues, muscular fatigue and a reach task on workers' postural stability on three different inclinations-0°, 14° and 26°. Nineteen subjects from roofing-related industries participated in the study.

Postural stability was measured in terms of sway (sway length and area) by a force platform. The electromyography (EMG activity levels of eight postural muscles (left and right quadriceps, hamstrings, tibialis anterior, and gastrocnemius) were measured to investigate the relationships between the EMG and sway variables in different test conditions. The conditions included 3 inclinations x 2 visual cues settings (with or without) x 3 levels of fatigue (full, half and no) x 2 tasks (forward reach and stationary). The 95<sup>th</sup> percentile value of the EMG activity for each muscle was used as the EMG measure. Additionally, a questionnaire was administered to acquire workers' subjective perceived sense of postural sway and instability (PSPSI) for each test condition. Results from a regression analysis showed that the eight muscles, except quadriceps, were significant predictors of sway area. Results from a repeated measure analysis of covariance showed that inclination, reach task and their interaction were found to have significant effects ( $p < 0.001$ ) on sway length and area, whereas visual cues were significant on sway length ( $p < 0.001$ ). Inclination was found to be significantly associated with the quadriceps and tibialis anterior, while task was significantly related to the hamstrings and gastrocnemii. Workers' PSPSI were significantly affected by inclination and fatigue. The mismatch (different significant effects of test conditions) between the PSPSI and sway variables may increase the propensity for loss of balance while working on inclined surfaces.

#### THE EFFECT OF CHALLENGING SOMATOSENSORY INPUTS ON THE RELATIONSHIP OF EYE MOVEMENT AND POSTURAL SWAY PATTERNS OF EXPERIENCED AND INEXPERIENCED WORKERS

By: Laurel Kincl  
2002 Ph.D

For the construction industry, especially the roofing industry, slips/trips and falls have the highest incident rate leading to an injury and fatality. To maintain upright balance, humans are equipped with a complex physiologic system. This complex system involves afferent systems providing information on the body's position, the central nervous system (CNS) processing the information and appropriate efferent signals to the muscles that keep a person upright. Three afferent systems (visual, somatosensory and vestibular inputs) are used for postural balance, which are redundant systems that relay important posture information to the CNS. A person may be able to maintain upright balance if one of these systems is missing or altered, since the remaining systems will compensate. This study investigated workers in the roofing and other industries, which require work on inclined and/or elevated work surfaces, which alter the worker's somatosensory inputs. To investigate the use of the visual environment when the somatosensory systems were challenged, eye movement patterns were measured. Eye movement and postural sway patterns of industrial workers ( $n=48$ ) with various work experiences (months of work experience on inclined surfaces), fatigue conditions (none, half and full), visual cues (none, H cue), tasks (stationary, reach) and surface inclinations ( $0^\circ$ ,  $14^\circ$ ,  $26^\circ$ ) were measured. Eye movement variables of length and area of movement as well as fixation data and postural sway variables of area and length were significantly affected ( $p < 0.05$ ) by incline, cue, and task and work experience. The effect of the eye movement variable on the postural balance was limited and further study is necessary. The use of visual cues is an effective means of increasing postural stability and could be used in occupational situations where no vertical or horizontal cues are naturally available.

#### AEROSOLIZATION DURING INDOOR LEAD ABATEMENT: CHARACTERIZATION OF RELEASED PARTICLES AND EVALUATION OF LEAD HAZARD CONTROL PROCEDURES

By: Kyoo-Tae Choe  
2001 Ph.D.

Lead is a toxic substance and a ubiquitous environment contaminant. Many studies have shown its negative health effects on psychological development, neuromotor systems and many other body organs. Lead was added to paint in the form of white lead to reinforce the paint and produce a tough and flexible film. It is estimated that more than 3 million tons of lead have been used in the form of lead-based paint in the U.S. during the past 100 years. As a result, about 38 million homes still contain leaded paint. For this reason, hundreds of millions of dollars have been spent in the U.S. for lead hazard control. The leaded particles aerosolized during lead hazard reduction work are a health hazard for the workers. Significant levels of leaded particles representing health hazards are aerosolized during lead abatement. Few studies regarding these aerosols have been performed.

The two main goals of the research described in this dissertation were 1) to characterize the airborne leaded particles and 2) to apply the acquired knowledge to the evaluation of various lead hazard control procedures.

The first goal was to investigate the fundamental characteristics of the particles aerosolized during lead abatement. An environmental Test Chamber was designed and constructed in the Kettering building at the University of Cincinnati. Wood doors coated with lead-based paint were abated in the chamber by dry scraping, wet scraping, or dry machine sanding. The airborne particle concentration was measured with the Grimm particle size spectrometer. The size distribution of the airborne particles changed substantially with time. The airborne particle concentration for each specific size was found to decay exponentially in calm air condition. Size selective air sampling on filters and subsequent laboratory lead analysis of them showed no significant effect of particle size on the percent lead.

The second goal was achieved by the following three studies. The first study was to investigate the relationship between the surface lead level on the substrate and the percent lead in the particles aerosolized during lead abatement. A significant relationship for dry scraping was found, but not for wet scraping and dry machine scraping. This was attributed to the difference in water absorption properties of the paint layer and different particle aerosolization mechanisms of each paint removal method. The second study has demonstrated that there was not need to extend either the first or the second waiting period beyond the currently recommended one-hour interval. The third study evaluated the final cleaning after lead abatement. The change in airborne lead concentration and the potential floor lead loading after each cleaning procedure was determined. Considerable resuspension of leaded particles was detected during dry sweeping. The first HEPA vacuuming significantly decreased the airborne lead mass. Wet mopping was effective in reducing the lead loading significantly below the clearance level. The second HEPA vacuuming resulted in further reduction of the airborne lead mass concentration.

The current cleaning procedure was found to be sufficient in reducing the floor lead loading below the U.S. Department of Housing and Urban Development (HUD) clearance standard of 40 ug/ft<sup>2</sup>. Several modifications were proposed to further improve the cleaning effectiveness.

## **ABSTRACTS OF MASTERS THESES**

AN EVALUATION OF THE EFFECTS OF ABRASIVE HAND CLEANERS ON THE EPIDERMAL LAYER WITH RESPECT TO DERMAL CARCINOGEN ABSORPTION FROM USED GASOLINE ENGINE OILS

By: Darren Burks  
1997 Master of Science

Approximately 950,000 people in the United States are employed as auto mechanics.<sup>(1)</sup> The persons employed in this occupation are exposed, to varying degrees, to used gasoline engine oils (UGEO). UGEO contain polycyclic aromatic hydrocarbons (PAH) which have been shown to be carcinogenic in long term animal studies and capable of producing DNA adducts in target tissues of mice dermally exposed during short term studies.<sup>(3-7)</sup> To reduce occupational UGEO exposures, many mechanics use various types of hand cleaners. These cleaners often contain abrasive constituents designed to aid the cleaning process. However, it has been postulated that the repeated use of abrasive hand cleaners can increase a person's exposure by damaging the protective mechanisms of the skin.<sup>(2,8)</sup>

During this study, 43 HSD (ICR) Br strain female mice aged 4 - 6 weeks were utilized to evaluate the effects of repeated applications of hard abrasive, soft abrasive and nonabrasive hand cleaners. The animals were randomly assigned to one of six experimental groups or one of three control groups (1 positive control group, 2 negative control groups). The mice were washed once daily for 10 consecutive days with one of the hand cleaners prior to a 5-day UGEO exposure. Following a 50 FL dermal dose of UGEO to the shaved interscapular region of each mouse, the exposed areas were washed with the hand cleaner at either 1 or 8 hours. The animals were sacrificed approximately 24 hours after the last exposure. The lungs and skin tissues were harvested. DNA was isolated from each of the tissue samples, and DNA adducts were labeled with <sup>32</sup>P-postlabeling procedures. The labeled adducts were separated and resolved by using thin layer chromatography. A scintillation counter was used to quantify the adduct levels.

The results of this study indicate that dermal absorption and transport of metabolites into the lungs is increased following the repeated application of solvent based hand cleaners regardless of the abrasive content. Total adduct levels measured in the skin tissues indicated a protective effect of hand cleaners following repeated applications. A statistically significant decrease in total adduct levels was seen in all experimental groups when compared to the positive control group skin tissue total adduct level. However, total adduct levels were higher (not statistically significant) in the lung tissues of the experimental groups when compared to the total adduct levels measured in the lung tissues of the positive control group except in the case of the experimental group washed with the soft abrasive hand cleaner at 1 hour post UGEO exposure.

It was concluded that a component(s) other than the abrasive constituents in solvent based hand cleaners allows for increased transport of DNA damaging agents from UGEO into the lungs via dermal absorption or inhibit the metabolism of the DNA damaging agents in the skin allowing for greater metabolism in the lungs. Further research is recommended to evaluate possible explanations for the increased levels of total DNA adducts in the lung tissues following the repeated application of solvent based hand cleaners.

#### ASSESSMENT OF THE ASSOCIATION BETWEEN DEVELOPMENT OF SILICOSIS AND THE HIGHEST SILICA EXPOSURE TASKS

By: GuoHua Liu  
1997 Master of Science

This report summarizes the result of an exposure response analysis for developing silicosis with respect to the highest silica exposure task metric. Previous study of cases only demonstrated that the highest job exposure intensity during the entire work history was an important determinant in the development of silicosis. This is the first investigation of any relationship between silicosis and the highest exposure task metric.

216 cases and 672 controls were selected from the North Carolina dusty trades files. The environmental sampling data, historical occupational data, and chest x-ray readings were collected from 1935 to 1980.

Four exposure groups were defined for both metrics of intensity of highest exposure task and cumulative exposure. The correlation coefficient between the two metrics was 0.09. The means for each exposure group were statistically different ( $p < 0.05$ ) from adjacent groups for each metric. The odds ratios for group 1, 2 and 3 vs. the lowest exposure group referent for both metrics were calculated using the Cochran-Mantel-Haenszel procedure. The odds ratios for the highest exposure task metric were 1.21 (95% CI=0.77-1.88), 3.02 (95% CI=1.89-4.84), and 4.65 (95% CI=2.89-7.47) respectively. The odds ratios for cumulative exposure were 0.75 (95% CI=0.49-1.13), 1.91 (95% CI=1.26-2.88), and 3.65 (95% CI=2.10-6.34) respectively. The odds ratios using the highest exposure task metric were approximately 1.5 times higher than that of the cumulative metric; however, the difference was not statistically significant. These results indicate that control of high exposure may reduce the risk of silicosis.

#### EVALUATION OF A PORTABLE X-RAY FLUORESCENCE INSTRUMENT FOR THE DETERMINATION OF LEAD IN WORKPLACE AIR SAMPLES

By: J. Clinton Morley  
1997 Master of Science

Occupational Safety and Health Administration (OSHA) regulations for worker exposure to lead specify worker protection levels based upon airborne concentrations of lead in air particulate. The on-site analysis of lead in air filter samples using a portable X-Ray Fluorescence (XRF) instrument, with an attachment to hold the filter, would expedite the exposure assessment process and facilitate compliance with the standard. Analytical results from a laboratory using National Institute for Occupational Safety and Health (NIOSH) Method 7105 "Lead by HGAAS" (Graphite Furnace Atomic Absorption Spectrophotometry or GRAA).

Sixty-five personal and area samples were collected with closed-faced 37-mm cassettes with preloaded 0.8  $\mu\text{m}$  cellulose ester membrane filters, and fifty-eight area samples were collected with open-faced 37-mm cassettes with pre-loaded 0.8  $\mu\text{m}$  cellulose ester membrane filters at bridge lead-abatement projects. The 37-mm closed-faced samples demonstrated a lead loading range of 0.1  $\mu\text{g}$  of lead/sample to 1514.6  $\mu\text{g}$  of lead/sample (values based upon laboratory GFAA analytical results).

Five readings were taken in separate location on each 37-mm filter: one at the middle (M), one at the top (T), one at the bottom (B), one at the left (L), and one at the right (R). The lead-impacted surface area of a 37-mm filter is 9.6  $\text{cm}^2$ . The window of the NITON 701 XRF device is 2  $\text{cm}^2$  and the results of each reading are reported as  $\mu\text{g}$  of lead/ $\text{cm}^2$ . The five readings in  $\mu\text{g}$  of lead/ $\text{cm}^2$  were applied to one of several algorithms which generated an analytical response in units of  $\mu\text{g}$  of lead/sample. The algorithms were tested statistically to identify the best fit algorithm. This best fit algorithm was then tested to determine the limit of detection (LOD) and limit of quantitation (LOQ) of the instrument and the precision, bias, and accuracy of the method.

Multiple variable linear regression with no intercept was used to develop the best fit algorithm for the five XRF readings of each air filter sample. For the open-faced data set and the closed-faced data set, the algorithm which generated analytical results which best fit the GFAA analytical results was  $2 * M + 3.8 * (T + B)$ . Although other algorithms were tested, this best fit algorithm was predicted prior to the study based upon sample geometry, and was the algorithm used by the manufacturer to develop the software.

Both the open-faced data set and the closed-faced data set were non-normally distributed; therefore, the non-parametric Wilcoxon signed rank test was used to determine statistical significance. Both data showed no statistically significant difference  $p$ -value was 0.72. The linear regression of the closed-faced

data set GFAA analytical result vs. the XRF analytical result identified a slope=0.959 and  $r^2=0.985$  with  $n=65$ . The Wilcoxon signed rank test for the open-faced data set p-value was 0.95. the linear regression of the open-faced data set GFAA analytical result vs. the XRF analytical result identified a slope=1.029 and  $r^2=0.937$  with  $n=51$ .

The LOD was estimated with an Environmental Protection Agency (EPA) method defined in 40 CFR Part 136, Appendix B. This method estimates the LOD using repeat readings of a sample at or around the estimated LOD. A 3.2 ug of lead/sample (value based upon laboratory GFAA analytical result) was analyzed five times using the XRF method. The standard deviation of the mean of the five analyses was multiplied by the students t-value for 4 degrees of freedom at the 99% confidence level. This method identified with 99% confidence that the XRF method LOD was 6.18 ug of lead/sample. This instrument LOQ is defined as 3.33 times the LOD, or 20.6 ug of lead/sample.

The LOD and LOQ were also estimated using NIOSH Standard Operating Procedure (SOP) 018<sup>(1)</sup>. The NIOSH SOP 018 definition of LOD is the mass of analyte, which gives a mean signal 3 standard deviations above the mean blank signal. The LOQ is defined as the mass of analyte, which gives a mean signal 10 standard deviations above the mean blank signal. Twenty-nine blank filter were analyzed using the XRF method. The mean blank signal was 1.57 and the standard deviation of the blank signal was 1.55. therefore, the LOD is  $1.57+3*(1.55)=6.22$  ug of lead/sample and the LOQ is  $1.57+10*(1.55)=17.1$  ug of lead/sample.

The XRF method precision was estimated by performing three repeat analyses of fourteen 37-mm closed-faced samples ranging from 10.3 ug of lead/sample to 612 ug of lead/sample. The mean and standard deviation were calculated for the three analytical results for each sample. The mean of the three readings was divided by the standard deviation to yield a point precision estimate for each sample. The mean of the point precision estimate as  $0.054+0.019$ (95% confidence interval).

The XRF method bias for the 37-mm closed-faced samples were estimated by subtracting the XRF method analytical value from the laboratory method analytical value and dividing by the laboratory method analytical value. The bias estimate was  $0.069+0.063$  (95% confidence interval).

The accuracy of the XRF method was estimated using the Nomogram Relating Accuracy to Precision and Bias<sup>(1)</sup>. The Nomogram was used to identify the single value estimate of accuracy and the interval estimate using the Bonferroin procedure. The single value estimate of accuracy was 16.4%. The 95% confidence statistic for accuracy was obtained by using the 97.5% confidence statistic for the bias (0.132) and the 97.5% confidence statistic for the precision (0.073). The 95% confidence statistic for accuracy was 27%. The 5% confidence statistic for accuracy was obtained by using the 0.025% confidence statistic for the precision (0.035) and the 0.025% confidence statistic for the bias (0.006). The 5% confidence statistic for accuracy was 7.1%. The 90% confidence interval for accuracy includes the 25% accuracy criterion. This is an inconclusive finding and indicates, "that there is neither 95% confidence that the method does or does not fulfill the accuracy criterion"<sup>(1)</sup>.

Fifty-one area samples were collected with closed-faced 25-mm cassettes with pre-loaded 0.8 um cellulose ester membrane filters at a bridge blasting lead-abatement project. The samples range from 0.34 ug of lead/sample to 895 ug of lead/sample (values based upon laboratory GFAA analytical results). The lead-impacted surface area of a 25-mm filter is  $4.14\text{cm}^2$ . Two readings were taken of each filter using the WRF method: one at the top of the filter (T) and one at the bottom of the filter (B). The best fit algorithm for the two readings was identified as  $2.16*(T+B)$ . The XRF data set was non-normally distributed; therefore, the Wilcoxon signed rank test was used to determine that there was a statistically significant difference between the field portable XRF method using 25 mm cassettes and the NIOSH approved laboratory analytical method, p-value=0.0265, slope=0.960,  $r^2=0.978$ ,  $n=50$ .

The statistical results of this study indicate that for the analysis of 37-mm closed-faced lead air filter samples, there is no statistically significant difference between the analytical results obtained with a field portable XRF method using the NITON 701 and the laboratory based NIOSH method 7105. The XRF method estimated LOD is 6.2 ug of lead/sample, indicating the XRF method estimated LOQ is about 20.6 ug of lead/sample. This LOQ is sufficiently sensitive to quantitate lead concentration below the OSHA action level and personal exposure limit. The 95% confidence statistic for accuracy is 27%, which includes the established 25% accuracy criterion. This is by definition an inconclusive finding; however, the accuracy of the XRF method was better than the accuracy of the approved laboratory GFAA method used in this study.

#### DEVELOPMENT OF A HIGHLY-SENSITIVE TRANSPORTABLE METHOD FOR ON-SITE ANALYSIS OF BENZENE IN EXHALED AIR

BY: Christine Newman  
1997 Master of Science

The results of this research provide a transportable method for analysis of benzene and other volatile organic compounds in exhaled breath at very low levels. This method provides a near-real time method to help assess the internal dose due to exposures to volatile organic compounds.

Billions of gallons of jet fuel are used annually by the United States Air Force. Due to the growing number of women exposed to jet fuel in the Air Force, there is a need to investigate potential reproductive health risks associated with these exposures. Jet fuels contain several aromatic hydrocarbons: benzene, toluene, o-, m-, and p-xylenes, and naphthalenes. There is some data available on the reproductive toxicity of these individual constituents, but very limited data available on reproductive health effects due to jet fuel as a whole.

Exhaled breath analysis has been proven to be an effective method for evaluating exposure to some compounds. Volatile organic compounds by nature, lend themselves to exposure assessment by exhaled breath analysis, due to their high vapor pressures, and metabolism mechanisms. The portable gas chromatograph has been used in the past to analyze a variety of air samples for a variety of constituents. It has also been proven for analysis of exhaled breath samples for benzene and perchloroethylene. This research utilizes a portable gas chromatograph to provide a transportable, sensitive and specific method for analyzing exhaled breath samples for benzene and other volatile organic compounds.

The method developed met the NIOSH accuracy criterion for benzene at 10 ppb, 1 ppb, and 0.1 ppb, which provides a 500 fold increase in the sensitivity from the standard NIOSH method which utilizes a portable GC for analysis of benzene in exhaled breath. Based on these results, the hypothesis for this research is supported.

Currently this technique is being used to investigate occupational jet fuel exposure of women at several US Air Force Bases. Several of the aromatic hydrocarbons present in jet fuel are being evaluated for their adverse reproductive health effects in women.

This research increases the potential of near-real time exhaled breath analysis for occupational exposure assessment. More work should be done to further explore the possible applications and boundaries of this method.

## RELEASE OF LEAD CONTAINING PARTICLES FROM A WALL ENCLOSURE MODEL

By: Joshua M. Harney  
1998 Master of Science

As leaded dust released from wall surfaces deposits on the floor and accumulates inside a wall enclosure space over time, the potential for it to escape into the indoor air environment through gaps and cracks in the enclosure panel becomes a concern. The effect of airflow and mechanical disturbance on the aerosolization of leaded dust behind an enclosure and its penetration through a horizontal gap were studied. A wall enclosure model was developed and built according to the dimensions detailed in the 1995 US Department of Housing and Urban Development Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing. The experiments were conducted with leaded house dust collected in residential indoor environments. In the first set of experiments, airflows with average velocities of 15 and 37 cm/s (determined to be relevant to occupational and residential environments) were blown down through the enclosure and out through a 6 mm gap at the bottom. In the second set of experiments, mechanical disturbance of 3 Hz was applied with an electromagnet-powered striker (mass = 7.5 g) in combination with these airflows. This combination resulted in significant release of dust particles, while the airflow alone did not cause much release. This release constituted an increase in mass concentration measured outside the enclosure near the gap of three to five orders of magnitude. The release rate fluctuated significantly. With mechanical disturbance present, the average aerosolization rate increased as the downflow air velocity within the enclosure increased. The predicted floor surface lead loading ( $\mu\text{g-Pb}/\text{ft}^2$ ) outside the enclosure resulting from dust release through the gap was found to be strongly dependent on distance from the enclosure gap. The range of lead contamination resulting from the dust release from a typical enclosure with the 6 mm horizontal gap was estimated to be nearly  $0.1 \mu\text{g}/\text{ft}^2$  ( $0.0001 \mu\text{g}/\text{cm}^2$ ) at a distance of 1 m from the gap to more than  $100 \mu\text{g}/\text{ft}^2$  ( $0.1 \mu\text{g}/\text{cm}^2$ ) within the narrow strip of floor about 1 to 2 cm from the enclosure gap.

## BIOTIC STABILITY OF METAL-COMPLEX DYES

By: Javier Ortega-Cesena  
1998 Master of Science

Metals are released in the environment as a result of their widespread use raising concerns on the detrimental impact they have on biota and potential human health adverse effects. Metal-complex azo dyes, a type of coordination compounds constituted by a heavy metal and an azo dye, contribute to increase the environmental burden of toxic metals. These dyes discharge into body waters during manufacturing and application processes and their fate is not yet understood.

Physicochemical characteristics largely influenced the toxicity of metals, as they become more or less accessible to living organisms. The adequate measure of and protection of against environmental toxicity of the numerous forms in which metals occur in aquatic systems has been debated through the national process of implementation of water quality criteria and standards for metals. The controversy lies on whether the considerations to assess metals bioavailability are accurately reflected by current knowledge. Thus, underestimating the effects of chemicals may result in serious environmental contamination and adverse health effects, whereas, overestimating potential hazards can result in undue economic burdens.

In this study, biotic stability of metal-complex azo dyes was investigated. The fundamental assumption is that biodegradation enhances bioavailability through the metal ion release from the parent compounds. We found that metal-dye complexes were consistently resistant to biodegradation by both microbial consortia and isolates known to degrade other azo dyes. Six metal-complex dyes were examined: acid blue 193+Cr, acid yellow 151+Co, acid alizarin violet + Cu, direct red 83+Cu, and reactive blue 21+ Cu.

Moreover, four free ligand dyes corresponding to their metallic dye counterpart were investigated: acid blue 193, acid yellow 151, acid alizarin violet, and direct red 83. None of these dyes were decolorized either under aerobic or anaerobic conditions. Both consortia and isolated microbial cultures were obtained from activated sludge from a public owned treatment wastewater plant and acclimated in a laboratory-scale bioreactor system developed in our laboratory. A presumably single culture, TXB65, was used through the study as ascertained to decolorize acid orange 7 (A07), acid orange 8 (A08), acid red 88 (AR88), and acid red 151 (AR151).

No degrade of the free ligand dyes was observed despite TXB65's capability to degrade structurally similar dyes. Toxicity of the bound metals to microbial cultures was ruled out to explain recalcitrancy of metal-complex azo dyes to biodegradation. Addition of varying concentrations of Cr, Co, and Cu to the bioreactor did not inhibit A07 degradation. These results strongly suggest that the metal remains bound to the dye upon biological degradation conditions since the metal-dye interaction is unlikely disturbed.

#### THE EFFECT OF MUSCULAR FATIGUE ON DYNAMIC MOTION OF WHOLE BODY CENTER OF GRAVITY

By: Jean Mangharam  
1998 Master of Science

Falls accounted for 33% of all fatal injuries to construction workers in 1995. The loss of postural balance of an individual can lead to a fall. It is unclear how muscular fatigue contributes to the complex process of human balance. The aim of this study was to measure the influence of muscular fatigue on an individual's pattern of movement during a fall forward task. Horizontal displacement and velocity of the center of gravity (COG) was measured by two-dimensional kinematic analysis, to characterize pattern of movement. Electromyography (EMG) was utilized in synchrony to describe the associated muscular activity levels of the lower limbs. Eleven workers participated as subjects in this study. The subjects were required to carry out a fall forward task until a step response was elicited, before and after a fatiguing task of the lower limb musculature. As a fatiguing task, a standard Minnesota manipulation board carried out in a prolonged semi-squat position to the instant of maximal fatigue or discomfort in the lower limbs, as significantly less after fatigue for the whole fall forward task ( $F=5.14$ ,  $p<0.05$ ; non-fatigued mean = 0.165m, fatigued mean = 0.155m). Fatigue was found to significantly affect the initially stepping hamstrings ( $F=5.59$ ;  $p<0.05$ ). Experience significantly affected the initially stepping hamstrings muscle ( $F=5.58$ ;  $p<0.05$ ). From these results, it may be inferred that the body attempts to change its patterns during a fall forward task after lower limb muscular fatigue, to control the fall. These results from the current study urge that training workers for high risk of fall environment alone, but also by physical exercise and prophylactic therapy to prevent the occurrence of postural instability in the occupational setting.

#### CONTROL OF WASTE NITROUS OXIDE FROM ANESTHESIA DELIVERY UNITS IN DENTAL OPERATIONS

By: Krystyn R. Bussa  
1998 Master of Science

Exposure to waste nitrous oxide ( $N_2O$ ) in the dental industry may be linked to reproductive difficulties, cancer, liver disease, and kidney disease. Short-term exposure to nitrous oxide has been shown to effect memory and responsiveness. Reducing ambient levels of nitrous oxide below the NIOSH REL of 25ppm has been challenging. A manufacturer of "anesthesia delivery units" suggested that the safety relief valve leaks at least 1% to the ambient air when the units are new; leakage is likely to increase with use. It has been postulated that leakage from this valve is a primary cause of exceeding the REL for nitrous oxide in

the dental environment. To test this hypothesis, a study was conducted on 11 anesthesia in-service delivery units from two leading manufacturers. A ventilated bag enclosing the delivery unit was constructed to capture leakage from the entire unit, including the valve. Measurements were taken during dental procedures for each of the units with the enclosure on and off. Units from the two different manufacturers were also compared. Personal and area air samples were collected in Tedlar® bags for the duration of nitrous oxide administration, then analyzed by an infrared analyzer. Leakage was detected from the safety relief valve of all the units. Enclosure was effective in lowering ambient levels of nitrous oxide in the dental operator. Area samples were reduced by about 62% (F-ratio test,  $p < 0.01$ ) while personal samples of the dentist performing the procedure were reduced approximately 46% ( $p < 0.07$ ), but samples on the dental assistant were reduced by about 30%, but was not significant ( $p < 0.23$ ). The nitrous oxide levels in area samples for enclosure on range from 1-10ppm, compared to 1-44ppm for enclosure off. Personal air samples for dentists ranged from 1-137ppm for enclosure on and 3-231 ppm for enclosure off. Personal air sampling for the assistant ranged from 3-52ppm for enclosure on and 5-146ppm for enclosure off. A significant difference was found in the leakage rates for enclosure on compared to enclosure off using a Student's t-test ( $p = 0.0002$ ). There was a nearly significant difference in leakage of the anesthesia unit between the two manufacturers ( $p = 0.07$ ). It is suspected that other sources, including improper scavenging flow rates, loose fitting mask, patient mouth breathing and proximity to the patient likely contributed to personal exposures to nitrous oxide than valve leakage.

#### EVALUATION OF JOB CHANGES WITHIN THE REFRACTORY CERAMIC FIBER INDUSTRY AND HOW THEY AFFECT AN EMPLOYEE'S OCCUPATIONAL EXPOSURES

By: Lynn L. Borland  
1998 Master of Science

Knowing the comprehensive history of a job or an employee's occupational exposure is important for determining worker exposure. Changes associated with jobs or job tasks can impact these exposures significantly. Often job descriptions are too general or are inadequate for determining a worker's true occupational exposure history. Collection of detailed task information may be helped for categorizing exposures.

This study used data collected annually by personnel interview with individual employees between the years of 1988 and 1993 at three separate Refractory Ceramic Fiber (RCF) plants. Initially, over 350 Current Employee Questionnaire (CEQ) interviews were evaluated and compiled on a computerized spreadsheet. Tasks were listed for each job title, year, and frequency reported from the interviews and cross-referenced to individual workers. To reduced inter-individual variability, only those interviews for which an individual worker was questioned for two or more years and did not change job titles were used. This reduced the number of CEQ interviews to 69.

A sign test was used to evaluate three situations: whether job tasks change over time when compared to the previous interview, the total number of task matches when compared to the previous interview, and regardless of frequency reported, the total number of task matches for one, two and three years. Statistical evolution of the first situation showed the results for daily, additional daily, weekly/, monthly and non-routine task frequencies at all plants were significantly greater than zero ( $p < 0.0001$ , standard deviation = 0.5). For second situation the results were significantly different from zero at plant A ( $p < 0.0001$  for daily, 0.0001 for additional daily, 0.0001 for weekly/monthly, and 0.0001 for non-routine), at plant B ( $p < 0.0001$  for daily, 0.0002 for additional daily, 0.0078 for weekly/monthly, and 0.0156 for non-routine) and at plant C ( $p < 0.0001$  for daily, additional daily, weekly/monthly, and non-routine). In the third situation, results varied since there was insufficient three-year data for two of the three plants. Tasks that were performed for one year ( $p < 0.0001$ , mean = 3 for all three plants) and two year ( $p < 0.0001$ , mean = 3 for all

three plants) were significantly greater than zero. However, data for tasks performed for three years was not significant for Plant A ( $n=5$ ,  $p=0.0625$ ,  $mean=2$ ).

The CEQ data was useful in evaluating whether job tasks change over time. Underlying reasons for task changes are possibly related to the fact that some tasks are only performed for a short period of time, workers rotate and fill in for other employees on occasion, or incomplete reporting by the employees due to recall bias. When evaluating the task matched independent of frequency reported, we see that the frequency of reporting tasks can increase the number of task matches between interview years.

Air monitoring data showed that exposures remain relatively constant, despite the associated changes in job tasks. This could be a result of the documented limitations of NIOSH method 7400, or simply the fact that the changes that occur to the job tasks are minor when compared to the routine tasks that are performed within a particular job title. Also important to note is that the data evaluated was representative of average exposures within a specific job title for the individual plants.

Results indicate that job tasks change over time; however, further investigation into this matter must be made before definite conclusions can be made concerning the long-impact on daily exposure measurements.

#### THE USE OF POSTURAL SWAY MEASUREMENTS AS A SAFETY MONITORING TECHNIQUE FOR WORKERS WEARING PERSONAL PROTECTIVE EQUIPMENT

By: Laurel D. Kincl  
1998 Master of Science

This study investigated the use of postural sway measurements as a safety monitoring technique to indicate the level of neuropsychological strain on a worker wearing personal protective equipment (PPE). Three levels of PPE, the EPA defined Levels A, B and C, were worn by each subject in random order while performing two tasks in random order: 1) a resting task where the subject was asked to sit quietly for five minutes and 2) a postural fatiguing task where the subject was asked to maintain a static semi-squat position for a maximum of five minutes. Postural sway measurements, measured using a micro-processor-based force platform system, were taken after each task measuring two variables, the sway area and sway length. These measurements were taken for three sway tests: 1) static test with eyes open on the plate (EO), 2) static test with eyes closed on the four inch foam (FC) and 3) dynamic test with the subject reaching for a five pound weight placed at knee height in front, lifting it to his chest and lowering back to shelf four times (RE). After the fatiguing task, the perceived exertion and discomfort were recorded.

Sixteen healthy volunteers (age:  $41.8 \pm 9.3$  years) participated in this study. The heart rate was significantly higher for the fatiguing task ( $p<0.05$ ), and the perceived exertion demonstrated levels A and B were significantly higher than level C ( $p<0.05$ ). The heart rate and perceived exertion were not significantly different for the subjects wearing level A for the upper back, lower back and thighs. The sway variables showed significant differences with the PPE levels and the tasks, with the fatiguing task significantly higher than the resting task ( $p<0.05$ ). For the PPE levels, the EO test condition level A was significantly higher than level C and for the FC test condition, the level B was significantly higher than level A. These results indicate that postural stability is altered with PPE use and with fatigued postural muscles and sway measurements be a potential safety monitoring technique.

## INVESTIGATION OF ENVIRONMENTAL CONTAMINATION IN WATERSHED AS BASIS FOR HUMAN EXPOSURE ASSESSMENT

By: Laura Ann Stambaugh  
1998 Master of Science

The hypothesis of this investigation is the following, "leaching of multiple sources of contaminants has occurred within the Lake Harsha Watershed from point and non-point sources of pollution resulting in long-term, low dose exposure of individuals." Sediments were collected from the Lake Harsha Watershed and the Fayetteville Reservoir to determine the occurrence, solubility and concentration of hazardous environmental contaminants within the sampling areas. Dried sediments samples were milled and extracted using a form of Soxhlet extraction prior to metal analysis via ICP-MS or organic screening via LC-PDA. Profiles of soil sediment for the local area as well as compare results obtained during this investigation. Elevated concentrations of heavy metals occurred within the RCRA site compared to the Batavia WWTP [Wastewater Treatment Plant] mix zone and Middle East Fork WWTP [Wastewater Treatment Plant]. ICP-MS results revealed elevated levels of stable and radioactive isotopes within the Williamsburg Reservoir. LC-PDA results revealed the presence of contaminants in extracts of a sediment specimen, obtained within the Lake Harsha Watershed, not found at two other sampling locations. In conclusion, the hypothesis of this investigation is supported by onsite sampling results and information obtained through literature review. The results further support using environmental contaminants within a watershed as a basis for human exposure assessment. The method of data collection, during this investigation of contaminants with the Lake Harsha Watershed, can be used as a model for human exposure assessment.

### Keywords

ICP-MS-a form of mass spectrometry using Inductively Coupled Plasma to screen for metallic substances.

LC-PDA-a form of liquid chromatography using a M996 Photo Diode Array detector to screen for organic substances.

Soxhlet [Tabor] Method-a form of Soxhlet extraction using a sequence of solvents [Freon, Methylchloride, Acetone, and Methanol] to extract and rotary evaporator to concentrate elute to form an aliquot for additional analysis.

Watershed-a geographic area in which water, sediments and dissolved materials drain to a common outlet [e.g. larger river, stream, reservoir].

## MEASUREMENT OF BODY CENTER OF GRAVITY AND CENTER OF PRESSURE WHEN WALKING UNDER TWO DIFFERENT ENVIRONMENTAL CONDITIONS

By: Ming-Lun Lu  
1998 Master of Science

Accidents related to slips and falls have been reported to be one of the major causes of occupational fatalities. In 1996, falls accounted for 11 percent of total fatal injuries in the U.S. and this number is still increasing. Studies have shown that 50% of falls are immediately preceded by a slip. Surface conditions and walking characteristics are considered to be two major factors that may lead to a fall. In order to reduce fall-related injuries, an understanding of the cause of slips and falls in the workplace is of great importance. Two important variables, the center of gravity (CG) and the center of pressure (CP) with respect to the base of support (BOS), have been utilized to assess postural stability during static and dynamic task performance. A preliminary study was carried out to investigate the relationship between the CG and Cp and the possible use of the CG-based and CP-based indices for evaluating balance while walking.

In addition to the CG and the CP with respect to the BOS, the average slide distance and the horizontal velocity of the CG were investigated in this study. Twenty-six gait tests performed by 21 subjects were conducted in two walking conditions, the best (good lighting, without a weight, dry walking surface, and new shoes) and the worst (poor lighting, with a weight in the right hand, slippery surface, and old shoes). Results showed that the slide distance and the maximum displacement of the CP with respect to the center of the BOS are the two most important variables for predicting slip occurrence. When the displacement of the CP with respect to the center of the BOS exceeded 15 centimeters, the probability of slip occurrence increased to at least 90%. Results from a quadratic regression model showed that the CG moved toward the center of the BOS and was closest to the center of the BOS when the single stance phase of gait was approximately 40% complete. The CP, however, stayed near to the center of the BOS and was within 10 centimeters during the entire single stance phase. The CG did not intersect the CP during the single stance phase. In addition, a lag time (approximately 0.05 second) between changes in the CG and the CP with respect to the BOS was found. The CG moved 0.05 second prior to the CP during the single stance phase, on average. Results from ANCOVA models showed that the CP-based index of postural stability couldn't be used as a surrogate for the CG-based index during the single stance phase. The average horizontal velocity of the CH and the slide distance were significant in the ANCOVA models, indicating that these two variables may be utilized to predict CG movement with respect to the BOS during the single stance phase.

#### THE ABIOTIC DEGRADATION OF REPRESENTATIVE AZO DYES UNDER REDUCING CONDITIONS

By: Xiaojie Xu Zavon  
1998 Master of Science

Azo dyes account for more than 60% of all applications of dyes and colorants, with an estimated release of 10-15% to the aquatic environment during manufacture and use. The possible degradation products of azo dyes in wastewater sludge/or aquatic sediments, including aromatic amines, are potential carcinogens. Most azo dyes are recalcitrant to aerobic biodegradation, but some are susceptible to anaerobic biodegradation. Additionally, non-biological processes, i.e., abiotic reactions, such as photochemical reactions, can contribute to the degradative fate of these compounds in the environment. The studies reported in this thesis focus on the fate of azo dyes in abiotic reducing environments.

The abiotic degradation of 15 acidic dyes was examined in the laboratory using an abiotic reduction system that mimicked the redox conditions found in environmental matrices such as sediments. Dye degradation was determined by measuring loss of the parent dye by spectroscopic methods. The extent, rate and order of the degradation reaction were determined by chemical kinetic studies.

Both metal-free and metal-complexed azo dyes were evaluated in this system with the latter generally being found to be more resistant to loss of parent dye, i.e., decolorization. Among the non-metal azo dyes examined, A07, A08, A010, AR14 and AR18 were degraded significantly, as determined spectroscopically following HPLC separations of the reaction mixtures. However, the degradation of AR88 was not significant at the low concentration (5 $\mu$ m) tested. The abiotic degradation of A07, A08 and AR18 were found to follow pseudo first-order kinetics with half-lives of 28, 36 and 39 hours, respectively. A010 was degraded via pseudo zero-order kinetics with a half-life of 52 hours. The kinetics of AR14 was not determined. The Energy of Activation ( $E_a$ ) of the A07 abiotic degradation reaction was determined to be 50 kJ/mol. The rate of the reaction was enhanced by raising temperature, raising electron donor concentration, or lowering the pH of the reduction system. These observations are consistent with this reaction be-

ing a redox reaction rather than a free radical reaction. Aromatic amines, which are potential carcinogens, were identified as initial dye degradation products for some abiotic reaction systems.

Since the physicochemical conditions (pH, redox potential) in the laboratory system are comparable to those found in the environmental sediments, it was concluded that many azo dyes could be degraded abiotically in anoxic environmental sediments with a half-life probably ranging from 3 to 6 for A07 (assuming the temperature range of the environmental sediments is 2-10 °C). The half-lives of other test dyes except AR88 could be of a similar order of magnitude to A07 based upon the results reported herein. Therefore, the results of the studies suggest that the azo dyes investigated most probably do not persist in environmental sediments, and their reductive degradation products, namely aromatic amines, possibly pose a significant health risk to humans. Workers involved in harbor dredging, sediment removal, and wastewater sludge processing and use may be at higher risk for exposure to the dye degradation products via this source.

#### EVALUATION OF A PORTABLE PROTOTYPE X-RAY FLUORESCENCE INSTRUMENT FOR THE MEASUREMENT OF LEAD IN DUST WIPE SAMPLES

By: Daniel T. Woody  
1999 Master of Science

The U.S. Department of Housing and Urban Development (HUD) and the U.S. Environmental Protection Agency have guidelines for acceptable levels of lead loading for floors, window sills, and window troughs. The on-site analysis of lead dust wipe samples using a prototype portable X-ray fluorescence (XRF) analyzer (Niton-701) with a sample holder and stand would provide real time results for risk assessments and clearance determinations for abatement projects. XRF analysis does not require extraction or other sample preparation which existing field and most laboratory methods (wet chemical) employ.

A total of 194-dust wipe sample were collected from various areas for risk assessment and clearance purpose. PaceWipes and Wash'nDri wipes were used to collect dust wipe sample from smooth floors and window troughs. The wipe sample lead loading range of the data set was 2.25 ug/ft<sup>2</sup> (2.42E-02 ug/cm<sup>2</sup>) to 59,700 ug/ft<sup>2</sup> (64.26 ug/cm<sup>2</sup>), based on values from laboratory Graphite Furnace Atomic Absorption (GFAA) analytical results.

Results using the XRF analyzer were compared with those of GFAA analysis using ASTM sample preparation and analysis methods. Each wipe was folded five times in order to decrease the dimensions of the wipe to 2cm x 4cm. The Niton-701 has a 1cm x 2cm detection window, allowing for a total of four readings, one in each of the four quadrants of the wipe to cover the entire area of the folded wipe. The XRF instrument reports results in ug lead/cm<sup>2</sup>. Final wipe results from the XRF when compared to laboratory GFAA results showed a statistically significant correlation with an R<sup>2</sup> value of 0.96 when analyzed on an In-In scale. The best fit line had a slope of 0.08 with a y-intercept of 0.57, n=194. The linear regression equation of  $\ln(\text{XRF}) = 0.57 + 0.08 * \ln(\text{GFAA})$ , can be used to predict XRF results when the GFAA value is known. In addition, a 95% confidence interval was calculated about the best fit linear regression line. These results can be used to estimate the XRF value for which one is 95% confident to be below the desired GFAA value. This kind of tool could be a highly beneficial aid for individuals working in the field who need to make real-time decisions regarding clearance criteria requirements and assessment of health risks.

The limit of detection (LOD) was estimated using an Environmental Protection Agency method. This method estimated the LOD by conducting repeat readings of sample at or near the estimated LOD. A sample containing 20.2 ug of lead (spiked using a primary standard) was analyzed eight times using the

XRF method. The standard deviation of the mean of the eight analyses was multiplied by the student t-value for 7 degrees of freedom at the 99% confidence level. With 99% confidence, the XRF method LOD was 11.75 ug of lead/wipe sample. The limit of quantitation (LOQ) is defined as 3.33 times the LOD, which is 39.14 ug of lead/wipe sample.

The LOD and LOQ were also estimated using a NIOSH procedure. Six low level calibration standards were prepared and spiked on the sampling media, ranging from 18.1 to 29.7 ug per wipe. The LOD was determined from linear regression analysis by multiplying the standard error of regression by 3 and dividing by the slope. The LOD of the XRF method was estimated to be 15.86 ug of lead/wipe sample. The LOQ was calculated by multiplying the LOD by 3.33, yielding a result of 52.83 ug of lead/wipe sample.

The XRF method precision was estimated by conducting eight repeat analysis of twenty wipe sample ranging from 182.7 ug of lead/wipe sample to 8867.5 ug of lead/wipe sample. The mean of the eight repeat results was divided by the standard deviation to yield a point precision estimate for each sample. The mean of the point precision estimates was used to determine the XRF method precision estimate as  $0.023 \pm 0.011$  (95% confidence interval).

The XRF method bias was estimated by subtracting the laboratory method analytical value (GFAA) from the XRF analytical value and then dividing by the laboratory analytical value for each of the samples. This provided a point bias estimate for each sample, and the mean of these point estimates is the total bias estimate. The bias estimate was determined to be  $-0.399 \pm 0.10$  (95% confidence interval).

The accuracy of the XRF method was estimated by dividing the XRF analysis result by the GAFF analysis result for each sample. The GAFF analytical results are assumed to be the "true" values for each wipe sample. This provided an accuracy point estimate for each of the samples. However, the accuracy point estimates ranged from 0.046 to 5.034, and therefore the mean value of these point estimates would be severely impacted by the extreme range of values. The median value for the accuracy point estimates would not be affected by the fluctuation of values and was utilized to estimate the accuracy of the RF analysis method. The XRF analysis method accuracy was calculated to be 34% with a 95% confidence interval of  $\pm 10\%$ .

These data support the on-site use of the portable Niton-701 analyzer with sample holder and frame as an acceptable method for estimating lead loadings of dust wipe samples.

#### DETERMINATION OF KNOWN EXHALATION VALVE DAMAGE USING NEGATIVE PRESSURE USER SEAL CHECK METHODS ON FULL FACE RESPIRATOR

By: Lisa J. Delaney  
1999 Master of Science

Employees wearing respirators in industrial settings rely on positive and negative pressure user seal checks to assess respirator fit. However, few studies have been performed to determine the adequacy of user seal checks in detecting poor fitting or damaging respirators. In this study, a negative pressure user seal check (NPUSC) method was evaluated for its ability to adequately detect known exhalation valve damage. Three damaged exhalation valves and one undamaged valve were used in the study. The exhalation valve damage included a warped valve, a valve with three slits, and a valve with a small amount of glue. Twenty-six test subjects, wearing North full-face piece respirators were asked to perform a NPUSC. Their response as to whether or not they passed the test were compared to the quantitative fit testing from both ambient aerosol and controlled negative pressure measurements. In addition, in-mask pressure differentials were measured using the Respirator Leak Checker (RLC) during the performance of NPUSCs. The RLC<sup>TM</sup> was developed in this laboratory as a more reliable method to assess the ability

of respirator wearers to properly conduct user seal checks. The data were analyzed to determine if the negative pressure user seal check procedure is an effective method for detecting known exhalation valve damages in full face-piece respirators. All test subjects reported passing the NPUSC with the undamaged valve. With the respirators equipped with the valve with slits, 73% of test subjects reported passing the NPUSC. With the respirators equipped with the valve with adhesive, 65% reported passing. All fit factors were below the Occupational Safety and Health Administration recognized pass/fail criteria except one test with the respirator equipped with the slit valve. Results from the RLC<sup>TM</sup> confirmed whether or not the subject properly conducted a user seal check, but did not detect respirators leakage. In conclusion, NPUSC performed by the user rarely identified damaged exhalation valves.

#### EVALUATING THE RISK FACTORS LEADING TO LOSS OF BALANCE DURING TASK PERFORMANCE ON ELEVATED/INCLINED SURFACES

By: Ruphong Liang  
1999 Master of Science

Evaluating the effect of the risk factors (age, weight, height, reaction time, environmental lighting, and visual cues) on task performance on elevated/inclined surfaces is the purpose of this study. A synchronized 5-camera video recording system was used in recording and collecting the 3-dimensional planes using the Video Bases Automatic Human Body Motion Analysis System (VBAHBMAS). The videotapes from 3 video cameras were digitized to quantitatively capture the movement of body segments in space. VBAHBMAS calculated the 3-dimensional coordinates and vectors of the whole body Center of Gravity (CG) with the digitized kinematics data. Comparing CG with the 3-dimensional coordinates and vectors of the whole body segments, Loss of Balance Variables-FSB (Functional Stability Boundary), WRTI (Weighted Residence Time Ratio), and IPSB (index of Proximity to Stability Boundary) were calculated. Nineteen subjects performed three tasks (stationary, bending, and reach) in a repeat fashion for each combination of the treatment conditions. Those treatment conditions included different inclination surfaces (ground, 1 foot from the ground, and 2 feet from the ground), different inclination surfaces (flat, 14 degree, and 26 degree), different visual cues (none, vertical cues put in the periphery visual field, and vertical and horizontal cues in the periphery and central field), and 2 different illuminations (good lighting and poor lighting). There were 117 different combinations of treatment conditions (including 2 different tasks) for each subject. The results of the Multivariate Repeat Measurement ANCOVA (Analysis of Covariance) show that task significantly affects all the dependent variables (WRTI, minimum IPSB, and minimum FSB) with p values equal to 0.0001. Inclination significantly affects the minimum FSB with p value equal to 0.0040. Age was found to have significant effect on WRTI and minimum IPSB models. Interaction term ELEVATION \* INCLINATION has statistically significant effect on WRTI (p=0.0273). INCLINATION \* LIGHTING has significant effect on minimum IPSB (p=0.0329). The results from this study will provide a better understanding of how risk factors (Age, Weight, Height, Reaction Time, Visual Cues, and Environmental Lighting) affect the task performance on elevated/inclined surfaces. Further study is needed to combine electromyography measurement outcome into analysis.

#### THE EFFECT OF WELD PROCESS AND VENTILATION METHOD ON PHYSICAL WORKLOAD, WELD FUME EXPOSURE, AND WELD PERFORMANCES IN A CONFINED-SPACE WELDING TASK

By: Steven J. Wurzelbacher  
1999 Master of Science

Shipyard welders, especially those working in confined-spaces, have not been adequately studied as an occupational group in terms of ergonomic factors affecting worker safety and performance. Such work-

ers typically weld in conditions that provide inadequate ventilation and that require static muscular work and awkward postures. Thus, the need for such research exists to establish the effectiveness of engineering interventions such as static load reduction and alternative ventilation methods on the basis of reducing musculoskeletal/physiological demand and weld-fume exposure among confined-space welders while also improving worker performance.

To accomplish these aims, this study measured the effect of weld process and ventilation method on the physical workload, weld fume exposure, and weld performance associated with a simulated confined-space welding task. Nine male welders from a participant shipyard performed eight flat welding tasks [four wire-fed welding tasks (Flux Core Arc Welding or FCAW) and four stick-welding tasks (Shielded Metal Arc Welding or SMAW)] in a functional mock-up. This mock-up was constructed by NIOSH to match the actual dimensions (~2ft\*2ft\*16ft) of a particular type of barge hull assembly-honeycomb. This honeycomb requires inside welding during its manufacture at the participant shipyard. During these tasks, ventilation method was alternated between a standard air horn and a fresh air diffuser prototype. Heart rate, Ratings of Perceived Exertion (RPE), Discomfort Assessment Surveys (DAS), total personal particulate concentrations ( $\text{mg}/\text{m}^3$ ), and area elemental concentrations ( $\text{mg}/\text{m}^3$ ) from air samples were recorded for each task. In addition, welding performances in terms of weld quality (as determined by an expert welder) and weld efficiency (arc time/ total weld time) was also determined by videotape analysis for each task.

Overall, statistical results (ANOVA) indicated that weld process (wire and stick welding) had a significant effect on workload and weld performance. Specifically, wire welding was associated with significantly higher RPE's ( $p=.0001$ ), general DAS outcome ( $p=.0076$ ), and weld efficiency ( $p=.0335$ ) while stick welding was associated with significantly higher weld quality ( $p=.0001$ ). Furthermore, ventilation method was found to have a significant effect on weld-fume exposure such that the standard air horn was associated with lower total particulate concentrations and area elemental concentrations in many cases exceeded the established NIOSH TLV/TWA's for stick and wire processes, using both ventilation methods. Thus, it is suggested that additional air sampling be conducted on the actual confined-space welding task that this study modeled so that alternative ventilation methods can be devised.

In conclusion, this study suggests that engineering interventions for confined-space welders involving weld process and ventilation method changes should be considered carefully because of the potential significant impact on workload, weld-fume exposure, and weld performance. Since the wire welding process may be associated with higher subjective workloads, it is suggested that musculoskeletal injury rates and air quality measures be closely monitored before and after any specific process change. Since current ventilation methods appear to be inadequate, it is suggested that additional air sampling be conducted on the actual confined-space welding task that this study modeled. Based on the results of this sampling, further ventilation control research and alternative PPE options (e.g. full face air purifying respirators, positive pressure supplied air respirators) may be needed.

#### RESIDUAL PESTICIDES IN HOUSING AND BEDDING AT MIGRANT LABOR CAMPS IN NORTHWESTERN OHIO: A FOLLOW-UP INVESTIGATION

By: Tonya B. Solomon  
1999 Master of Science

Few data are available regarding residual home pesticide exposure of migrant farm workers and their possible health effects. The purpose of this investigation were to evaluate the potential exposure of migrant workers to residual pesticides that may be carried from the field into labor camp housing, to docu-

ment hygiene practices and to conduct postural sway measurements to detect subtle changes in a person's ability to maintain upright balance.

Interviews were conducted with 26 migrant workers and family members to evaluate conditions that could contribute to potential pesticide exposure, such as personal hygiene facilities and practices, laundry facilities and practices and use of protective equipment. 36% of the respondents had received safety training about pesticides; 52% used personal protective devices; 100% indicated that they showered daily and washed their hands after work in the field; 68% indicated they washed their bedding weekly.

Dust samples were analyzed for pesticides and metals. The metal analysis showed that there were not any significant amounts detected above the outdoor soil samples. Analysis for several pesticides, lindane, azinphos-methyl, diazinon, carbaryl, and methoxychlor demonstrated that the pesticides were below the limit of detection (ppm) of the instrumentation that was used. Analysis should be repeated with the correct methodology and instrumentation that is sensitive to a limit of detection in the ppb range.

Evaluation of bed linens showed areas of apparent contamination, as measured by comparison to a gray scale. Chemical analysis of the bedding should be conducted using methods that will detect pesticides in ppb concentration.

The results of the study were not conclusive to detect any associations between practices, and house contamination. Instrumentation that is more sensitive to low residual levels needs to be investigated.

#### EFFECT OF SAMPLING TIME AND RELATIVE HUMIDITY ON BIOEFFICIENCY OF FILTER SAMPLERS COLLECTING BIOAEROSOLS

By: Zheng Wang  
1999 Master of Science

The effect of sampling time on the bioefficiency of two personal filter samplers (the Button Aerosol Sampler and the 37-mm standard cassette) was investigated for the collection of airborne microorganisms under a relative humidity of 30% and 85%. Test microorganisms consisted of *Penicillium melinii* fungal spores, *Bacillus subtilis* endospores and *Pseudomonas fluorescens* vegetative cells. Polycarbonate filters mounted in the samplers were challenged with aerosolized microorganisms and air was drawn through the samplers for a period of time ranging from 2 minutes to 8 hours. A modified CAMNEA method (Collection of Airborne Microorganisms on Nuclepore filters, Estimation and Analysis) was used to analyze the viable and total microorganisms from the filter by vortexing and ultrasonic agitating, and analyzing the extraction suspension by cultivating and epifluorescence microscopic counting. The extraction efficiency of this method was found to be 96-98%. Furthermore, it was revealed that the ultrasonic agitation did not cause further injuries to sensitive *P. fluorescens* in addition to the vortexing stress.

The effect of sampling time varied greatly depending on the microbial species collected. For *P. melinii* spores, a consistent relative culturability of 65-80% could be maintained at a relatively humidity of 30% during a sampling period of 30 minutes to 8 hours. There was no significant difference in the relative culturability of *P. melinii* when the relative humidity was increased from 30% to 85%. The relative culturability of *B. subtilis* spores decreased from 17% to 5% by increasing sampling time from 5 minutes to 4 hours at the relative humidity of 30%. The performance of filter samplers collecting *B. subtilis* can be improved by increasing the relative humidity from 30% to 85%. The sensitive *P. fluorescens* cells were not able to recover when collected under a relative humidity of 30%. When the relative humidity was increased to 85%, the relative culturability of *P. fluorescens* cells were not able to recover when collected under a relative humidity of 30%. When the relative humidity was increased to 85%, the minutes and 0%

with sampling of 30 minutes or longer. This investigation suggests that sampling time and relative humidity are critical factors influencing performance of filter samplers collecting airborne microorganisms.

#### FUNCTIONAL LOCOMOTION AND GROSS AND FINE NEUROMOTOR PERFORMANCE IN CHILDREN WITH CHRONIC LEAD EXPOSURE

By: Edward D. Auyang  
July 2000 Master of Science

Functional locomotion and fine and gross motor performance were studied for ninety-five children with chronic lead exposure [mean age: 72.0 months (range: 64-90); mean initial blood lead: 27.9  $\mu\text{g}/\text{dl}$  (range: 20-44); mean blood lead: 15.77  $\mu\text{g}/\text{dl}$  (range: 6.19-33.93)]. Functional locomotion was assessed using kinetic gait analysis. Ninety-five children were included for neuromotor and neuropsychological analysis. Of the ninety-five, seventy-eight had completed the gait protocol at the time of analysis. The gait protocol consisted of four trials each of three tasks: 1) walking normally, 2) walking and stepping over an obstacle placed at mid-patella height, and 3) walking along a line. Analysis yielded the gait parameters of maximum vertical force, cycle time, and excursion distance. The Bruininks-Oserstsky Test of Motor Proficiency and the NEPY neuropsychological assessment were administered to all ninety-five subjects. The BOTMP Balance, Bilateral Coordination, and Fine Motor Composite subtests and the NEPSY Sensorimotor and Visuospatial Domain subtests were used for analysis. The gait and test battery variables were examined for their associations with various blood lead variables including initial blood lead, second visit blood lead, follow-up blood leads post-treatment, maximum blood lead, and average blood lead.

Analysis showed statistically significant positive correlations ( $p < 0.05$ ) between blood lead and maximum medial (obstacle walk), maximum lateral (normal walk and line walk), and maximum vertical force (normal, obstacle, and line walk). Multivariate regression analysis verified these relationships. The increase in forces suggests increased effort required by the subject to maintain balance. This indicates that a neuromotor deficit may be present. Statistically significant associations were not found between blood lead and neuromotor test batteries. Several statistically significant correlations were found between BOTMP Fine Motor Composite, maximum medial force, and maximum lateral force. Regression analysis yielded a marginally significant ( $p = 0.06$ ) model relating maximum medial force with BOTMP Fine Motor Composite for the obstacle walk. The findings of the study suggest that there are lead-associated changes in functional locomotion that result in increased exertion of force in order to compensate for neuromotor deficits due to chronic lead exposure.

#### EVALUATION OF HOUSE DUST FROM BEDDING AND FLOORS TO DETERMINE POTENTIAL PESTICIDE EXPOSURES AT A MIGRANT LABOR CAMP IN NORTH WESTERN OHIO

By: Terry M. Bliss  
2000 Master of Science

Migrant farmworkers' chronic exposure to pesticides by direct and secondhand routes potentially places them at increased risk of developing numerous health problems (Moses, 1989, Zahm and Blair, 1993). A pilot study funded by the National Institute of Occupational Safety and Health (NIOSH) was conducted to evaluate potential exposure of migrant workers to residual pesticides that may be carried from the field into labor camp housing. Contamination of living spaces was evaluated by collection of dust sample in bedding such as mattresses and bed covers, and floor areas, including the entryways, and steps and near beds. All sampling was conducted at a vegetable farm in Northwestern Ohio. Samples were fractionated to  $< 250\mu\text{m}$  size particles and analyzed. This fraction has been found to be important in dermal exposure

assessment characterized for soils (Driver et al., 1989). Subsequent analysis of samples was conducted to determine the amount of heavy metal that are used or were formerly used in pesticides formulations. These include the heavy metals lead, arsenic, copper and Zinc (Ohio State University, 1990).

Results of metals analysis found concentrations from 1.4 to 2.7 times background in floor samples and 2.5-5.2 times background for bedding samples using background levels from soil sample taken in a neighboring county. Using the t-test, the differences between house dust samples and background soil were found to be statistically significant in all but lead in the floor samples. Additionally bedding samples were found to have statistically significant higher concentration of heavy metals than floor samples, except for Arsenic.

Common organic pesticides that are used for pest control on crops grown in the region may include azinphos-methyl, carbaryl, diazinon, endosulfan, lindane, malathion, methomyl, methoxychlor and methyl parathion (Ohio State University, 1997, Ohio State University, 1990). A Soxhlet extraction procedure was performed on the samples to perform organic pesticide analysis, but only sample was analyzed. High concentrations of fatty acids were detected, but no pesticides. A cleanup procedure must be developed and completed to separate any potentially existing pesticides from the organic matrix.

The results of this research will be useful to public health authorities or community development and assistance groups. These agencies are charge with developing and implementing programs to assure that the workplace and living spaces for migrant labor personnel and their families are healthful.

#### THE CORRELATION BETWEEN QUARTZ MEASUREMENTS BASED ON LOCATION AND TYPE OF SAMPLES FOR SEVERAL DUSTY TRADES INDUSTRIES IN NORTH CAROLINA

By: Timothy V. Rittgers  
2000 Master of Science

The North Carolina Dusty Trades program was started in 1935 in response to the recognition of various occupational hazards, including silica. One of the provisions of this program was to determine hazards and make recommendations to reduce silica exposure to workers. To determine the potential hazard, air sampling was conducted. The air sampling results from the occupational and environmental information contained in this data for 12 mining and mineral commodities were used as the information source for this thesis.

The cyclone air sampling information (in milligrams per cubic meter) was converted to count data (million particles per cubic foot) using a formula developed by Dr. Carol Rice. This information was then used to determine if a linear relationship exists between converted cyclone data and a concentration of respirable silica based upon the mineral commodity. It was found that simple linear regression modes were appropriate for seven of the twelve commodities. These were feldspar/mica, foundry, granite, kaolin, lithium, others, and crushed stone. It is reasonable to assume that these models may be used to estimate the reasonable to assume that these models may be used to estimate the respirable silica concentration based upon actual impinger result. This estimate could then be used in retrospective silica exposure studies to better predict the concentration of respirable silica a worker may have been exposed to. Due to the small numbers of samples used to develop the models, other groups of comparable data should be investigated.

The data from the North Carolina Dusty Trades program was also used to determine if there is any correlation between area hi-volume cyclone and corresponding personal cyclone respirable silica percentages

for several mineral commodities. The personal cyclone and hi-volume cyclone data were not significantly correlated.

#### THE RELATIONSHIP OF URINARY 1-HYDROXYPYRENE AND DNA ADDUCT LEVELS FROM ENVIRONMENTAL TOBACCO SMOKE EXPOSURE

BY: Scott Anthony Henn  
2001 Master of Science

Smoking is believed to be the single most important risk factor for developing bladder cancer. Tobacco smoke consists of many known and suspected human carcinogens. Many of these compounds have been measured at higher levels in ETS than in mainstream smoke. Since 1981, it has been known that spouses of smokers, who are exposed to ETS, are at increased risk for cancer. Biomarkers have been used for years to give researchers an indication to an individual's level of exposure and potential for health effect resulting from harmful xenobiotics. The two most frequently used and widely accepted biomarkers for exposure to tobacco smoke with regards to bladder cancer are urinary 1-HP and DNA adducts found in exfoliated urothelial cells. This study was conducted to investigate the relationship that exists between the two biomarkers of environmental tobacco smoke exposure. Urine samples from 39 women, of which 21 were spouses of smokers and 18 were spouses of non-smokers, were analyzed to quantify levels of 1HP and total DNA adduct levels. Analysis of the 1HP was performed using an HPLC with fluorescence detection. DNA adducts in exfoliated urothelial cells were assessed by <sup>32</sup>P-postlabeling. This study failed to produce statistically significant results in evaluating the mean differences of 1HP and total DNA adducts between the two smoking groups; and the relationship between 1HP and total DNA adducts within the groups. Measurable differences in mean levels of 1HP, without an outlier, were obtained with a 1.4 fold increase in spouses of smokers along with a 2.5 fold increase in total DNA adducts. There are discrepancies that exist between the biomarkers, suggesting that there are other variables, most likely genetic, that play a role in health effects. The findings in this study are significant because it does show that there are measurable differences between the two smoking groups. The exposure source in this study was very low because it was limited to exposure from spousal smoking. The ability to distinguish a difference between non-exposed and exposed individuals with both biomarkers causes this to be an area that will receive a heightened interest and research in the future.

#### DETERMINATION OF THE FEASIBILITY OF USING THE PORTABLE X-RAY FLUORESCENCE (XRF) ANALYZER IN THE FIELD FOR MEASURING THE LEAD CONTENT OF SIEVED SOIL

By: Andrea M. Armstrong  
2002 Master of Science

Soil samples collected in areas with potential lead contamination are generally analyzed using flame atomic absorption spectrometry (FAAS), inductively coupled plasma emission spectrometry (ICP-AES) or other laboratory methods. Laboratories, generally prepared sample for analyses by drying, and sieving to a homogenous fraction followed by acid digestion, all of which usually takes several days. Previous work has indicated that a field-portable x-ray fluorescence (XRF) analyzer is capable of producing soil lead results that are comparable to results by FAAS or ICP-AES. There would be considerable savings in time and effort if a field method, including sieving, could be developed, which does not require laboratory digestion and analysis. Results could, therefore, be reported in a timelier manner to residents and others shortly after sample collection. The goal of this study was to determine the practicality of using the portable XRF analyzer in the field for analysis of lead on field-sieved soil samples. The practicality of using the XRF was determined by the amount of time it took to prepare and analyze the samples in the field and by the ease in which the procedure could be accomplished on site.

Other objectives of the study included determining the effects of moisture on sieving the soil. When performing the field analysis, soil samples were desegregated and ground using a mortar and pestle and sieved through a No.120 sieve pan to obtain particles < 125 $\mu$ m. Soil samples were obtained from yards of Cincinnati area housing built before 1978.

Seventy-eight samples were collected and analyzed at 30 different locations. Mean soil lead concentrations were 816 ppm before drying and 817 ppm after drying by portable XRF, and 1042 ppm when digested and analyzed by FAAS. Correlation of field portable XRF and FAAS results were excellent for samples sieved to less than 125 $\mu$ m with R-squared values of 0.992 and 0.9903 before and after drying respectively. The percent saturation of the soil ranged from 10% to 90%. At 65% saturation soil will not pass through the sieve, therefore the field method with sieving is not practical when the soil is 65% saturated or higher.

#### PRACTICALITY OF USING AIR LEAD MEASUREMENTS BY PORTABLE X-RAY FLUORESCENCE TO MANAGE WORKER PROTECTION PROGRAMS

By: LT Edward L. Bock III, USCG  
2002 Master of Science

The purpose of this research was to determine the practicality of using airborne lead measurements obtained with field portable x-ray fluorescence (XRF) technology to manage worker protection programs. The NITON<sup>®</sup> XL-700 Series XRF was used to measure airborne lead samples from the U.S. Coast Guard Barque EAGLE while undergoing repairs at the Coast Guard Shipyard. Lead-based paint was used extensively during construction of EAGLE, which was completed in 1936 in Hamburg, Germany.

47 airborne lead samples were collected in 37mm cassettes on mixed cellulose ester filters over two weeks. Twenty (20) personal and twenty-seven (27) area samples were obtained. Samples collected during week one were analyzed by XRF the following Sunday, when no work was scheduled on EAGLE. Samples obtained during week two were analyzed daily with field portable XRF. The samples were analyzed using NIOSH Method 7702, Lead by Field Portable XRF to determine lead mass. Using known air volume and lead mass, airborne lead concentration was calculated. To verify instrument performance, the samples were later analyzed by NIOSH Method, 7082, Lead by Flame AAS.

The range of airborne lead concentration was 8 to 939 $\mu$ g/m<sup>3</sup>. With daily monitoring by field portable XRF, airborne lead concentration was reduced 77 percent from week one to week two. The average concentration was 176.9 $\mu$ g/m<sup>3</sup> during the first week, while the average was 41.3 $\mu$ g/m<sup>3</sup> during the second. With the exposure data gathered in near real-time, workers reduced concentration by implementing controls including vacuum equipped tools and improved ventilation. On twelve (12) occasions during week one, workers engaged in jobs that produced airborne lead concentrations that exceeded the action level. During week two, when daily monitoring by field portable XRF was instituted, workers exceeded the action level six (6) times.

Provided that a sheltered workspace with minimal distractions is available to conduct analysis, field portable XRF technology was found to be an excellent tool to quickly analyze airborne lead in a dynamic work environment. Laboratory analysis, which can take weeks, is too slow to ensure worker health and safety in a dynamic work environment.

## COMPARISON OF TWO AERIAL DISPERSION MODELS FOR THE PREDICTION OF CHEMICAL RELEASE ASSOCIATED WITH MARITIME ACCIDENTS NEAR COASTAL AREAS

By: Teo Keong Kok

2002 Master of Science

Two computer models for predicting the aerial dispersion from chemical release were compared. The U.S. Environmental Protection Agency's (EPA) Aerial Location of Hazardous Atmospheres (ALOHA) model and the RITE Emergency Response Software model's predictions were compared. A sector of Cincinnati, which most closely resembles the coastal, urban terrain of Singapore, was chosen to test the models. Two chemicals, chlorine and propane, were used to simulate accidental releases. Release data for a range of meteorological conditions were input to both methods. The plume travel directions and maximum plume travel distance at Immediately Dangerous to Life and Health (IDLH) values from source were predicted by the models. Results were compared by paired t-Test and Analysis of Variance methods. Analysis showed statistically significant difference ( $p=0.001$ ) between the predicted angles of the ALOHA and RITE models. The Analysis of Variance (ANOVA) for the RITE predicted angles showed that stability class would significantly affect the predicted angle for both chemicals. Chemical type, temperature and humidity were not significantly related to the RITE model's predicted plume direction.

Analysis also showed statistically difference ( $p=0.001$ ) between the ALOHA and RITE models in predicting maximum distance at IDLH values. The ANOVA for the RITE model predicted distance at IDLH values showed that both stability class and chemical type were statistically significant predictors of distance at IDLH values. Temperature and humidity were not significantly related to the RITE model's predicted maximum plume distance.

The finding of the study suggested that the RITE model is the preferred one to use as it takes into account wind steering effect as well as topography of the site. The model should be used to evaluate a range of release scenarios as a planning test. The result will be useful to emergency responders in planning and test. The result will be useful to emergency responders in planning and preparation activities.

## IMPACT OF ARSENIC ON BENZO[A]PYRENE DNA ADDUCT LEVELS IN SKIN AND LUNG IN THE MOUSE

By: Craig D. Evans

2002 M.S.

Concomitant exposures to arsenic and polycyclic aromatic hydrocarbons (PAHs) such as benzo[a]pyrene (BaP) are widespread. BaP acts by binding to and mutating critical sites on DNA; the mechanism(s) of arsenic carcinogenesis remains unknown. Data from epidemiological studies of arsenic copper smelter workers and arsenic ingestion in -drinking water suggest a positive interaction for arsenic exposure and smoking and lung cancer. A previous in vitro study showed that arsenic potentiated the formation of DNA adducts at low doses of BaP and arsenic. The present study was conducted to test the effect of arsenic on BaP DNA adduct formation in vivo.

We hypothesized that arsenic would significantly increase BaP adduct levels in C57BL/6 mouse target organs: skin and lung. Treatment groups were: 5 mice, - BaP / - Arsenic; 5 mice, - BaP / + Arsenic; 15 mice, + BaP / - Arsenic; and 15 mice, + BaP / + Arsenic. Mice were administered 0.5 mg/kg of sodium arsenite in drinking water, ad libitum, for 13 days (starting 9 days before BaP treatment), and 200 nanomoles BaP / 25 ml acetone (or acetone) was applied topically, once/day for 4 days. DNA was extracted from tissues and assayed by  $^{32}P$ -postlabelling. Statistical comparisons were made using independent t-

tests (unequal variances assumed). The BAP adduct levels in the + BaP groups were significantly different than - BaP controls. Arsenic treatment increased BAP adduct levels in both lung and skin; the increase was statistically significant in the lung ( $p = 0.038$ ). However, skin BAP adduct levels appeared related to skin arsenic concentration. These results corroborate our in vitro findings and provide a tentative explanation for arsenic and PAHs interactions in lung carcinogenesis.

**APPENDIX C**  
**PRESENTATION ABSTRACTS 1997 – 2002**  
**INDUSTRIAL HYGIENE**

**1997**

**A SIMPLIFIED APPROACH TO TESTING PERSONAL INHALABLE AEROSOL SAMPLERS.**  
*O. Witschger, K. Willeke, S. Grinshpun, V. Aizenberg, University of Cincinnati, Cincinnati, OH; J. Smith, P. Baron, NIOSH, Cincinnati, OH*

The suggested protocol for comparison of samplers with the ACGIH inhalable sampling convention has been found by several researchers to be expensive, time-consuming, difficult, and imprecise. The present work was initiated to reduce the cost and improve the accuracy of the test protocol by mounting samplers on a simplified test body instead of a full-sized manikin. The approach was tested by first ensuring that the flow field near the sampler was similar for the full-sized manikin as for the simplified test body. The simplified test body consisted of a rectangular body with a sampler situated in the center of each vertical face. The three principal sampling regimes encountered with a manikin-mounted sampler are represented by this simpler body: isoaxial sampling, 90-degree sampling, and sampling in the wake of the manikin. The velocity vectors along trajectories approaching two commercial inhalable samplers on the manikin and on the simplified test body were measured in a wind tunnel using a 3D laser Doppler velocimeter and by smoke stream observations. The manikin results indicated a range of flow fields depending on the specific manikin, the sampler location, the symmetry of the manikin's body, and the orientation of the manikin's arms. The measurements on the simplified test body indicated that the airflows approaching the samplers fall within the range of flow patterns on a manikin. A measurement of 70  $\mu\text{m}$  particles at 50 and 200 cm/s indicate that the two bodies give equivalent results at each of the three sampling angles. The advantage of the simplified test body is that fewer measurements need to be made, a smaller wind tunnel can be used for testing and less aerosol has to be generated. Faster, less expensive and more precise testing will allow the evaluation of a greater variety of inhalable samplers for industrial hygiene use.

**CARPENTERS' PERCEIVED EXERTION AND BODY DISCOMFORT SYMPTOMS ASSOCIATED WITH THEIR TASKS -- AN ON-SITE EVALUATION .** *Dimov, H. Applegate, R. Stinson, Greater Cincinnati Occupational Health Center, Cincinnati, OH; A. Bhattacharya, Y. Li, G. Lemasters, University of Cincinnati, Cincinnati, OH; L. Greathouse, Texaco, Inc., Houston, TX*

The purpose of this study was to determine how carpenters subjectively perceived the exertion level and body discomfort associated with their daily tasks. Two psychophysical instruments were utilized in this study. The Borg's whole body physical exertion instrument, a measure of overall physical demand, and the body segment (modified Bishop-Corlett Scale) instrument, a measure of rating pictorial body segmental discomfort, were given to 65 carpenters at the work site after the end of their shift. Carpentry specialties evaluated on-site were ceiling, drywall, concrete form work, finish work, piledriving, fixtures, welding, and scaffolding. The mean Borg's score for the subjects combining all specialties was 14.4 (2.4 SD), a score between "somewhat hard" and "hard," for perceived overall physical effort demanded by the task. Results indicate that the perception of whole body physical exertion was a direct indication of the specific task-associated exertion and was not influenced by age nor the number of years as a carpenter. The findings from the body segment discomfort scale of the total group, indicates that the top three discomfort frequency by body segments were mid- to lower back (54.6%), knees (41.7%), and the neck (35.3%). Significant differences by body segment discomfort in a multivariate comparison among specialties appeared for two specialties: drywall, with back (63.3%) and knee (54.5%) discomfort were higher than other body segments ( $p=0.03$ ); and finishing, with hand/wrist (80.0%) higher than all other body segments ( $p=0.03$ ). Project funded by National Institute for Occupational Safety and Health and work performed at the Greater Cincinnati Occupational Health Center.

EFFECT OF COLLECTION MEDIUM ON SURVIVAL OF AIRBORNE BACTERIA COLLECTED BY ELECTROSTATIC METHOD. *G. Mainelis, K. Willeke, S. Grinshpun, T. Reponen, V. Ulevicius, P. Hintz*

Most of the current bioaerosol sampling methods employ mechanisms of impaction or impingement that are known to impart significant stress on microorganisms during the collection process. By electrically charging the bioaerosol particles and then transporting them through an electric field, the particles can be gently removed from the air flow to a collection medium. However, our tests have shown that this works only if the process of bringing the bioaerosol particle in contact with the collection medium is done in a non-traditional way.

The tests were performed with a commercially available Electrostatic Aerosol Sampler (model 3100, TSI Inc., St. Paul, MN) that was modified to hold an insertable collection trough. Experiments with *Pseudomonas* fluorescence bacteria have shown that the electrostatic precipitation section effectively removes the bacteria to the top of the agar surface; however, since the bacteria "gently land" on the agar surface, they are insufficiently coupled to the agar for effective colony growth.

When the bacteria were collected and submerged into a liquid medium and then transferred onto agar, the bacterial recovery rate increased by one to two orders of magnitude in comparison to direct collection on agar. Physical collection efficiency of the modified Aerosol Sampler thus exceeded 80 percent when collecting *P. fluorescens* at a flow rate of 1 L/min. In order to assess the level of injury sustained by bacteria in the electrostatic precipitator, two types of injuries were measured: metabolic and structural.

TIME-WEIGHTED POSTURE INTENSITY EXPOSURE ASSESSMENT OF CARPENTRY TASKS AT CONSTRUCTION SITES *A. Bhattacharya, Y. Li, G. Lemasters, University of Cincinnati, Cincinnati, OH; M. Dimov, R. Stinson, Greater Cincinnati Occupational Health Center, Cincinnati, OH*

As carpentry tasks have a long cycle time, a posture intensity assessment should include contribution of time associated cumulative changes in the posture. At 16 construction sites, 33 hours of arm and back posture data were collected on 22 carpenters using a portable ergonomic dosimeter in order to quantitate time-weighted posture exposure intensity associated with ergonomic loading for 3 carpentry specialties: ceiling, drywall and form work. The time dependent data (collected every one second) of arm and back posture angles were assigned a weighting according to a second order polynomial expression of "neutral," "low," "medium," "high," and "very high" risk posture categories. For the arm posture, the weights were "Neutral (-20 &#lt;math>\alpha</math> 20)" :: 12/14; "Low (20 &#lt;math>\alpha</math> 45)" :: 12/14; "Medium (45 &#lt;math>\alpha</math> 90)" :: 12/14; "High (90 &#lt;math>\alpha</math> 135)" :: 22/14 and "Very High (135 &#lt;math>\alpha</math>)" :: 32/14. Similar weightings assigned for back postures were: "Neutral (-20 &#lt;math>\alpha</math> 20)" :: 12/14; "Low (20 &#lt;math>\alpha</math> 45)" :: 12/14; "Medium (45 &#lt;math>\alpha</math> 90)" :: 22/14 and "High (90 &#lt;math>\alpha</math>)" :: 32/14. The total weight=12+22+32=66. These weightings were assigned to every data point for each carpenter. With the above weighting strategy the posture exposure intensity was then calculated as the time-weighted average (TWA) value. The results show that arm loading for ceiling task (TWA 7.4 +/- 5.7) was significantly higher than that for form work task (2.2 +/- 0.55); back loading for ceiling task (3.3 +/- 1.65) was significantly lower than that for form work and drywall (9.7 +/- 5.0, 5.7 +/- 2.2). In summary, the method used to quantitate and characterize posture loading allowed us to include the contribution of time dependent changes in postures associated with carpentry tasks

USE OF GEOGRAPHIC INFORMATION SYSTEM FOR DETERMINATION OF EXPOSURE DUE TO ENVIRONMENTAL LEAD. *R. Bagchee, C. Clark, University of Cincinnati, Cincinnati, OH*

Exposure to environmental lead is a critical problem, especially for children. Years of particulate fallout of lead from automobile exhaust and degradation of lead-based paint has contributed to elevated lead content in the household dust, which results in an increased exposure of children living in or near areas

with elevated levels of interior dust lead. Geographic Information System (GIS) is a computer-based system that provides a powerful visualization tool for handling spatially related data. Under the Cincinnati Soil Lead Abatement Demonstration Project, six areas of Pendleton, Mohawk, Findlay, Glencoe, Back, and Dandridge were sampled for interior and exterior lead over a period of time. The measured lead level distribution from the Pendleton area was mapped into a GIS level, merging it with a multilayered digitization of the geographical data from the same area. All the soil sample locations at the Pendleton area were digitized by sampling sites, parcels, and sampling line as subpolygons within the soil coverage. The use of GIS in merging the multilayered data has allowed the data to be organized by spatial reference, and facilitated the maintenance and visualization of the lead exposure levels. The spatial relation between soil lead data and family-based data such as the lead concentration of the sampled interior dust was evaluated. The open-ended multilayered structure of the database maintains the capability of upgrading further detailed information as it becomes available from other additional studies. Thus, the use of GIS in the determination of environmental lead exposure enhances the visual representation, allows the study of what-if scenarios, and allows better management of data, while maintaining accuracy and speed of parallel sets of data, allowing better evaluation of the environmental lead impact.

USE OF VISUAL CUES IN REDUCING THE RISK OF FALL DURING WORK AT ELEVATED AND/OR INCLINED SURFACES. *Bagchee, A. Bhattacharya, P. Succop, M. Medvedovic, University of Cincinnati, Cincinnati, OH*

As per the Bureau of Labor Statistics, falls from elevated and/or inclined surfaces at construction sites are one of the major causes of fatality and injury. Visual input received by the worker at inclination/elevation is modified, adding to the increased burden on the postural balance. This study was designed to use strategically placed visual cues in the visual field of the subject to reduce the risk of fall by minimizing the postural imbalance. Ten subjects (age=38.55 +/-9.2 years) participated in this study. A combination of two elevations (0 inches and 24 inches), two inclinations (0 degrees and 26 degrees), and seven visual cue arrangements were used. The subjects performed two tasks of 30-second duration: stationary (quiet stance) and reach (reaching forward/downward to retrieve a 5.5 lb weight from knee level). The subjects stood on a combination platform (with proper elevation and/or inclination) placed on a force plate. The enclosure walls were fitted with a combination of vertically and/or horizontally placed phosphorescent strips as visual cues. Length of the CP travel obtained from the force plate (sway length, SL) presents an indirect measure of the body's postural stability. Higher SL may be associated with greater effort in maintenance of balance. A repeated measures analysis indicated that SL increased significantly with increasing elevation and incline ( $p$  is less than 0.05). Addition of visual cues significantly lowered the SL in static tasks ( $p$  is less than 0.05). The increase in the SL with elevation was minimum for both tasks when using a visual cue involving a vertical line and a horizontal line forming an inverted T, directly in front of the subject. Results from this study would be useful in designing intervention in the workplace in the form of carefully placed visual cues that would reduce the postural imbalance in workers at elevated/inclined surfaces, thus reducing the risk of fall.

1998

AIRBORNE PARTICLE SETTLING FOLLOWING ABATEMENT WORK. *S.A. Grinshpun, K. Choe, J. Harney, S. Trakumas, M. Trunov, K. Willeke, University of Cincinnati, Cincinnati, OH; W. Friedman, HUD Office of Lead Hazard Control, Washington, DC*

The 1995 HUD Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing indicate that clearance dust sampling should be performed no sooner than 1 hour after the final cleanup to let airborne leaded dust settle. However, there is no reference given of a scientific field study in support of this recommendation. The length of this waiting period (before reentry by unprotected workers, inspec-

tors, or residents) needs to be determined through well-designed experiments using scientifically proven approaches and methodology to supplement the ab initio calculation in the guidelines.

A test chamber of 25 m<sup>3</sup> was designed and built for this study. The leaded dust was aerosolized in this chamber from lead-paint surfaces by utilizing commonly used abatement procedures. Dry and wet sanding, as well as both dry and wet scraping, were applied in each test. The changes in airborne particle size distribution and concentration were measured by dynamic techniques such as aerodynamic particle sizing, optical particle counting, photometry, and electronic microscopy from time 0 to 6 hours. The tests were conducted in conditions of calm air, moderate, and high air turbulence levels at four different ventilation rates ranging from 0.1 to 10 air exchanges per hour. Filter sampling (and subsequent electron microscopic analysis) was performed in parallel for comparison with some selected tests. The time-dependent particle size distributions and aerosol concentrations obtained by the real-time aerosol instruments were related to the time-integrated mass concentrations obtained by filter sampling and the size distributions determined by electron microscopy.

The efficiency of settling and the time characteristics of the dust settling process were found to depend on several parameters including the particle concentration, particle aerodynamic characteristics, air turbulence, and ventilation rate in the indoor environment. Thus, the particle settling time is affected by the type of abatement method, activity, and working conditions.

#### CAPABILITY OF AEROSOLIZED QUALITATIVE FIT-TEST AGENTS (SWEETENER AND BITREX) TO DETECT KNOWN LEAKAGE IN HALF-MASK RESPIRATORS. *R. McKay, E. Davies, University of Cincinnati, Cincinnati, OH*

This study was designed to evaluate and compare the ability of two qualitative respirator fit-test agents (saccharin and Bitrex) to be detected by respirator wearers, when the respirators were modified to include fixed size leaks. In recent years the number of persons who require fit-testing has increased, partly in response to the needs of health care workers with potential exposure to infectious bioaerosols. Many health care providers have chosen qualitative respirator fit-testing using saccharin and/or Bitrex for a variety of reasons, including (but not limited to) low initial equipment cost.

Respirators were modified to include a midline sampling probe between the nose and mouth for quantitative fit-testing with a TSI7 PortaCount7. A second modification included the introduction of a shortened 14-gauge intravenous catheter at the bridge of the nose. The fixed leak was designed to produce fit factors <100 when unplugged, with an average fit factor of 67 among 26 respirator wearers. A complete fit-test was not performed, since one purpose of this study was to determine the ability of respirator wearers to detect a known fixed leak during a single normal breathing exercise, without introducing unknown and potentially variable size leaks. Sensitivity threshold screening included a placebo and requirement to correctly characterize the taste of the agent used. This step was introduced after a separate field study of emergency room personnel provided unreliable responses to sensitivity threshold screening with saccharin.

Quantitative fit factors without leaks ranged from 96 to >20,000 and 22 to 160 with the leak present. Twenty-four of 26 subjects had fit factors <100 (92%) when fixed leaks were induced. All subjects correctly detected Bitrex with fixed leaks (sensitivity = 100%). Nine of 26 subjects (35%) were unable to detect saccharin in the presence of a known fixed leak even though the average fit factor for these subjects was 77. When the two subjects with fit factors >100 were excluded, saccharin only identified 16 of 24 respirators with known leaks (sensitivity = 67%).

There were several important aspects of our study design worth noting, including the introduction of a placebo during sensitivity threshold test, limiting the subject response time to a single maneuver, using a

higher concentration of Bitrex than reportedly used by others, and requiring the subjects to characterize the taste of the qualitative test agent. In conclusion, leak detection was correctly identified with Bitrex, but not saccharin.

COMPARISON OF HIGHEST SHORT-TERM EXPOSURE INTENSITY AND CUMULATIVE EXPOSURE METRICS IN A CASE-CONTROL STUDY OF SILICOSIS. *G. Liu, P. Succop, C. Rice, University of Cincinnati, Cincinnati, OH*

This report summarizes the result of an exposure-response analysis for developing silicosis with respect to the highest silica exposure task metric. Previous study of cases only demonstrated that the highest job exposure intensity during the work history was an important determinant in the development of silicosis. This is the first investigation of any relationship between silicosis and the highest exposure task (HET) metric. Two-hundred sixteen cases and 672 controls were selected from the North Carolina dusty trades files. The environmental sampling data, historical occupational data, and chest X-ray readings were collected from 1935 to 1980. Four exposure groups were defined for each metric, intensity of HET, and cumulative exposure. The correlation coefficient between the two metrics was 0.10. The means for each group were statistically different ( $p < 0.05$ ) from adjacent groups for each metric. The lowest exposure group is the referent. The odds ratio for groups 1, 2, and 3 vs. referent for both metrics were calculated using the Cochran-Mantel-Haenszel procedure. The odds ratio for HET metric were 1.21 (95% CI=0.77-1.88), 3.02 (95% CI=1.89-4.84), and 4.65 (95% CI=2.89-7.47), respectively. The odds ratio for cumulative exposure were 0.75 (95% CI=0.49-1.13), 1.91 (95% CI=1.26-2.88), and 3.65 (95% CI=2.10-6.34), respectively. The odds ratios using the HET metric were approximately 1.5 times higher than that of the cumulative metric; however, the difference was not statistically significant. These results indicate that control of highest exposure may reduce the risk of silicosis.

CONTROL OF WASTE NITROUS OXIDE FROM ANESTHESIA DELIVERY UNITS IN DENTAL OPERATORIES. *K. Bussa, K. Crouch, NIOSH, Cincinnati, OH; J. McGlothlin, Purdue University, West Lafayette, IN; G. Talaska, P. Succop, C. Clark, University of Cincinnati, Cincinnati, OH*

Long-term exposure to waste nitrous oxide (N<sub>2</sub>O) in the dental industry may be linked to adverse reproductive outcomes. Leakage from the relief valve of the anesthesia delivery unit may be a significant exposure source of N<sub>2</sub>O in the dental environment. To test this hypothesis, 11 anesthesia delivery units were studied during dental surgery. A Tedlar bag was placed over the delivery units to capture leakage. The bag had penetrations to accommodate exhaust and supply flows, in which N<sub>2</sub>O concentration measurements were made. Measurements were taken during dental procedures for each of the units with and without the enclosure. Personal and area air samples also were collected in Tedlar bags for the duration of N<sub>2</sub>O administration, and then were analyzed by an infrared analyzer. Overall, area and personal samples were consistently reduced when the enclosure was used. Area samples were significantly reduced (F-ratio test,  $p < 0.01$ ), while personal samples of dentists were reduced marginally ( $p < 0.07$ ). However, samples on dental assistants were reduced but not significantly ( $p < 0.23$ ). N<sub>2</sub>O in area samples for enclosure-on ranged from 1-10 ppm, compared with 1-44 ppm for enclosure-off. Personal air samples for dentists ranged from 1-137 ppm for enclosure-on and 3-231 ppm for enclosure-off; for the assistants, the samples ranged from 3-52 ppm for enclosure-on and 5-146 ppm for enclosure-off. These data indicate that leakage from the on-demand valves makes a significant contribution to total N<sub>2</sub>O exposure, exposure can be reduced by elimination of this source.

ERGONOMIC INTERVENTIONS IN THE FURNITURE MANUFACTURING INDUSTRY. *J. Mangharam, University of Cincinnati, OH; J. McGlothlin, NIOSH, Cincinnati, OH*

Researchers from the University of Cincinnati and the National Institute for Occupational Safety and Health (NIOSH) recently conducted ergonomic evaluation at four upholstery furniture manufacturing plants. The goal of the evaluations was to devise engineering and administrative control strategies to reduce and prevent musculoskeletal disorders associated with furniture manufacturing. While conducting

the evaluations it was determined that there were work-related risk factors associated with musculoskeletal disorders of the upper limbs while manually pulling, "shaping," and stapling fabric over padding to the furniture frames. Also, it was determined that there was excess risk for back disorders during manual handling of finished furniture. Manual handling of finished furniture routinely exceeded the 1991 NIOSH recommended weight limit when ergonomic controls were not used. However, it was determined that there were several low-cost ergonomic interventions at the different furniture plants, such as manual jack stands with "quick" clamps to adjust and secure the part at the operator's working height for easy two-hand assembly; pivot tables on conveyor lines to rotate the furniture to the worker to avoid excessive reaches; ergonomically designed paint spray guns to reduce awkward postures during furniture painting; lightweight staple guns to ease shoulder loading while stapling fabric to wood frames; and gravity feed ramps to reduce manual handling of finished furniture. While there were several examples of ergonomic controls at each of the furniture manufacturing plants, many of the controls and applications at each of the plants were different. Sharing of ergonomic controls among plants throughout the furniture industry will help reduce and prevent musculoskeletal injuries and illnesses.

EVALUATION OF A PORTABLE X-RAY FLUORESCENCE INSTRUMENT FOR THE DETERMINATION OF LEAD IN WORKPLACE AIR SAMPLES *J.C. Morley, K. Ashley, J. Deddens, NIOSH, Cincinnati, OH; S. Clark, University of Cincinnati, Cincinnati, OH*

OSHA regulations for worker exposure to lead specify worker protection levels based on airborne concentrations of lead dust. The rapid, on-site determination of lead in air filter samples using a portable X-ray fluorescence (XRF) instrument with an attachment to hold the filter would expedite the exposure assessment process and facilitate compliance with the OSHA standard.

A total of 65 lead in air filter samples were collected with closed-faced, 37-mm cassettes at bridge blasting lead-abatement projects. The lead loading range of the sample set was 0.1 to 1514.6 mg of lead/sample. Samples were initially analyzed with a field portable Niton7 700 Series XRF using an experimental nondestructive XRF method. Samples were subsequently analyzed using the NIOSH Sampling and Analytical Method 7105 (Graphite Furnace AA) as a reference method. The paired data were not normally distributed; therefore, the nonparametric Wilcoxon signed rank test was used. There was no statistically significant difference between the data from the field portable XRF method and the NIOSH method ( $p$ -value= 0.72). Linear regression of the data resulted in a slope of 0.959 and an  $r^2$  of 0.985. The XRF instrument limit of detection (LOD) and limit of quantitation (LOQ) were determined to be 6.2 and 17.1 mg of lead/sample, respectively. The XRF method accuracy was  $\pm 27\%$ .

These data indicate that there is no statistically significant difference between the field portable XRF method and NIOSH Method 7105. The instrument LOQ of 17.1 mg of lead/sample is sufficiently sensitive to quantitate lead exposures below the OSHA action level of 30 mg/m<sup>3</sup>, given a sample volume of 570 liters. Although the method accuracy of  $\pm 27\%$  is greater than the NIOSH accuracy criterion of  $\pm 25\%$ , the method was evaluated using field samples. Laboratory prepared aerosol samples would be expected to give better precision. This research led to the development of NIOSH draft Method 7702, "Lead by Field Portable XRF."

EXPLORATION OF ELECTROSTATIC PRECIPITATION FOR BIOAEROSOL COLLECTION. *G. Mainelis, K. Willeke, S. Grinshpun, T. Reponen, University of Cincinnati, Cincinnati, OH; P. Hintz, NIOSH, Morgantown, WV*

Commonly used bioaerosol sampling mechanisms, such as impaction and impingement, are known to impart significant stress on microorganisms during the collection process. For quantitative exposure assessments in outdoor and indoor environments, bioaerosol collection methods with low microbial injury rates are desired. By imposing a small electrical charge on the bioaerosol particles and then exposing them to an electric field, the particles can be gently collected on a collection medium.

In our experiments we used a modified electrostatic aerosol sampler (EAS) (model 3100, TSI Inc., St. Paul, MN) to collect the airborne microorganisms by electrostatic forces. This sampler, originally designed to collect biologically inert particles, was modified to hold an insertable collection trough. The experiments were performed with three types of airborne microorganisms, including one biochemically similar to *Mycobacterium tuberculosis*. Agar, water, and a filter were used as collection media.

The physical collection efficiency of the sampler exceeded 80% for all three collection media and for all three microorganisms. The biological efficiency of this modified sampler was found to be greatly dependent on microorganism and collection medium used. When collected on a filter inside the EAS and then transferred to a nutrient medium, more than 90% of *Bacillus subtilis* spores, but only a few percent of sensitive *Pseudomonas fluorescens* bacteria were cultured. The microbial recovery of spores was also found to be significant, when collecting onto agar or into water.

We conclude that the modified EAS can be used to enumerate culturable airborne bacteria. However, to optimize this technique for the collection of a wide range of bioaerosol particles, including very sensitive ones, the electrostatic and other sampling parameters need to be optimized in a new electrostatic bioaerosol sampler.

NEW METHOD FOR SAMPLING AIRBORNE DUST AND MICROORGANISMS BY THE COMBINED ACTION OF LIQUID IMPINGEMENT AND CENTRIFUGATION. *K. Willeke, X. Lin, S. Grinshpun, T. Reponen, University of Cincinnati, Cincinnati, OH; M. Harper, SKC, Inc., Eighty Four, PA*

The most common methods used to collect airborne dust and microorganisms for occupational and environmental exposure assessment are inertial impaction, centrifugal removal, and impingement into liquid. Each of these sampling methods has advantages and disadvantages. We have developed a new approach in an effort to integrate the advantages of these different inertial separation methods and to overcome the limitations of the sampling devices that are currently available. In our new "Swirling Aerosol Collector," also referred to as "BioSampler," the aerosol flow is directed at an angle toward a curved surface, and the particles are removed by the combined action of impaction and centrifugation.

The performance of the new BioSampler has been evaluated in the Aerosol Research and Exposure Assessment Laboratory at the University of Cincinnati. During normal operation the sampler is used with a liquid that swirls upward on the inner surface and removes the collected particles. The sampler can also be used without a collection liquid. In that case, the inner collection surface is coated with a sticky substance or remains uncoated. The collection efficiency of the sampler is about 100% over a wide range of particle sizes. For 0.5- $\mu$ m particles, it is reduced to about 90%, when the device is operated at 12.5 L/min with the inner collection surface coated or "wetted" by the swirling liquid. Since this method of collection is more gentle than conventional techniques, particle bounce from the collection surface is significantly reduced.

When the BioSampler was tested with water as its collection fluid, it had a better collection efficiency for submicrometer particles than the widely used AGI-30 impinger. A conventional impinger can only be used with water or liquids of similar viscosities. It maintains constant collection efficiency for a relatively short sampling period, since violent bubbling produced during impingement reaerosolizes collected particles and generally evaporates the liquid in 1 to 2 hours. In contrast to conventional impingers, the BioSampler can be used with nonevaporating liquids having much higher viscosities than water. Thus, the BioSampler can sample over 8-hour shifts or longer time periods. Because of the swirling motion of the collection fluid, the BioSampler also has the advantage of significantly less reaerosolization of collected particles.

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 particulate 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<sup>3</sup>, 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 μm) 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.

RELEASE OF PARTICULATES FROM ENCLOSURES IN INDOOR AIR ENVIRONMENTS. *J. M. Harney, K. Choe, M. Trunov, S. Trakumas, S. Grinshpun, S., K. Willeke, University of Cincinnati Cincinnati, OH; W. Friedman, HUD Office of Lead Hazard Control, Washington, DC*

Deteriorating paint peels off walls as particles of different sizes. Covering walls with panels, or enclosures, is one way to prevent peeling lead-based paint from reaching house occupants. It is believed that dust particles may escape through the cracks and gaps of an enclosure into the indoor air environment, thus negating some of the benefits of abatement by enclosure. The 1995 HUD guidelines for enclosure systems specify that all enclosure systems shall include the sealing of all joints, edges, and corners with suitable materials. However, no accurate data are presently available in support of this sometimes costly procedure.

The release of dust particles from wall enclosures was studied experimentally, using a test enclosure unit. This unit included a vertical and a horizontal surface to imitate the wall and the floor, and had a cross-section area of 200 cm<sup>2</sup>. The test dust, collected from interior surfaces of 10 houses with previously identified lead hazards was "salted" on the horizontal surface within about 20 mm of the vertical wall (a typical space behind an enclosure). The aerodynamic particle characterization of the test dust was performed prior to the tests using an Aerodisperser and an Aerosizer (Amherst Process Instruments Inc., Hadley, MA). The inlet of the aerodynamic particle sizer was placed at different distances from the edge of the dust sample in 10-mm increments. Air sampling was also done with 37-mm filter cassettes. The test system allowed the application of a downward airflow as well as mechanical disturbances to the wall. Air velocity and the magnitude and frequency of the mechanical disturbances were controlled.

The fraction of aerosolized dust escaping from the enclosure through gaps of different sizes was measured. The overall efficiency of this process was a product of the aerosolization efficiency and the particle penetration efficiency. Airflow characteristics, frequency and magnitude of mechanical disturbance, and gap size, and orientation were the factors that affected these individual efficiencies, which were sharply dependent on the aerodynamic particle size.

RESIDUAL PESTICIDES IN HOUSING AND BEDDING AT MIGRANT LABOR CAMPS IN NORTHWESTERN OHIO. *T.M. Bliss, L. Kincl, E. Auyang, J. Baker, L. Dye, P. Everitt, J. Mangharam, E. Paternak, C. Rice, University of Cincinnati, Cincinnati, OH*

Few data are available regarding residual home pesticide exposure of migrant farm workers and possible health effects. Field conditions often provide no opportunity for washing skin or clothing to minimize pesticide contamination. Contamination of living spaces, including surface dust and bedding, may prolong exposure if pesticides are "carried home" The purpose of this investigation was to evaluate potential exposure of migrant workers to residual pesticides that may be carried from the field into labor camp housing, document hygiene practices, and conduct postural sway measurements.

Loose house dust samples were collected on paper filters using a handheld vacuum from bedding and mattresses, and on furniture and floor spaces. Samples were fractionated and weighed. The fraction considered to be most likely to contribute to residual contamination were those passing through a 250-micron sieve. The average amount collected was 1.8 g/m<sup>2</sup> ( ± 0.9, n=13). Samples are also being analyzed for lead, arsenic, copper, zinc, and organic pesticides including azinphos-methyl, carbaryl, diazinon, endosulfan, lindane, malathion, methomyl, methoxychlor, and methyl parathion.

Interviews were conducted with 32 migrant workers and family members to evaluate conditions that would contribute to potential pesticide exposure, such as personal hygiene facilities and practices, laundry facilities and practices, and use of protective equipment. Seventy-eight percent of the respondents had received safety training about pesticides. A dust mask was the only personal protective device reportedly used when handling pesticides by 100% of the respondents. One-hundred percent of the respondents also indicated that they showered daily and washed their hands after work in the field; however, only 59% indicated they washed bedding at least weekly.

Postural sway testing, which quantitatively measures the movement pattern of the body's center of pressure over a sway area (SA), was also conducted. Any subtle changes in a person's ability to maintain upright balance can be used to indirectly assess the status of the person's neurological system. Ten subjects performed eight sway tests that included two trials of the following tests: (1) eyes open (EO), (2) eyes closed (EC), (3) eyes open on foam (FO), and (4) eyes closed on foam (FC). Results show an increase in SA by 58% for EO, 11% for EC, 106% for FO, and 60% for FC compared with potentially unexposed population.

Educational programs are recommended to inform farm workers of the findings to help assure that hygiene measures are practiced to minimize residual exposures.

SURVIVAL AND GROWTH OF BACTERIA ON RESPIRATOR FILTERS. *Z. Wang, T. Reponen, K. Willeke, S. Grinshpun, University of Cincinnati, Cincinnati, OH*

All nine types of respirators certified under the 1995 National Institute for Occupational Safety and Health regulations for respirators can be used by health care workers for the prevention of Mycobacterium tuberculosis (MTB) transmission. The N95 half-mask particulate respirator is the most frequently used for this purpose. Questions have been raised regarding the possibility of MTB growth on respirators due to handling, storage, and reuse. This study was conducted to determine whether MTB may grow, and how long it may survive on a respirator filter

Bacillus subtilis (BS), Pseudomonas fluorescens (PF), and M. smegmatis (MS) were selected as MTB simulant bacteria. Bacteria were aerosolized with a Collison nebulizer from three different suspensions: deionized water, human saliva, nutrient broth (tryptic soy broth for BS and PF, Middlebrook 7×10 for MS). Deionized water represented loading with bacteria only, human saliva represented loading during

respirator wear, and nutrient broth represented the extreme situation with optimal nutrients. A preconditioned 37-mm filter was cut from a N95 respirator and was challenged 10 minutes with the aerosolized bacteria and nutrients in an aerosol exposure chamber. The airflow rate through the filter was 5 L/min during the loading cycle. This corresponds to a breathing rate of 85 L/min under heavy work load. Loaded filters were incubated at 85% relative humidity. The incubation temperature was 37°C for BS and MS and 28°C for PF. Analyses were conducted after 0, 1, 3, 6, 9, and 13 days of incubation. Before studying the survival, several elution methods were evaluated: vortexing, ultrasonicing, and mechanical shaking after submerging the exposed filter in a buffer solution. The total bacteria were counted with a hemocytometer while the viable count was analyzed by cultivating diluted bacterial suspensions on agar.

The data indicate that vortexing is the best elution method, with the highest total and culturable bacteria. It was, therefore, used in this study. None of these three test bacteria were able to grow on the N95 respirator material. However, BS could survive on filters over 13 days while MS survived for 1-3 days depending on the nutritional conditions. This indicates that used respirators may be a potential MTB transmission source if improperly stored and reused.

**THE EFFECT OF DIRECT GLARE ON POSTURAL BALANCE.** *L.D. Kincl, E. Auyang, L. Luo, M. Lu, M. Medvedovic, A. Wong, A. Bagchee, A. Bhattacharya, University of Cincinnati, Cincinnati, OH*  
Visual information is critical for maintaining safe and upright balance during manual material handling. Glare in the workplace, such as in the mining and construction industry, may interfere with a worker's ability to use the appropriate visual information. This study investigated the effect of a direct glare on postural stability. Postural stability was quantitated as the movement pattern of the body's center of pressure, using the variables of sway area (SA) and sway length (SL), with a force platform. An increase in these variables implies an increase in postural instability. Five healthy subjects (age:  $27.2 \pm 3.3$  years; 4 male, 1 female) performed 12 randomized sway tests consisting of 2 trials of 2 sway tasks for 3 lighting conditions. The two tasks were: (1) stationary: the subject stood quietly on the force platform, and (2) reach: the subject performed four cycles of lifting a 5-lb. weight placed at knee height in front of him or her. For the lighting conditions, a halogen lamp with a 250-watt bulb was placed facing toward the subject on the left side to provide a glare source. They are described as (a) ambient lighting with no glare (illumination ratio (IR) of left to right cheek: 37:39 ft. cd.); (b) ambient lighting with a direct glare (IR: 44:44 ft. cd.); and (c) direct glare only (IR: 16: 0.4 ft. cd.). The results show SA and SL increased significantly ( $p < 0.025$ ) from the ambient to the glare conditions for the stationary task, 29 and 27%, respectively, and the SL by 7% ( $p < 0.05$ ) for the reach task. This demonstrates direct glare is a potential risk factor for modifying postural stability during material handling tasks.

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**DETERMINATION OF POSTURAL STABILITY AND REQUIRED COEFFICIENT OF FRICTION OF SHOE-GROUND SURFACE IN A LOW-SEAM MINE SCALING TASK.** *E. Auyang, M. Lu, P. Succop, L. Kincl, R. Liang, T. Mitchell, A. Wong, M. Medvedovic, A. Bhattacharya, University of Cincinnati, Cincinnati, OH*

Scaling is a commonly performed underground mining task used to remove scales from a mining surface. The purpose of this experiment was to quantify postural sway to predict the potential for loss of stability associated with the thrusting action of this task. Ten subjects (age = 27.3 years, SD 5.14) performed repeat trials of 30-second tests while squatting on a force platform. The force platform was placed 24 inches away from a textured 42-inch ceiling. Using a simulated scaling tool, the subject completed a series of 12 randomized trials wearing work shoes and steel-toed boots. The trials consisted of (1) stationary task—subject maintained the squatting position; (2) guiding task—subject guided the tip of the tool three times along a 24-inch path; and (3) scraping task—subject scraped the tip of the tool three times

along a 24-inch path on the textured surface. The postural stability was quantified with variables of postural sway length (SL), sway area (SA), maximum medial-lateral excursion (ExcurML), and maximum anterior-posterior excursion (ExcurAP). The required coefficient of friction (RCF) was calculated from the shear forces in the horizontal plane and vertical force. A general linear regression model was used to determine the effects of task and shoe type on the variables of postural stability and RCF. The task effect was statistically significant for all stability and RCF variables ( $p < 0.0001$ ). A t-test showed that ExcurAP was significantly elevated for work shoes compared to boots. The responses of SL, SA, ExcurML, and ExcurAP were the largest for the scraping task, implying that the task had the greatest potential for postural instability. Similarly, the RCF value for the scraping task was the largest, implying the need for shoes with higher frictional properties than those for other types of tasks.

**BEHAVIOR OF FUNGAL SPORES VERSUS STANDARD TEST PARTICLES IN VENTILATION FILTERS.** *E. Jankowska, Central Institute for Labor Protection, Warsaw, Poland; T. Reponen, K. Willeke, S. Grinshpun, Univ. of Cincinnati, Cincinnati, OH; K. Choi, AAF International, Louisville, KY*  
Fungal spores can have adverse health effects on humans. One approach to control the exposure to fungal spores and other particulate air contaminants is to filter them out of the air. The aim of this study was to compare efficiency of ventilation filters with standard test particles and fungal spores, and to compare the reentrainment rate of these particles from the filters. Two fungal species, common indoors, *Penicillium brevicompactum* and *P. melinii*, were selected for the tests. Potassium chloride (KCl) particles were used as standard test particles as recommended by the proposed ASHRAE standard 52.2P. We tested two filter media, commonly used for general ventilation: filter media A from a prefilter and media B from a final filter. Filtration efficiency was determined at an air velocity of 56 cm/sec for media A and 9 cm/sec for media B, which corresponded to the same face velocity for both filters  $V(f) = 2.54$  m/sec. The reentrainment velocity varied from 56 to 300 cm/sec for media A and from 9 to 300 cm/sec for media B. The concentration and size distribution of particles were measured with an aerosol size spectrometer. The filtration efficiency varied from 70 to 85% for media A, and from 98.3 to 99.8% for media B. The efficiency was slightly lower for fungal spores than for KCl. When the reentrainment velocity was the same as the loading velocity, the reentrainment rate was less than 1%. When the reentrainment velocity was increased to 245 cm/sec, the reentrainment rate varied from 1 to 6% for *P. brevicompactum*, from 2 to 13% for *P. melinii*, and from 0.1 to 0.4% for KCl particles. Thus, the reentrainment of fungal spores was higher than that of KCl particles. Especially during irregular operation of the ventilation system, when the air velocity suddenly increases, reentrainment of fungal spores may be significant.

**COLLECTION AND SURVIVAL OF AIRBORNE MICROORGANISMS WHEN COLLECTED ELECTROSTATICALLY.** *G. Mainelis, K. Willeke, S. Grinshpun, T. Reponen, S. Trakumas, University of Cincinnati, Cincinnati, OH; P. Baron, NIOSH, Cincinnati, OH*  
Most of the current bioaerosol sampling methods employ mechanisms of impingement or impaction that have been shown to impart significant stress on the microorganisms during the collection process. In the search for a more "gentle" bioaerosol collection method, we investigated the applicability of an electrostatic technique for the collection of airborne microorganisms. Experiments performed with an electrostatic aerosol sampler (EAS) (Model 3100, TSI, Inc., St. Paul, MN) showed that more than 90% of *Bacillus subtilis* var. *niger* (BG) spores collected on the filter material inside the EAS were able to form colonies. In contrast, the recovery rate of sensitive *Pseudomonas fluorescens* bacteria was close to zero, which may have been caused by the charging that occurred in the corona discharge section. This process is known to be harmful to certain microorganisms. Thus, to investigate the charging of bacteria, a new experimental system was designed and built. In this system, the charging of airborne microorganisms was achieved not by traditionally used corona discharge, but by means of a less-harmful induction charging. In this setting, bacteria were aerosolized in droplets and imparted a charge ranging from -7000 to 7000 elementary charges. The bacteria carrying a desired charge was then selected using a parallel plate mobility analyzer. In our tests, the dependence of the bacterial viability on the amount of the imparted

charge was investigated. For this purpose, the BG spores and *P. fluorescens* vegetative cells that carry a preselected amount of charge were sampled with a BioSampler (SKC, Inc., Eighty Four, PA), and their viability was analyzed by comparing culturable and total counts. The results showed that the bacteria imparted with a low number of elementary charges had a survival ratio close to 100%. When the number of imparted elementary charges increased up to a few thousand, the survival ratio significantly decreased, with BG spores showing better tolerance to high charges than the vegetative cells of *P. fluorescens*. We concluded that the charging process is a very important component of the electrostatic collection of the microorganisms. The analysis and optimization of this process will lead to an improved method for bioaerosol collection.

PILOT EVALUATION OF AN EXPOSURE ASSESSMENT PROTOCOL FOR MAINTENANCE ACTIVITIES AND NONROUTINE TASKS. *Grimsley, F., Rice, C., Malone, R., Ayer, H., Bingham, E., University of Cincinnati*

Historically, maintenance activities and nonroutine tasks were often omitted from industrial hygiene sampling strategies. These activities and tasks can lead to occupational health hazard exposures. A protocol was developed to evaluate and document potential exposures that can occur during routine and non-routine tasks. The protocol included a walkthrough survey material safety data sheet review, and four survey instrument to assess and identify activities that could lead to inhalation and dermal exposures. Each of the instruments is displayed. The survey instruments were used to conduct employee interviews, work practice observations, and skin and clothing observations. The instruments specifically sought information on job tasks; duration and frequency of tasks; routes of exposure; work practices; hand, skin, and clothing contamination; and personal protective equipment usage. The protocol and survey instruments were field tested in the automobile manufacturing industry and are effective in identifying routine and nonroutine activities that could lead to inhalation and dermal exposures from chemicals. Evaluation of employee reports of exposure during specific tasks such as painting showed concordance between reported skin exposure and observation ( $n=30$ ;  $p<0.01$ ). However, the interview instrument did not work well among production line employees who were required to be mobile during their tasks. Modification in the protocol resulted in having the individuals complete the instrument during team meetings. A comparison of chemical protective clothing reported by employees versus what was observed did show a difference. For example, some employees reported that for a specific clean-up procedure chemical protective rubber gloves were used, when in practice some employees used surgical latex gloves. The authors conclude that the protocol and survey instruments are valuable tools for assessing potential exposures during maintenance activities and nonroutine tasks.

SETTLING OF LEADED DUST IN INDOOR ENVIRONMENT. *M. Trunov, S. Grinshpun, University of Cincinnati, Cincinnati, OH; W. Friedman, K. Choe, HUD Washington, DC; K. Willeke, University of Cincinnati, Cincinnati, OH*

Settling of airborne particles generated by indoor lead abatement was examined experimentally. The conventional assessment of clearance time is based on a tranquil settling theoretical model. It assumes that indoor air environment is perfectly calm, which is a disputable assumption. Therefore, we have investigated the evolution of the airborne particle concentration and size distribution in a controllable environment following the lead abatement work, through direct particle monitoring. In our initial study, we developed a 25-m<sup>3</sup> test facility and procedures to determine airborne particulate concentrations (with a 7-stage Anderson impactor, Respicon sampler, and Grimm real-time dust monitor) and lead fractional concentrations (by flame and graphite furnace atomic absorption spectroscopy). The dust monitor measured 15 optical particle size channels from 0.3 to 20  $\mu$ m in real time. In this study, dry sanding and scraping were the abatement methods used on old doors with lead-based paint (although the methods are not recommended by HUD or EPA) to generate a broad range of particle sizes and concentrations. Abatement was followed by a 1-hour wait for settling and 30 minutes of HEPA vacuuming. Dust levels were measured for 15 hours after the work, in each of 18 tests. The total and size-fractional airborne particle

concentrations decreased exponentially in all tests. This result is consistent with the theoretical model of constantly-mixed air, which predicts a longer settling period than the model of tranquil settling. The contributions of inevitable small room temperature gradients and initial turbulence were evaluated. The aerosol was found to have 2.5%–6.5% lead by mass. Further work on additional abatement methods and dust control techniques is being conducted.

**CONTROL OF WASTE NITROUS OXIDE FROM ANESTHESIA DELIVERY UNITS IN DENTAL OPERATORIES.** *K. Bussa, K. Crouch, NIOSH, Cincinnati, OH; J. McGlothlin, Purdue University, West Lafayette, IN; G. Talaska, P. Succop, C. Clark, University of Cincinnati, Cincinnati, OH*

Long-term exposure to waste nitrous oxide (N<sub>2</sub>O) in the dental industry may be linked to adverse reproductive outcomes. Leakage from the relief valve of the anesthesia delivery unit may be a significant exposure source of N<sub>2</sub>O in the dental environment. To test this hypothesis, 11 anesthesia delivery units were studied during dental surgery. A Tedlar bag was placed over the delivery units to capture leakage. The bag had penetrations to accommodate exhaust and supply flows, in which N<sub>2</sub>O concentration measurements were made. Measurements were taken during dental procedures for each of the units with and without the enclosure. Personal and area air samples also were collected in Tedlar bags for the duration of N<sub>2</sub>O administration, and then were analyzed by an infrared analyzer. Overall, area and personal samples were consistently reduced when the enclosure was used. Area samples were significantly reduced (F-ratio test,  $p < 0.01$ ), while personal samples of dentists were reduced marginally ( $p < 0.07$ ). However, samples on dental assistants were reduced but not significantly ( $p < 0.23$ ). N<sub>2</sub>O in area samples for enclosure-on ranged from 1–10 ppm, compared with 1–44 ppm for enclosure-off. Personal air samples for dentists ranged from 1–137 ppm for enclosure-on and 3–231 ppm for enclosure-off; for the assistants, the samples ranged from 3–52 ppm for enclosure-on and 5–146 ppm for enclosure-off. These data indicate that leakage from the on-demand valves makes a significant contribution to total N<sub>2</sub>O exposure, exposure can be reduced by elimination of this source.

**INVESTIGATIONS OF ELECTROBIOLOGICAL PROPERTIES OF AIRBORNE MICROORGANISMS.** *K. Willeke, G. Mainelis, P. Baron, S. Grinspun, T. Reponen, S. Trakumas, M. Trunov*

Keywords: Bioaerosols, electrical charge, charging, viability, bacteria

The majority of the available bioaerosol sampling devices employs collection techniques that are known to impart significant stress on the microorganisms during or after sampling, e.g. impaction at high velocity may inactivate the microorganisms. We have studied a more gentle removal method by electrostatically charging the microorganisms and then removing them in an electric field. In our tests with a modified electrostatic aerosol sampler, more than 80% of the microorganisms entering the EAS were removed from the airstream. More than 90% of *Bacillus subtilis* var *niger* (BG) spores collected on the filter material inside were able to form colonies. In contrast, the recovery rate of sensitive *P. fluorescens* vegetative cells was close to zero. We hypothesized that the stress was caused by corona discharge that was used as the charging mechanism in the device (Mainelis et al., 1999).

These data have shown that the charging process is very important for the physical and biological performance of an electrostatic sampler employed to sample bioaerosols. Thus, to investigate the role of the net electrical charge on the survival of airborne microorganisms, we designed and built a new experimental system. In this system, droplets containing bacteria are aerosolized from a conductive liquid suspension and then enter an electric field oriented across the generation point where the droplets acquire electrical charge due to the field-induced charging. As an additional air stream dries the droplets, the charged particles are transported towards a parallel mobility analyzer through which microorganisms carrying a desired charge are selected. These are then sampled with a BioSampler (SKC Inc., Eighty Four, PA) operated at 5.5 Lpm. An optical single particle counter (Grimm Technologies Inc., Douglasville, GA) measures the total concentration of bacteria entering the BioSampler.

In our experiments we investigated how the sign and amount of charge carried by BG spores and *P. fluorescens* vegetative cells affect their viability. The viability of the collected microorganisms was analyzed by comparing culturable and total counts. The culturable counts were obtained by plating 0.3 mL of collection suspension onto Petri plates with Trypticase Soy Agar, incubating the plates for 24 hours at 30°C and then counting the colony forming units. The total count of the microorganisms in each sample was obtained by filtering the sample through a black polycarbonate filter, staining it with an Acridine Orange solution and then counting the total number of the microorganisms under an Laborlux S epifluorescent microscope (W. Nuhsbaum Inc., McHenry, IL). To minimize the osmotic shock to the microorganisms during sampling, both BG spores and *P. fluorescens* bacteria were collected into phosphate buffer.

Our results showed that both the sign and the number of charges carried by the airborne microorganisms are very important to their viability. The viability of both microorganisms carrying a net negative charge did not depend significantly on the amount of charge. The viability of the microorganisms carrying a net positive charge was lower than that of microorganisms charged negatively, and decreased significantly with increasing amount of positive net charge. In the latter case, the BG spores showed a higher tolerance to high positive charge than the vegetative cells of *P. fluorescens*. Other types of microorganisms found in the environment are presently being investigated. Their responses to electrical charges are being grouped as to their microbiological properties. The data on the viability of charged microorganisms serve as the design parameters for the development of an electrostatic sampler for bioaerosol collection. These data also determine the threshold levels above which airborne microorganisms are inactivated for environmental control purpose.

#### STATIONARY AND PERSONAL MONITORING OF BIOAEROSOLS. *S. Grinshpun, T. Reponen, K. Willeke, V. Aizenberg, Z. Wang, S. Trakumas, M. Trunow, G. Mainelis*

Most of the commercially available bioaerosol samplers have been developed as stationary devices; only a few samplers can be used for personal exposure monitoring in environments contaminated with airborne microorganisms. In this laboratory study, six bioaerosol samplers representing both classes were evaluated: the Andersen Cascade Impactor, AGI-30 impinger, Biosampler, Air-O-Cell, Burkard Persona Air Sampler, and the Button Sampler. The tests were performed with monodisperse polystyrene latex particles ranging from 0.3 to 5 microns and five microorganisms representing vegetative cells and spores: *P. fluorescens* ( $\approx 0.08$  micron), *B. subtilis* ( $\approx 1$  micron), *S. albus* ( $\approx 1$  micron), *P. brevicompactum* ( $\approx 2.6$  micron), and *P. melinii* ( $\approx 3.2$  micron). The sampling efficiency was determined for all six samplers with respect to the total microbial count. The bioefficiency was determined for the four viable samplers through a comparison of the viable and total microbial counts.

The physical collection efficiency of the Button Sampler was about 100% for all tested particles. The other five samplers differed considerably from each other by their collection efficiency: the particle 50% cut-off size ranged from  $<0.3$  micron for the Biosampler to about 2.5 – 3 micron for the Air-O-Cell and the Burkard Sampler. The Biosampler was found to be the best one among the viable samplers in the maintaining the biological sampling efficiency over several hours. The bioefficiency of the Button Sampler was about 100% when tested with resistant spores. However, for vegetative bacterial cells sensitive to desiccation stress, the bioefficiency was low, as has also been found with other filter samplers.

#### FINE PARTICLE REMOVAL BY AND EMISSIONS FROM VACUUM CLEANERS WITH MULTIPLE FILTRATION STAGES *T. Reponen, S. Trakumas, K. Willeke, S. Grinshpun, M. Trunow, G. Mainelis*

Millions of vacuum cleaners are used around the world for household and industrial purposes. The primary goal of vacuum cleaners is to remove particles from surfaces and retain them. However, most vacuum cleaners also emit particles due to the penetration of small particles through the system and due to

the emission of particles from the rotating parts of the motor. Many bioaerosols and other particles, including those containing lead, are in the submicrometer size range, and can therefore be emitted and affect human health. Recently, several vacuum cleaner manufacturers have introduced multistage filtration systems to remove particles in the 0.3 – 1.0 micrometer range. However, data on the performance of these new systems are lacking.

We have developed and evaluated test methods for measuring the overall filtration efficiency and performance characteristics of vacuum cleaners. The particle penetration and emission was quantified at different stages of vacuum cleaner as a function of particle size. Through performance evaluations of the different components of intact vacuum cleaners, we are able to evaluate particle transmission through each component and to assess leakage. This information is useful for predicting changes in time of the filtration and emission characteristics of the vacuum cleaners due to loading of the filters.

For some models, the flow rate exiting a vacuum cleaner have been found to be as much as 25% higher than the flow rate entering it through the nozzle, due to intake of air into the vacuum cleaner downstream from the nozzle. Testing of several vacuum cleaner models has shown that the initial filtration efficiency of the primary filtration bags varies from 68% to 96% for 0.35 micrometers particles and from 97% to 99% for 1 micrometer particles, with most of the remaining small particles removed by a final high efficiency filter. However, in most cases, the primary purpose of the final filter is to remove particles emitted by the vacuum cleaner motor. The high particle emission rate from the motor- up to 1 million particles per second – combined with the dust passed through the bag filter may overload the high efficiency filter in a short time, depending of the particle size distribution of the dust picked up from the floor or carpet.

#### GENERATION, COLLECTION AND SURVIVAL OF CHARGED MICRORGANISMS. *G. Mainelis, K. Willeke, S. Grinshpun, T. Reponen, and S. Trakumas*

Commonly used bioaerosol sampling methods, such as impaction and impingement are known to impart significant stress on the microorganisms during the collection process. In a search for a gentler method, we modified an electrostatic aerosol sampler to collect bioaerosols. Our tests have shown that the electrostatic technique can effectively and gently remove hardy microorganisms from the airstream; however, it imparts significant stress to sensitive bacteria. We hypothesized that the stress was caused by corona discharge (Mainelis et al., 1999).

Since the charging process is a key element of any electrostatic aerosol sampler, we built a new experimental system to investigate the role of the net electrical charge on the survival of airborne microorganisms. As droplets containing bacteria were aerosolized from liquid suspension, they received a charge from an electric field across the generation point. After the droplets dried, microorganisms carrying a desired charge were selected using a specially designed parallel plate mobility analyzer and were sampled with a BioSampler (SKC Inc., Eighty Four, PA).

In our experiments we investigated how the sign and amount of charge carried by *Bacillus subtilis* var niger (BG) spores and *Pseudomonas fluorescens* vegetative cells affect their viability. The viability of collected bacteria was analyzed by comparing culturable and total counts. Our results showed that both the sign and number of charges carried by the airborne microorganisms are very important to their viability. The viability of both microorganisms carrying net negative charge did not depend significantly of the amount of charge. The viability of the microorganisms carrying net positive charge was lower than that of microorganisms charged negatively, and decreased significantly with increasing amount of positive net charge. In the latter case, the BG spores showed a higher tolerance to high positive charge than the vegetative cells of *P. fluorescens*. Other types of microorganisms found in the environment are presently being investigated. Their responses to electrical charges are being grouped as to their microbiological

properties. The data on the viability of charged microorganisms serve as the design parameters for the development of an electrostatic sampler for bioaerosol collection. These data also determine the threshold levels above which airborne microorganisms are inactivated for environmental control purposes.

**SAMPLING OF BIOLOGICAL AEROSOLS: PARTICLE COLLECTION EFFICIENCY AND SURVIVAL OF VIABLE MICROORGANISMS.** *S.A. Grinshpun, K. Willeke, T. Reponen, G. Mainelis, M. Trunov, S. Trakumasm, V. Aizenberg, Z. Wang*

A large variety of methods are currently available for conducting bioaerosol measurements in indoor and outdoor environments. These methods utilize various collection principles including impaction onto a glass or agar surfaces, impingement into a liquid, collection on a filter electrostatic precipitation and others. The objective of bioaerosol sampling is the efficient removal and collection of airborne microorganisms from the air with a minimal effect on their microbiological characteristics, e.g., culturability or biological integrity (Buttner et al., 1997). The overall performance of a bioaerosol sampler depends on its inlet characteristics and physical and biological efficiencies of microbial collection in this sampler. The inlet and collection characteristics of a sampler are known to be pronouncedly particle-size dependent. The inlet efficiency of bioaerosol samplers has been investigated in our earlier studies (Grinshpun et al., 1994). This paper summarizes our finding on the collection characteristics of different bioaerosol sampling methods, including their physical and biological collection efficiencies.

The physical and microbiological collection efficiencies were determined for seven conventionally used aerosol samplers, including the Two and the Six-Stage Andersen Impactors (Graseby Inc., Atlanta, GA, USA), Air-O-Cell sampling cassette (Zefon International Inc., St. Petersburg, FL, USA), the Burkard Personal Volumetric Air Sampler (Burkard Manufacturing Co., Rickmansworth, UK), the AGI-4 and the AGI-30 liquid impingers (Ace Glass Inc., Vineland, NJ, USA), and the Electrostatic Aerosol Sampler (TSI Inc., St. Paul, MN, USA) modified for bioaerosol collection. In addition, two recently developed samplers; the Button Personal Inhalable Aerosol Sampler and the Biosampler (SKC Inc., Eighty Four, PA, USA) were evaluated with respect to their collection efficiencies. Different mechanisms for the collection of airborne microorganisms were examined using inert particles (PSL spheres ranged from about 0.3 to 5  $\mu\text{m}$  in aerodynamic diameter) and biological particles (bacteria and fungi ranged from 0.7 to 3.2  $\mu\text{m}$ ). The list of tested species included several bacteria, namely *Bacillus subtilis* var niger (BG spores), *Mycobacterium bovis* (BCG), *Micrococcus luteus*, *Pseudomonas fluorescens*, and *Streptomyces albu*, as well as several fungi, namely *Cladosporium cladosporioides*, *Penicillium brevicompactum*, and *Penicillium melinii*.

The tests were conducted in the Bioaerosol Sampler Evaluation Facility (Thompson et al., 1994) developed in our laboratories and extensively used in our previous studies. Direct-reading aerosol size spectrometers were utilized in the test chamber to measure the particle concentrations and size distributions upstream and downstream of a specific bioaerosol sampler. The optical and aerodynamic particle sizes were determined using the Grimm Dust Monitor (Grimm Labortechnik GmbH, Ainring, Germany) and an Aerosizer (TSI-Amherst Process Instruments Inc., Hadley, MA, USA), respectively. The biological and non-biological particles were aerosolized with either a Collison nebulizer (BGI Inc., Waltham, MA, USA) or one of our newly developed bioaerosol generators (Reponen et al., 1997). The physical collection efficiency of each sampler under each set of conditions was determined using the dynamic measurement data on upstream and downstream aerosol concentrations. The biological particles collected in a sampler were incubated following conventional microbiological procedures, after which the colony forming units were counted. The biological efficiency of a sampler was determined as a change of the percentage of culturable microorganisms measured at the source and in the air sample taken with the bioaerosol sampler.

The effect of the sampling flow rate, sampling time, collection medium and other parameters on the performance characteristics of the samplers were studied. The physical collection efficiency of bacterial and fungal spores in impactors with solid collection media was found to be a complex function of several parameters, such as individual spore surface characteristics, the initial percentage of aggregates, deaggregation rate during impaction, and particle bounce rate. The biological efficiency of impaction on an agar was found to be affected by the degree of embedding of collected microorganisms into the agar surface. Microbial stress was found to depend non-monotonically on the sampling flow rate. When collecting with the glass – or agar-slide impactors or with filter samplers, microbial survival ratio decreased with sampling time due to the desiccation. The evaporation of the collection fluid as well as the particle bounce and re-aerosolization were identified as effects reducing the collection efficiency of conventional liquid impingers, such as AGI-30. The Button Sampler was found to be the most efficient as a device for the total bioaerosol enumeration although it may not assure high culturability of a long period of time when collecting sensitive microorganisms. The Biosampler combining impaction and impingement in a swirling (centrifugal) airflow was found to be suitable for a long-term collection of culturable bioaerosol particles. Evaporation of the liquid component of the collection media observed inside the Electrostatic Aerosol Sampler may significantly decrease physical and biological efficiencies of the electrostatic precipitation if collecting stress-sensitive bacteria.

Experimental data collected in this study show how to optimize sampling parameters and operational conditions when using different methods for collecting biological particles.

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#### LABORATORY COMPARISON OF PERSONAL SAMPLERS FOR ENUMERATION OF AIRBORNE SPORES. V. Aizenberg, S. Grinshpun, T. Reponen, K. Willeke, Z. Wang

Some of the most widely used samplers for the total bioaerosol enumeration utilize impaction on glass slides as the particle collection mechanism. While extensively used in various environments, they share several common drawbacks. For instance, some microbial staining procedures (e.g., acridine orange staining) cannot be used with glass slides. Also, airborne microorganisms smaller than the cut-off size of the respective impactor cannot be adequately detected. In contrast, a collection on a filter with appropriate characteristics is not subject to these limitations.

Performance of three devices used for the total enumeration of airborne spores was evaluated under controlled laboratory conditions. The devices included in this study were the Air-O-Cell sampling cassette, the Burkard personal volumetric air sampler, and the Button Sampler. The former two are glass-slide impaction instruments, while the latter one utilizes filter collection. The samplers were challenged with PSL particles of up to 5  $\mu\text{m}$  and several microorganisms, including *S. albus*, *P. brevicompactum*, and *P. melinii*.

An optical particle counter was used to determine the physical collection efficiency of the three samplers when challenged with the PSL particles. As expected, the collection efficiency of the button sampler was

close to 100% for the entire size range studied (0.44-5.1  $\mu\text{m}$ ). The cut-off sizes of both impactors were found to be between 2.1 and 2.3  $\mu\text{m}$ .

The acridine orange (with epifluorescent microscopy) and lactophenol cotton blue (with bright light microscopy) staining techniques were used for microscopic enumeration of the collected spores. When both techniques were used to stain the button sampler filters, no significant difference in microscopic counts was found (at the 95% significance level). When the lactophenol cotton blue staining was used to compare total counts yielded by all three samplers, the button sampler consistently showed statistically higher results. Thus, the filter collection method utilized with the button sampler is suitable for the total airborne spore enumerations.

#### NEW METHOD FOR LONG-TERM SAMPLING OF AIRBORNE BACTERIA AND FUNGI. T.

*Reponen, X. Lin, K. Willeke, S. Grinspun, M. Harper*

A new method for sampling airborne bacteria and fungal spores has been developed to minimize the limitations of the current sampling methods and to prolong the sampling periods. The "BioSampler", based on this method, was evaluated in the laboratory and in the field in comparison with the widely used AGI-30 impinger. The laboratory studies indicated that the BioSampler provides better collection efficiency and more gentle collection for bacteria and fungal spores than the AGI-30. The AGI-30 is only used with water-based collection liquids. Since these liquids evaporate quickly, sampling is limited to less than 30 minutes. When the BioSampler was used with heavy-white mineral oil, which is a non-evaporating liquid, the measured concentrations for bacteria and fungal spores remained almost constant for the four-hour testing period. Field evaluations showed that samples obtained with the BioSampler over several hours detected culturable bacteria and fungi at lower ambient concentrations than those obtained with traditional liquid impingers sampling over short time periods.

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#### A WALKTHROUGH ERGONOMIC CHECKLIST FOR EVALUATING SLIP/FALL POTENTIAL IN LEAD ABATEMENT TASKS. *L. Kincl, M. Lu, E. Auyang, A. Bhattacharya, P. Succop, Biomechanics and Ergonomics Research Laboratories\* Division of Epidemiology and Biostatistics, Department of Environmental Health, University of Cincinnati, Cincinnati, OH*

The purpose of this study is to develop a tool to determine the ergonomic risk factors of cumulative trauma disorders (CTDs) and slips/ fall potential associated with the lead abatement and lead risk assessors' tasks. For this purpose, an existing and validated checklist of ergonomic walkthrough surveys developed for carpentry tasks was enhanced utilizing postural instability potential weights for specific postures common at lead abatement sites and an additional section to obtain information on slip/fall risk factors. This paper discusses the slip/fall risk development for the enhanced checklist. Based on studies with industrial workers, the following risk factors have been rank-ordered according to the increasing risk of postural instability: task type, poor ambient lighting, elevated working surfaces (ladders or scaffolding), inclined working surfaces, and surface condition (slipperiness). Walkthrough surveys were conducted and laboratory data was collected to determine categories and ranking of slip/fall risk factors to be added to the modified ergonomic checklist.

CLEARANCE WAITING PERIOD AFTER LEAD-BASED PAINT ABATEMENT. *W. Friedman, Office of Lead Hazard Control, U.S. Department of Housing and Urban Development, Washington, DC; S. Grinspun, K. Willeke, K. Choe, M. Trunov, S. Trakumas, University of Cincinnati, Department of Environmental Health, Cincinnati, OH; P. Middendorf, V. Ainslie, Georgia Institute of Technology, Atlanta, GA; J. Millette, MVA Inc., Norcross, GA*

Clearance testing of lead dust loading on horizontal surfaces is required after lead-based paint abatement in certain U.S. pre-1978 residential and other facilities. A waiting period is required between cleanup and clearance so most airborne dust can settle. The current waiting period guidance uses a tranquil particle settling model assuming perfectly calm room air — an untested assumption.

The evolution of the airborne particle concentration and size distribution following “worst-case” dry sanding or dry scraping of lead-based painted wooden doors was evaluated in a 860 ft<sup>3</sup> environmental test chamber using real-time particle size spectrometry and chemical analysis, and used to project floor lead loadings as those particles settle. Size-fractional airborne particle concentrations decreased exponentially, with or without air exchange. Even very low levels of air mixing affect particle settling.

These results are consistent with the stirred model (constantly mixed air), which predicts longer settling than the tranquil model. A data-based method was developed for calculating the underestimate of lead loading from conducting clearance testing at a finite time rather than waiting forever. About 90% of airborne lead mass settled 1 hour after active abatement, before final cleaning.

Cleaning (even when less stringent than recommended by HUD) followed by a second waiting period further decreased airborne lead; the additional floor dust lead loading after the 1-hour second waiting period is <20  $\mu\text{g}/\text{ft}^2$ . For this “worst-case scenario,” the lead loading underestimate is <~30%. For more realistic conditions, underestimates are projected to be <<40  $\mu\text{g}/\text{ft}^2$ , the new HUD clearance standard for floor dust lead.

The laboratory findings above were confirmed in a second laboratory’s chamber, and in initial field trials in older housing. This study demonstrates that there is no need to increase either waiting period, even using the data-based air mixing model, and suggests ways to decrease overall waiting.

DETERMINATION OF KNOWN EXHALATION VALVE DAMAGE USING NEGATIVE PRESSURE USER SEAL-CHECK METHODS ON FULL-FACE RESPIRATORS. 217. *L. Delaney, NIOSH, Cincinnati, OH; R. McKay, University of Cincinnati, Department of Environmental Health, Occupational Medicine, Cincinnati, OH*

Employees wearing respirators in industrial settings rely on users’ positive- and negative-pressure seal checks to assess respirator fit. However, few studies have been performed to determine the adequacy of user seal checks in detecting poor-fitting or damaged respirators.

In this study, the negative-pressure user seal check (NPUSC) method was evaluated for its ability to adequately detect known exhalation valve damage. The damage included a warped valve, a valve with three slits, and a valve with a small amount of glue. Twenty-six test subjects, wearing full-face piece respirators, were asked to perform a NPUSC. Their responses as to whether they passed or failed the NPUSC were compared with fit-testing results from two quantitative fit-test methods. In addition, in-mask pressure differentials were measured during the performance of NPUSCs using equipment developed in the UC respirator laboratory.

This method was developed as a more reliable technique to assess the ability of respirator wearers to properly conduct user seal checks. The data were analyzed to determine whether the NPUSC procedure is an effective method for detecting known exhalation valve damage.

All test subjects reported passing the NPUSC with the undamaged valve. With the respirator equipped with the warped valve, 95% of test subjects reported passing NPUSCs. With the respirator equipped with the valve with adhesive, 65% reported passing.

All fit factors were below the OSHA recognized pass/fail criteria, except one test with the respirator equipped with the slit valve. Results from the in-mask pressure measurements confirmed that 98% of all user seal checks were properly conducted. It was unable, however, to detect respirator leakage. In conclusion, NPUSC performed by the user rarely identified damaged exhalation valves.

**DETERMINATION OF PAH PASSAGE THROUGH HUMAN SKIN AFTER EXPOSURE TO USED GASOLINE ENGINE OIL AND KEROSENE. 289. *G. Talaska, University of Cincinnati, Cincinnati, OH; C. Collins, Georgia Institute of Technology, Atlanta, GA***

Millions of mechanics and persons who maintain their own automobiles are potentially exposed to used gasoline engine oil (UGEO). UGEO is carcinogenic in mice. Washing mice with cleaners soon after exposure to UGEO and using certain barrier creams prior to exposure recently showed a reduced level of DNA damage in skin. However, although one of these cleaners (kerosene) reduced the level of DNA damage in the skin, its use was associated with an increase in DNA damage in the lung.

The purpose of this study was to determine whether kerosene facilitated the passage of polycyclic aromatic hydrocarbons (PAH) through human skin. Twelve human skin samples were treated with UGEO in modified Bronaugh cells. In addition, samples of the same skin were treated with UGEO and washed with kerosene one hour later.

Samples of the receptor fluid were taken every half-hour for four hours. PAHs were extracted and analyzed by high performance liquid chromatography (HPLC) at each interval.

The data were analyzed to determine whether PAH passage was different between washed and unwashed skin. There is a trend of a greater amount of benzo(a)anthracene passing through the skin after it had been washed with kerosene. The total amount of PAH breakthrough is also greater after a kerosene wash. These data suggest that kerosene facilitates the absorption of PAH through human skin.

**ELECTROSTATIC CHARGE DISTRIBUTIONS ON AIRBORNE MICROORGANISMS. 201. *G. Mainelis, K. Willeke, S. Grinshpun, T. Reponen, S. Trakumas, University of Cincinnati, Cincinnati, OH; P. Baron, NIOSH, Cincinnati, OH***

Several studies showed that bacteria suspended in liquid may carry as many as 10,000 elementary charges. This study was undertaken to determine the electrical charge distributions on bacteria in the airborne state. This information is important, since high electric charges on airborne microorganisms may result in high transport losses in flow systems. High electric charges also suggest that the sampling of airborne microorganisms by an electrostatic collection technique, a potentially "gentle" bioaerosol collection method, may be possible without the need for prior charging.

Thus, to investigate the charge on airborne bacteria we built a new experimental system, in which bacteria are aerosolized and then channeled into a parallel plate mobility analyzer. By adjusting the electric field inside the analyzer we selected bacteria carrying known charge ranges. By comparing their concentrations with those entering the analyzer, we obtained the electrical charge distributions on the bacteria.

Our tests with *Pseudomonas fluorescens* bacteria, commonly found in air environments, have shown that airborne bacteria have a net negative charge, but the individual bacteria can be charged either negatively or positively. When the bacterial suspension was aerosolized with compressed air, the bacteria acquired up to? 14,000 elementary charges per bacterium; 50% of these bacteria carried between -1000 and +400 elementary charges.

When the same bacterial suspension was aerosolized using bursting bubbles, the bacteria acquired maximum charges of? 1500 and 50% of the bacteria had between -200 and +150 electrical charges. Thus,

aerosolized bacteria have sufficiently high electric charges to be collected by an electrostatic field without prior charging.

**EVALUATION OF SILICOSIS IN RESPONSE TO HIGHEST TASK SILICA EXPOSURE WITH IMPUTED VALUES WHERE NO MEASUREMENTS WERE MADE.** 393. *F. Grimsley, C. Rice, H. Ayer, S. Clark, P. Succop, Univ. of Cincinnati, Cincinnati, OH; R. Rinsky, NIOSH, Cincinnati, OH*  
More than one million workers are exposed annually to silica in the workplace. The purpose and specific aims of this study were to investigate ways to estimate silica exposure in unsampled tasks and to evaluate the relationship between highest task silica exposure imputed and the development of silicosis. Data from the North Carolina Dusty Trades, a unique resource for exposure-response studies of the effects of silica exposure, is the basis for the study.

Three methods of imputation were used. The methods were estimating exposures based on the mean exposure at sampled commodity-specific tasks, the lower bound of the 95% confidence interval of the median of commodity-specific tasks, and maximum likelihood estimate. The three imputation methods are described and presented.

The results of this study indicate that the highest task-related silica exposure is related to the development of silicosis with an odds ratio of 2.22 and is statistically significant ( $p=0.001$ ). These results can serve as a guide to changes in sampling methods and targeted control techniques that should be implemented to decrease disease in the workplace.

**INJURY TRENDS FOR ADOLESCENTS WITH PERINATAL AND EARLY CHILDHOOD LEAD EXPOSURE.** *Kincl, L. and Dietrich, K., Department of Environmental Health, University of Cincinnati Medical School, Cincinnati, OH.*

The purpose of this study was to investigate adolescents with a known childhood lead burden to determine if they are at an increased risk of injury. The specific aims of this study were to obtain work and injury histories (since age 14) of the Cincinnati Lead Study cohort. Questionnaires were mailed to the cohort, which were self-administered and returned to the principal investigator with a response rate of 42%. Both parametric and nonparametric statistical analyses were conducted. The descriptive information on work history showed 43% of the study group had a job at the time the questionnaire was administered and 58% had had at least one job in the past. Most subjects reported working in industries and occupations that were expected given the age (14-19 years) such as service (30%) and retail (25%) type jobs and 49% received some type of training on the job. The descriptive information on the injuries indicated that sprains (32%) and cuts (22%) were the most common type of injury, most happened at home (61%) and the upper extremities (50%) were the most common body part injured. Student's t-test and correlation analyses were completed to determine statistical noteworthiness ( $p<0.15$ , two-tailed test) of blood lead concentration variables (prenatal, neonatal, mean for each year from 1-6, and mean lifetime blood lead concentrations) and potential covariates (measures of perinatal health, quality of early rearing environment, socio-economic status, adolescent drinking and drug history, personality and social deviancy, and intelligence) with the categorical variables of injured, limited activity, missed school, missed work, medical care received, and fall and the continuous variable of number of injuries (transformed to its natural logarithm). The variables found to be noteworthy were included in logistic regression or general linear regression models as appropriate which were tested for statistical significance ( $p<0.05$ , one-tailed test). The results demonstrated that elevated mean lifetime blood lead concentrations were significantly related to the being injured, an increasing number of injuries, the injuries causing limited activity and medical care, and the event or activity leading to the injury being a fall or loss of balance. An elevated maternal prenatal blood lead concentration was also associated with limited activity and falls and an elevated neonatal blood lead concentration with the limited activity. Gestational age was related to the injured variable and the quality of early home stimulation was related to the limited activity. Further

study into blood concentrations and incidence of injury is necessary to fully understand the occupational safety and public health implications.

**PERFORMANCE OF THE BUTTON AEROSOL SAMPLER FOR TOTAL AND VIABLE ENUMERATION OF AIRBORNE MICROORGANISMS.** *S. Grinshpun, V. Aizenberg, T. Reponen, Z. Wang, R. Gorny, K. Willeke, University of Cincinnati, Cincinnati, OH*

The Button Aerosol Sampler was previously evaluated for stationary and personal monitoring of non-biological particles in work environments. In this study, its performance was tested under controlled laboratory conditions with respect to the total and viable enumeration of airborne microorganisms.

The physical collection efficiency was determined by measuring the concentrations of monodispersed particles upstream and downstream of the Button Sampler using a model 1.108 Grimm dust monitor. The total microbial count was performed using microscopic techniques, and the viable count was done through culturing. For the total bioaerosol enumeration, the Button Sampler was challenged with inert PSL particles ranging from 0.44  $\mu\text{m}$  to 5.10  $\mu\text{m}$  in diameter as well as with bacterial and fungal spores (*Streptomyces albus*, *Bacillus subtilis*, *Cladosporium cladosporioides*, *Penicillium brevicompactum*, and *Penicillium melinii*) ranging from 0.84  $\mu\text{m}$  to 3.07  $\mu\text{m}$  in diameter.

For the viable count, the tests were conducted with spores of *P. melinii* and *B. subtilis* and vegetative cells of *Pseudomonas fluorescens* at a relative humidity (RH) of 30% and 85%. The collection efficiency of the Button Sampler was close to 100% for the entire particle size range studied.

The uniformity of the particle deposition on the Button Sampler filters was found to be very consistent. A modified CAMNEA method, involving vortexing and ultrasonic filter agitation, followed by 96%–98% efficient suspension extraction, inoculation, staining, and epifluorescent microscopic counting, was developed to analyze the viable counts. *P. melinii* demonstrated consistent culturability when sampling for 30 minutes to eight hours, while less than 20% of *B. subtilis* spores formed colonies after the four-hour sampling. *P. fluorescens* vegetative cells were unable to form colonies at RH = 30%, but were able to recover at RH = 85% if sampled for 2–10 minutes.

The Button Aerosol Sampler was found suitable for the total enumeration of airborne microorganisms. It was also shown to be suitable for the viable enumeration of resistant spores.

**SAMPLING OF AIRBORNE BACTERIA AND FUNGAL SPORES IN METALWORKING FLUID ENVIRONMENTS USING THE BIOSAMPLER®.** 198. *T. Reponen, A. Freeman, G. Mainelis, K. Willeke, S. Grinshpun, University of Cincinnati, Cincinnati, OH*

Workers exposed to metalworking fluid (MWF) aerosols are at increased risk of developing a variety of respiratory and skin diseases. Microbial contamination of MWFs is suspected to be one of the causative factors for these adverse health effects. Little information is available on the composition and concentration of airborne microorganisms in metalworking sites, since none of the available air sampling methods allows long-term collection of a broad-spectrum of microorganisms.

Previous laboratory and field testing of the newly developed BioSampler® have shown that the BioSampler provides better collection efficiency, more gentle collection of microorganisms, and longer sampling times than the conventional all-glass impingers. In this field study, we compared the performance of the BioSampler with the 2-stage Andersen impactor in two metalworking plants.

Plant 1 had confirmed cases of hypersensitivity pneumonitis and occupational asthma as well as workers with a variety of respiratory complaints. The workers at Plant 2 did not have any significant health complaints. The BioSampler operated for four hours with mineral oil as the collection fluid. Ten 5-minute

and 10 15-minute samples were taken with the Andersen impactor during the 4-hour sampling period. The measurements were performed in winter and in spring.

Overall, the bacterial and fungal concentrations were relatively low in both plants, below 1100 CFU/m<sup>3</sup>, while the bacterial concentrations were up to 50 times higher in Plant 1 than Plant 2. Furthermore, the composition of airborne bacteria was different in Plant 1 from that in Plant 2 and in outdoor air.

The Andersen sampler indicated lower microbial concentrations during 15-minute sampling than during 5-minute sampling. This finding can be attributed to the effect of desiccation and impaction stress. The BioSampler gave equivalent or higher concentrations than the Andersen sampler.

These results indicate that the BioSampler is a promising tool for exposure assessment of airborne microorganisms in MWF sites.

SHIPYARD CONFINED SPACE WELDING INTERVENTION *S. Wurzelbacher, S. Hudock, O. Johnston, S. Shulman, NIOSH/Division of Physical Sciences and Engineering, Cincinnati, OH; B. Lowe, Division of Biomedical and Behavioral Science, Cincinnati, OH*

Shipyards welders, especially those working in confined spaces, have not been adequately studied as an occupational group in terms of ergonomic factors affecting worker health, safety, and performance. These workers can weld under conditions that provide inadequate ventilation and require static muscular work and awkward postures.

This study measured the effect of the welding process and ventilation method used in a confined workplace on physical workload, weld fume exposure, and weld performance. Nine male welders from the participating shipyard performed four wire-fed welding tasks and four stick-welding tasks in a functional mockup, constructed by NIOSH, to match actual dimensions of the double-hull honeycomb (0.6 m × 0.6 m × 4.9 m).

During these tasks, the ventilation method was alternated between a standard air horn and a prototype fresh air diffuser. Heart rate, electromyographic (EMG) activity, ratings of perceived exertion (RPE), discomfort assessment surveys (DAS), total personal particulate concentrations, and area elemental concentrations were recorded for each task. In addition, welding performance in terms of weld quality and efficiency were determined for each task.

Statistical analysis indicated that weld process had a significant effect on workload and weld performance. Wire welding was associated with higher RPEs ( $p = 0.0001$ ), general DAS outcome ( $p = 0.0076$ ), and weld efficiency ( $p = 0.0335$ ), while stick welding was associated with higher weld quality ( $p = 0.0001$ ). EMG analyses showed that stick welding was associated with greater localized muscle fatigue than wire welding. The standard air horn ventilation method was associated with lower total particulate concentrations ( $p = 0.0282$ ).

This study suggested that engineering interventions for confined space welders involving weld process and ventilation method changes should be considered carefully due to potential impact on workload, weld fume exposure, and weld performance.

MEASUREMENT OF ELECTRICAL CHARGES ON AIRBORNE MICROORGANISMS. *K. Willeke, G. Mainelis, S. Grinshpun, T. Reponen, P. Baron*

Our earlier research has shown that the collection of airborne microorganisms by electrostatic forces can be gentle and efficient. However, if the microorganisms are electrically charged in the sampler's inlet, sensitive bacteria may become non-viable from stress induced by the charging process (Mainelis et al.,

1999). We have now investigated dispersion conditions which result in sufficient charges on the microorganisms so that electrically charging them for subsequent electrostatic removal from the sampled aerosol flow is not necessary.

#### CHARACTERISTICS OF PERSONAL AEROSOL SAMPLERS FOR AIRBORNE SPORES. S.

*Grinshpun, T. Reponen, V. Aizenberg, Z. Wang, R. Gorney, K. Willeke*

The performance of two personal filter samplers, the Button Aerosol Sampler and the 37-mm closed face filter cassette, was tested under controlled laboratory conditions for the total and viable enumeration of airborne microorganisms. The test particles included inert PSL particles, fungal spores (*Penicillium brevicompactum*, *Penicillium melinii*, *Cladosporium cladosporioides*, *Aspergillus versicolor*), bacterial spores (*Sterptomyces albus*, *Bacillus subtilis*), and bacterial vegetative cells (*Pseudomonas fluorescens*, *Serratia marcescens*). The aerodynamic size of the test particles was measured using an aerodynamic particle size spectrometer (Aerosizer, model API Mach II; TSI-Amherst Process Instruments Inc., Hadley, MA, USA). Polycarbonate filters (0.2 micrometer pore size; Millipore Co., MA) mounted in; the samplers were challenged with aerosolized test particles. An optical particle counter (model 1.108; Grimm Technologies Inc., Douglasville, GA) was used to determine the physical collection efficiency by measuring the concentrations of particles upstream and downstream of the sampler. The culturability of microorganisms was tested at relative humidity of 30% and 85%. After challenging the filters with microorganisms, air was drawn through the samplers for periods ranging from 2 minutes to 8 hours. The microorganisms were then extracted from the filters by a modified CAMNEA method, involving vortexing and ultrasonic agitation of the filters. This method was found to extract the microorganisms with 96%-98% efficiency. The extraction suspension was analyzed by cultivating for the culturable count, and by epifluorescence microscopic counting to get the total count of microorganisms. The relative culturability was calculated by dividing the culturability (culturable count/total count) of the microorganisms in the extraction suspension by the original culturability of microorganisms before aerosolization.

Both samplers showed similar data on the physical and biological sampling efficiencies. The physical collection efficiencies of both samplers were close to 100% for the entire particle size range studied (0.2 to 5.1 micrometer). Their bioefficiencies depended significantly on the sampling time and microbial species. *Penicillium melinii* and *Aspergillus versicolor* demonstrated consistent relative culturability when sampling for 30 minutes to 8 hours. No significant difference in relative culturability was detected for these spores when the humidity increased from 30% to 85%. The relative recovery of *Bacillus subtilis* spores decreased from 17% to 5% when the sampling time increased from 2 minutes to 4 hours at RH=30%. While the relative culturability was slightly higher at RH=85% than at RH=30%, it also decreased with the sampling time. *Pseudomonas fluorescens* bacteria were culturable only at RH=85% if sampled 10 minutes or less. *Serratia marcescens* showed the same trend although its relative culturability was found to be slightly higher than that of *pseudomonas fluorescens*. The study suggests that sampling time and relative humidity are critical factors influencing the bioefficiency of filter samplers.

#### INVESTIGATION OF CHARGED AIRBORNE MICROORGANISMS. *G. Mainelis, K. Willeke, S.*

*Grinshpun, T. Reponen, R. Gorney*

Our previous studies with a modified Electrostatic Aerosol Sampler have shown that microorganisms sampled by this device have been effectively removed from the airstream. However, the microbial recovery rate of collected sensitive *Pseudomonas fluorescens* bacteria was close to zero. We hypothesized that this was caused by the sampler's conventional corona charging mechanism (Mainelis et al., 1999). Since prior studies had indicated that liquid-borne microorganisms might carry thousands of elementary charge units, we investigated dispersion conditions which result in sufficient charges on the microorganisms so that the electrostatic collection technique is possible without the need for prior charging.

In our newly developed experimental system, the test bacteria are aerosolized from a liquid suspension and then channeled into parallel plate mobility analyzer. By adjusting the electric field inside the analyzer, we selected the bacteria carrying specific charge ranges. We obtained the electric charge distributions on the airborne bacteria by measuring the bacterial concentrations in those charge ranges and comparing them with total bacterial concentrations.

Our tests conducted with *P. fluorescens* bacteria have shown that airborne bacteria have a net negative charge, but the individual bacteria may be charged negatively or positively. When the bacterial suspension was aerosolized with a Collison nebulizer without an impaction wall, the bacteria acquired a charge distribution ranging from about 13,000 negative to about 13,000 positive charges. In contrast, NaCl particles of the same size (0.65-0.8  $\mu\text{m}$ ) acquired only between 1000 negative and 1000 positive charges. We also found that the amount of electric charge carried by airborne bacteria significantly depends on the aerosolization method. When the same *P. fluorescens* bacteria were aerosolized using a bursting bubble aerosol generator, the maximum charge acquired by the bacterial cells did not exceed 1,500 positive or negative charge. Our research has shown that dispersed bacteria have sufficiently high charges to be collected by an electrostatic field without prior charging.

#### NEW METHODS OF AEROSOL SAMPLING FOR MICROBIAL AND CHEMICAL ANALYSES

*G. Mainelis, K. Willeke, S. Grinshpun, T. Reponen*

Most aerosol samplers collecting biological and non-biological airborne particles onto a substrate utilize and impaction, impingement or filtering technique for the collection process. The method of collection used may affect the biological and chemical integrity of the sample. We have developed two new samplers. In the Biosampler, the aerosol flow is directed at an angle toward a curved inner surface, and the particles are collected into a swirling liquid, primarily by impaction and centrifugation. The liquid is then available for microbial and (or) chemical analyses. This sampler is gentle to the microorganisms and has a high collection efficiency, it can be operated with a non-evaporative liquid, and thus used for long-term sampling. In another sampler, the Button Sampler, the aerosol particles are sampled onto a filter by extracting them from the air through a curved porous surface. This sampler is quite insensitive to wind direction and collects the sampled particles uniformly on the filter, which is advantageous for subsequent chemical or microbial analyses.

#### EVALUATION OF A NEW PERSONAL SAMPLER FOR ENUMERATING AIRBORNE SPORES

*T. Reponen, S. Grinshpun, V. Aizenberg, Z. Wang, R. Gorny, K. Willeke*

The performance of a new personal sampler, the Button Aerosol Sampler, was tested under controlled laboratory conditions for total and viable enumeration of airborne microorganisms. Test particles included inert PSL particles, fungal and bacterial spores, and bacterial vegetative cells. The collection efficiency was close to 100% for the entire particle size range studied (0.44 – 5.10  $\mu\text{m}$ ). *Penicillium melinii* and *Aspergillus versicolor* demonstrated consistent culturability when sampling for 30 minutes to 8 hours, while less than 20% of *Bacillus subtilis* spores were culturable after 4-hour sampling. *Pseudomonas fluorescens* and *Serratia marcescens* vegetative cells were culturable only at RH=85% if sampled 10 minutes or less. The Button Aerosol Sampler was found to be suitable for the total enumeration of airborne microorganisms and for the viable enumerations of resistant spores.

#### **2001**

ASSESSMENT OF SLIPPERINESS OF WORK SURFACES ON SUBJECTIVE SLIP/FALL MEASURES AT AN AUTOMOBILE PARTS MANUFACTURING FACILITY. *M. Lu, L. Kincl, A. Bhattacharya, University of Cincinnati, Cincinnati, OH; J. Dewees, ERGO Accommodations Inc., Florence, KY.*

Subjective measures for slips/falls such as workers' perceived sense of slips/falls have been studied in our laboratory and considered as an easy and reliable method. However, they have not been evaluated in the field. This study was conducted to investigate the effects of slipperiness and lighting of work surfaces on the subjective measures for slips/falls in an automobile parts manufacturing facility. A manual towed-sled slip meter was used to measure the surface slipperiness quantitated as dynamic coefficient of friction (COF) in the production lines (A to G) of the facility. Questionnaires were self-administered by the associates of the facility and used to obtain the subjective measures, including Bishop-Corlett's body discomfort, Borg's overall physical exertion, self-reported slip/fall incidences, overall perceived sense of slips/falls and subjective rating of slipperiness while performing various job tasks. The associates in production lines A, B and C that had COF mean values below recommended value 0.5 ( $0.43 \pm 0.2$ ,  $0.41 \pm 0.1$ , and  $0.44 \pm 0.13$  for A, B, and C, respectively) had a higher slips/falls risk potential than those in other production lines. Results from an inter-correlation analysis between the subjective measures showed the overall perceived sense of slips/falls and the rating of work surface slipperiness were found to be significantly correlated with self-reported slip/fall incidences ( $r=0.52$ ,  $p<0.0001$  and  $r=0.39$ ,  $p<0.0001$ ), suggesting the subjective measures can be used as good predictors for slip/fall incidences in the workplace. Results from a general linear regression model showed the lighting and mean COF of work surfaces had no significant effect on the subjective measures. This may be caused by the facts that the lighting was sufficient for the tasks performed in the facility and that the COF measured did not represent the slipperiness between the shoe and the work surface. Evaluation of slip/fall potential may involve other risk factors such as job activity.

#### IDENTIFICATION OF ERGONOMIC HAZARDS ASSOCIATED WITH LEAD HAZARD REDUCTION WORK USING FOCUS GROUPS. *J. Gordon, W. Menrath, E. Auyang, L. Kincl, A. Bhattacharya, University of Cincinnati, Cincinnati, OH.*

Focus Groups, consisting of experienced lead hazard reduction workers, were comprised to obtain the workers "expert" opinion in identifying problem/high ergonomic risk tasks. The groups were divided between Lead Risk Assessors/Inspectors and Lead Abatement Contractors/Workers. The meetings were useful in identifying the sequence of job tasks required for each type of work, as well as determining which of these were the most physically demanding/strenuous. A self-reported symptom survey was used to capture information regarding typical body part discomfort experienced at the end of a workday or during particular tasks. The Risk Assessors/Inspectors rated performing x-ray fluorescence (XRF) readings as most physically demanding/strenuous task. Symptom surveys provided from this group showed that pain and discomfort was most often found in the neck, mid-to-lower back, and wrists. Participants indicated that the XRF instrument caused ergonomic problems and should be re-designed. The Lead Abatement Contractors/Workers ranked demolition as one of the most physically demanding/strenuous tasks. Here, symptom surveys showed pain and discomfort was most often located in the mid-to-lower back. Areas of improvement mentioned by both groups included increasing ergonomic training and selection of ergonomic tools. Participants were able to provide some ideas for reducing the physical effort levels required for certain tasks. Participants also discussed physical environmental conditions common at worksites. Cold and heat stress, poor lighting, slip/fall hazards, and deteriorated building conditions were most common in both groups. Some participants had received medical treatment for work-related injuries such as cuts/scrapes, back problems, knee problems, and broken bones. These meetings helped to increase the understanding of the study team regarding job task requirements, as well as providing information useful in conducting future in-depth ergonomic assessments.

#### MEASUREMENT AND CONTROL OF AIRBORNE MICROORGANISMS USING ELECTROSTATIC METHODS. *Mainelis, R. Gorny, K. Willeke, S. Grinshpun, T. Reponen, University of Cincinnati, Cincinnati, OH; P. Baron, NIOSH, Cincinnati, OH.*

Most of the widely used bioaerosol sampling devices employ collection techniques that are known to reduce viability of sampled microorganisms. An electrostatic collection method, where airborne particles

are electrically charged and then removed from the air by electrostatic forces, has the potential for being a "gentle" collection technique. Our tests with an Electrostatic Aerosol Sampler showed that charged microorganisms could be effectively removed from the airstream. However, charging by a conventional corona discharge inactivated sensitive airborne cells. The goal of this study was to determine how the bacterial recovery and injury depended on the amount of electric charge imparted on bacteria.

In our tests, the charging of airborne microorganisms was achieved not by the traditionally used corona discharge, but by applying induction charging. In this setting, bacteria were aerosolized and then imparted a charge ranging from -10,000 to +10,000 elementary charges. The bacteria carrying a desired electric charge were selected using a parallel plate mobility analyzer and collected with a BioSampler (SKC Inc., Eighty Four, PA) for a subsequent analysis of their relative recovery and injury.

The results showed that the relative recovery of *Pseudomonas fluorescens* bacterial cells carrying from -4,100 to +30 electrical charges ranged from 40 to 60%, while the recovery of the same cells carrying about -9,000 charges was below 20%. The relative recovery of *P. fluorescens* cells carrying more than 2,700 positive charges was less than 1.5%. In contrast, the relative recovery of *Bacillus subtilis* var *niger* did not depend on the amount of imparted electric charge. The extent of metabolic and structural injury of *P. fluorescens* cells also did not depend on the amount of electric charge carried by airborne bacteria. The study showed that polarity and magnitude of imparted electric charge is very important when developing microorganism collection methods employing electrostatics.

PESTICIDE USE WORK PRACTICE OBSERVATIONS AND PESTICIDE RESIDUES IN SOIL/DUST SAMPLES AT FARMS AND HOUSING OF RURAL AND AGRICULTURAL AREAS OF INDIA. *P. Rao, S. Clark, G. Talaska, University of Cincinnati, Cincinnati, OH; J. Muniz, Oregon Health Sciences University, Portland, OR; S. Mukherjee, Pramukh Swami Medical College, Karamsad, India.*

Much of the housing of the farm population in India is located immediately adjacent to the agriculture fields. Manual work methods are still commonly used in spite of the fact that, as a result of major efforts in recent years to increase food production, there has been a ten-fold increase in the use of pesticides and a seventeen-fold increase in the land area where pesticides are used. In an attempt to determine the potential for pesticide exposure, a survey was conducted on five farms in rural areas of the state of Gujarat, located in northwest India adjacent to Pakistan. Pesticide use work practice observations were made and soil/dust samples for pesticide analysis were collected from farm fields, pesticide mixing and storage areas and inside housing. Samples were analyzed by a modified USEPA method with a gel permeation sample clean-up procedure. Potential exposure pathways observed included: eating, drinking and smoking during pesticide use; lack of use of protective equipment; and storage of pesticides and spraying equipment inside the homes, sometimes along with food grains. Children and other family members played/worked in locations where pesticides were used, prepared and/or stored. Four organophosphate pesticides (chlorpyrifos, diazinon, methyl parathion, malathion) and six organochlorine pesticides (dieldrin, heptachlorepoxyde, lindane, p'p'-DDD, p'p'-DDE, p'p'-DDT) were detected in the samples. Pesticide residue levels were higher inside the homes than in areas outside. Levels of organochlorine residues were usually higher than for organophosphates. The highest organochlorine level was for p'p'-DDT (2500 ppb) and the highest organophosphate level was 700 ppb (chlorpyrifos). Levels of DDT were almost twice as high as the breakdown products DDE and DDD. Further qualitative and quantitative exposure assessments on larger populations could be useful to aid in the development of large-scale efforts to reduce pesticide exposures.

SAMPLING EFFICIENCIES OF THREE PERSONAL AEROSOL SAMPLERS WITHIN AND BEYOND THE INHALABLE PARTICLE SIZE RANGE. *V. Aizenberg, P. Baron, NIOSH, Cincinnati, OH; K. Choe, S. Grinshpun, K. Willeke, University of Cincinnati, Cincinnati, OH.*

A Simplified Test Protocol previously developed for the performance evaluation of personal inhalable aerosol samplers was used in a specially designed compact close-loop open-section wind tunnel. Traditional wind tunnels usually cannot handle particles larger than about 100 micrometers because rapid particle sedimentation makes it virtually impossible to achieve uniform aerosol distribution in the test zone. In contrast, the new wind tunnel facility was found useful for handling very large particles. The sampling efficiencies of three personal inhalable aerosol samplers (IOM, GSP, and the Button Personal Aerosol Sampler) were measured with 65-, 96-, 165-, and 241 micrometer particles at four inlet orientations (0, 90, 180, and 270 degrees) to the wind of 50 and 100 cm/s velocity. Analysis of Variance (ANOVA) conducted on the data obtained with the 65-micrometer particles has indicated that there was no statistically significant difference in the samplers' performance when they are tested in the small and in the large wind tunnels following the Simplified Test Protocol and the conventional approach (samplers on a full-size human manikin). The data show that the sampling efficiency of the IOM sampler depends significantly on wind velocity and is above 100% for particles of 165 and 241 micrometer mass median aerodynamic diameter. This dependence is not statistically significant for the GSP and the Button Sampler, whose sampling efficiencies were similar to each other and do not change with increasing test particle size at the indicated wind velocities. Also, it was found that the sampling efficiencies of the GSP and the Button Sampler closely follow independent data obtained with a breathing rotating manikin at the wind velocity of 100 cm/s. Use of the new wind tunnel design is expected to enhance our ability to extend the inhalable convention beyond 100 micrometers.

**SIGNIFICANCE OF RADIATION EXPOSURE FROM WORK-RELATED CHEST X-RAYS FOR EPIDEMIOLOGIC STUDIES OF RADIATION WORKERS.** *J. Cardarelli, H. Spitz, C. Rice, C. Buncher, H. Elson, P. Succop*

Occupational epidemiology studies provide an opportunity to evaluate the health risks from exposure to low-levels of ionizing radiation. The studies rarely include exposures from medical sources. In two studies of atomic bomb survivors, the authors concluded that medical x-ray exposures should be evaluated to better understand the effects for low-level exposures to ionizing radiation (Yamamoto et al., 1988; Antoku et al., 1972). The aim of this study is to investigate multiple source of worker exposures to external ionizing radiation at a uranium enrichment plant (a low-level exposure facility) between the early 1940s and 1990s and determine if work-related x-ray exposures added substantially to their cumulative occupational dose.

**EXPOSURE ASSESSMENT STRATEGIES AND VALIDATION FOR ESTIMATION OF RADON EXPOSURE AMONG NUCLEAR WORKERS.** *R. Hornung, S. Pinney, G. Killough and J. Lodwick*  
We will describe the exposure assessment strategy used to estimate exposures to radon (Rn-222) decay products among workers at the Fernald Feed Materials Production Center, a uranium processing plant operated under contract to the U.S. Department of Energy. We used a stochastic mathematical Model, specifically developed to estimate radon levels to residents in the area surrounding the plant, to estimate radon exposure to workers employed at the plant from 1952 to 1988. We also employed CR-39 alpha particle detectors throughout the plant to both augment and validate the estimates generated by the model.

**CHARACTERISTICS OF A NEW PERSONAL SAMPLER FOR COLLECTION OF AIRBORNE SPORES.** *T. Reponen, S. Grinshpun, R. Gorney, V. Aizenberg, Z. Wang, K. Willeke*

Most of the commercially available bioaerosol samplers have been developed as stationary devices (not as personal samplers). The button Aerosol Sampler (SKC Inc., Eighty-Four, PA, USA) has previously been evaluated for stationary and personal training the tests conducted with non-biological particles have shown that its sampling efficiency follows closely the inhalability convention (1). It has also been shown to feature low transmission losses and low sensitivity to the wind direction and velocity. In this study, the performance of the Button Sampler was tested for the total and viable enumeration of airborne

microorganisms and compared to that of the standard 37-mm filter cassette, the Burkard sample and the Air-O-Cell sampler.

**PILOT EVALUATION OF AN EXPOSURE ASSESSMENT PROTOCOL FOR MAINTENANCE ACTIVITIES AND NONROUTINE TASKS** *Grimsley, F., Rice, C., Malone, R., Ayer, H., Bingham, E.* Historically, maintenance activities and nonroutine tasks were often omitted from industrial hygiene sampling strategies. These activities and tasks can lead to occupational health hazard exposures. A protocol was developed to evaluate and document potential exposures that can occur during routine and non-routine tasks. The protocol included a walkthrough survey material safety data sheet review, and four survey instrument to assess and identify activities that could lead to inhalation and dermal exposures. Each of the instruments is displayed. The survey instruments were used to conduct employee interviews, work practice observations, and skin and clothing observations. The instruments specifically sought information on job tasks; duration and frequency of tasks; routes of exposure; work practices; hand, skin, and clothing contamination; and personal protective equipment usage. The protocol and survey instruments were field tested in the automobile manufacturing industry and are effective in identifying routine and nonroutine activities that could lead to inhalation and dermal exposures from chemicals. Evaluation of employee reports of exposure during specific tasks such as painting showed concordance between reported skin exposure and observation (n=30;p<0.01). However, the interview instrument did not work well among production line employees who were required to be mobile during their tasks. Modification in the protocol resulted in having the individuals complete the instrument during team meetings. A comparison of chemical protective clothing reported by employees versus what was observed did show a difference. For example, some employees reported that for a specific clean-up procedure chemical protective rubber gloves were used, when in practice some employees used surgical latex gloves. The authors conclude that the protocol and survey instruments are valuable tools for assessing potential exposures during maintenance activities and nonroutine tasks.

## 2002

**AIRBORNE MICROORGANISM COLLECTION BY A NEW ELECTROSTATIC PRECIPITATOR** *K. Willeke, S. Lee, G. Mainelis, A. Adhikari, T. Reponen, S. Grinshpun, S. Cho, H. Wang and M. Trunov* Many aerobiological measurements and the protection of governmental/military establishments from bioterrorism require the development of new bioaerosol collectors that can be operated efficiently at low power. We have developed and evaluated a new bioaerosol collectors that can be operated efficiently at low power. We have developed and evaluated a new bioaerosol sampler in which the microorganisms are collected by electrostatic means. An ionizer charges the incoming microorganisms, if they carry insufficient charge for efficient collection in the device. The microorganisms are collected on two square agar plates placed along the flow axis. Laboratory experiments have shown that bacterial cells and spores are generally collected more efficiently than inert particles. We attribute this difference to the natural negative charge contained in the cell membranes of microorganisms. The results of field measurements parallel those obtained through laboratory experiments.

**BIOAEROSOL COLLECTION BY A NEW ELECTROSTATIC PRECIPITATOR.** *K. Willeke, G. Mainelis, A. Adhikari, T. Reponen, S. Grinshpun, S. Lee, S. Cho, University of Cincinnati, Cincinnati, OH*

Airborne microorganisms may cause a wide range of respiratory and other health disorders in individuals exposed to occupational or residential environments. Governmental and military establishments have also become very concerned about intentional microorganism release into air by terrorists. Therefore, there is considerable interest in the IH community for a sampling technique that collects airborne microorganisms efficiently at low power input.

Based on several years of research on the electrostatic properties of airborne microorganisms, we have developed and evaluated a new bioaerosol sampler in which the organisms are collected by electrostatic means. An ionizer in the inlet charges the incoming organisms, if they carry insufficient charge for efficient collection in the device. The organisms are collected on two square agar plates that are placed along the flow axis.

Laboratory experiments with inert NaCl particles versus different bacterial cells and spores have shown that the collection of microorganisms is generally more efficient than that of inert particles, even after electric charge neutralization with a Kr-85 radioactive source. We attribute this difference to the natural negative charge contained in the cell membranes of microorganisms. A small amount of ionization in the inlet section was found to increase the collection efficiency of microorganisms significantly more than that of inert particles. With no charges applied at the inlet, charge-neutralized *Bacillus subtilis* cells and spores were collected at 4 Lpm with an efficiency close to 80%. With an ionizing current of 110 mA, the efficiency increased to 90% to 100%, depending on the precipitation voltage. The new electrostatic precipitator is small and uses standard microbiological analysis techniques, and is thus suitable for industrial hygiene field use.

CARCINOGEN-DNA ADDUCTS ARE INCREASED IN EXFOLIATED UROTHELIAL CELLS OF WIVES OF SMOKERS: BIOLOGICAL MONITORING OF PASSIVE SMOKE EXPOSURE S. Henn, B. Schumann, P. Succop, G. Talaska, University of Cincinnati, Cincinnati, OH

Tobacco smoking is the most important environmental carcinogen, increasing the rate of urinary bladder cancer 2 to 9 times. The risk of this cancer in passive smokers has been more difficult to assess. Passive smoke contains more of the urinary bladder carcinogen, 4-aminobiphenyl, on a per weight basis than does mainstream smoke. We attempted to use carcinogen biomarkers to reduce misclassification associated with this exposure. We obtained first morning urine samples from 21 wives of non-smokers and 22 wives of smokers and measured exfoliated urothelial cell DNA adduct and IHP levels.

IHP levels increased non-significantly in the wives of the smokers (mean= 0.27:g/l, SE= 0.06, versus 0.192:g/l, SE= 0.02)(p= 0.17). This is an estimate of exposure for the preceding 24 hours. Daily exposure variability of smokers' wives contributes heavily to the inability to see significant differences in spot sample. There was a statistically significant difference in the levels of DNA adducts in the exfoliated urothelial cells of the wives of smokers (2.8 adducts per 108 nucleotides, SE = 0.8) versus the wives of non-smokers (1.1/108 nucleotides, SE = 0.4, p < 0.05). DNA adduct levels integrate exposure over a much longer time and these data indicate that the variation in daily exposure (as indicated by IHP levels) is smoothed by the measurement of DNA adducts. The correlation between individual IHP and the DNA adduct levels was not significant (r=0.3), which further suggests that at these low levels of exposure there is too much daily exposure variation to accurately predict biological effect from a single measurement. A biological monitoring program including both metabolite and DNA adduct analysis, in particular, repeated measurements of the excretion of metabolites is needed to better assess daily variation in exposure. (Supported by NIOSH T42-CCT-510420 and NIEHS P30-ES0-6096.)

DETERMINATION OF THE FEASIBILITY OF USING THE PORTABLE X-RAY FLUORESCENCE (XRF) ANALYZER IN THE FIELD FOR MEASURING THE LEAD CONTENT OF SIEVED SOIL. A. Armstrong, S. Clark, P. Succop, W. Menrath and S. Roda, University of Cincinnati, Cincinnati, OH  
Soil samples collected in areas of residential contamination are generally analyzed using atomic absorption spectrometry (AAS) or other laboratory methods. Prior to analysis, the samples are frequently prepared by drying the samples, and then the samples are sieved followed by an acid digestion step, all of which usually takes several days. Previous work has indicated that an FPXRF (field-portable x-ray fluorescence) analyzer is capable of producing soil lead results that are comparable to results by AAS on

samples sieved to less than or equal to 125 micrometers. A considerable savings in time and effort would occur if a field method, including sieving, could be developed which does not require laboratory digestion and analysis and provides the results in a timely manner to inform residents and others. The goal of this study was to determine the practicality of using the portable XRF analyzer in the field for analysis of sieved soil for lead. Other objectives of the study included determining the effects of moisture on sieving relative to the analysis of lead in soil. When performing the field analysis, sieving was performed (<125 mm) and grinding was performed to reduce the particle size of the fraction ( $\geq 125$ ). A moisture reading was also taken for use in determining the moisture level of the soil. Testing was performed using the soil from yards of Cincinnati area housing built before 1978. 120 samples were collected and analyzed at 30 different locations. The mean lead level before drying the samples was 816 ppm with a range of 22.8 ppm to 9080 ppm. The percentage saturation ranged from 10% to 90%. At 65% saturation or higher soil did not pass through the sieve, therefore the field method with sieving is not practical when the soil is 65% saturated or higher.

DEVELOPMENT OF A RAPID ON-SITE METHOD FOR THE ANALYSIS OF DUST WIPES USING A FIELD PORTABLE X-RAY FLUORESCENCE ANALYZER. *S. Clark, W. Menrath, P. Succop, M. Chen, J. Grote, University of Cincinnati, Cincinnati, OH*

Lead levels of dust wipes collected from housing undergoing risk assessment and those for which lead hazard control work had been completed were analyzed using field portable X-ray fluorescence analyzers (XRF). The dust wipes were then digested and analyzed by atomic absorption (AA) spectroscopy in the laboratory. In order to be 95% certain that the AA lead level of a dust wipe would be 40 ug or lower, the current HUD standard for floor dust wipes, the XRF lead level should not exceed 26.8 ug. The apparent limit of detection for this instrument was 6 ug. The corresponding XRF levels for AA values of 250 ug (window sill standard) and 800 ug (window trough standard) are 98.8 ug and 256 ug, respectively. For a prototype instrument tested earlier, the corresponding XRF levels were 33.2, 134 and 322 ug, respectively. An inter-instrument comparability study to determine the variability of six instruments from the same manufacturer revealed close agreement among the instruments, with one instrument tending to have readings that were about 11% lower than the others which varied from the overall mean by -4.6 to +6.6 %. Because instrument performance can change over time, it is recommended that a series of quality control samples covering the range of interest be tested each day the instrument is used. Using appropriate quality control procedures, the portable XRF analyzer is capable of providing reliable lead wipe level determinations. Research is currently underway to explore the utility of the portable XRF to provide on-site lead loading levels as the clean-up after lead hazard reduction is completed, to reduce the rate of clearance failures.

EVALUATION OF BIAXIAL ELECTROGONIOMETERS FOR ERGONOMIC POSTURE LOADING DURING LEAD ABATEMENT AND RISK ASSESSMENT TASKS *J. Gordon, M. Lu, A. Bhattacharya, University of Cincinnati, Cincinnati, OH*

Risk factors of lead abatement work and lead risk assessments are task dependent and can involve awkward postures and repetitive motions. An electrogoniometer system was tested for ergonomic posture evaluations on the wrist and elbow. Accuracy testing and lab-evaluation were performed on two types of biaxial electrogoniometers (Penny and Giles Ltd.). These electrogoniometers are designed to measure the angular displacement between two end blocks of an electrogoniometer in two planes. First, the electrogoniometer was attached to a manual universal goniometer (JAMAR) and moved about the axis in 2° increments to measure angles between -150° and 150° (as recommended by the manufacturer). Based on three trials, regression coefficients for electrogoniometers XM65 (wrist) and XM110 (elbow) in the X plane were 0.9996 and 0.9997, respectively. In the Y plane, regression coefficients were 0.8321 and 0.9987, respectively. Next, the electrogoniometers were evaluated in the laboratory by comparing arm posture angles with a 3-D computerized motion analysis system (MOTUS, Peak Performance Technology). For this evaluation, a subject wore the electrogoniometers as well as passive reflective markers on

the joints of interest. The subject began in a neutral position and then performed static and dynamic posture tasks in a standard protocol which included bending the elbow 90° or extending the wrist 40° in both planes. These tasks were performed on two different days to address not only the evaluation of the system, but also placement issues. The average difference in degrees during static and dynamic tasks for the XM110 was 7°. The average difference during static and dynamic tasks for the XM65 in the X and Y planes was 4°. These two evaluations showed that the electrogoniometers meet our requirements for obtaining posture data on lead abatement workers and risk assessors. The electrogoniometers are currently in use at lead risk assessment and abatement sites.

**EVALUATION OF THE AEROSOLIZATION OF MICROORGANISMS FROM METAL WORKING FLUIDS.** *H. Wang, T. Reponen, A. Adhikari, S. Sivasubramani, S. Grinshpun, M. Trunow, K. Willeke*  
Workers exposed to metal working fluid (MWF) aerosols may be at risk of developing a variety of respiratory and skin diseases. About 1.2 million workers in the United States are occupationally exposed to MWFs. Furthermore, it has been reported that MWFs are the second most common cause of work-related asthma in the state of Michigan. Microorganisms present as contaminants in MWFs are suspected to be one of the causative agents for respiratory symptoms and diseases in worker. Until now most of the research has been focused on the investigation of microorganisms in MWF reservoirs. Limited information is available on the composition and concentration of airborne microorganisms at metalworking sites.

The aim of this study was to characterize the aerolization of different microorganisms from MWFs. This study was performed with *Pseudomonas fluorescence* cells and *Aspergillus niger* spores aerosolized by a Collision nebulizer from three different suspensions: sterilized water, 5% semi-synthetic MWF and 5% soluble oil MWF. The resulting bioaerosols were dried, charge-neutralized and passed into the measurement chamber. The airborne microorganisms in the measurement chamber were sampled by Button Inhalable Aerosol Samplers at an airflow rate of 4 liters/min. The microorganism concentrations in the nebulizer suspensions and on the Button Sampler filters were analyzed by microscopic counting. The microorganism concentrations in the nebulizer were adjusted to 10<sup>7</sup> particles/m<sup>3</sup>. The resulting concentration of airborne microorganisms ranged from 10<sup>4</sup> to 10<sup>6</sup>. It was found that the aerosolization of microorganisms depends more on the type of microorganism rather than on the type of suspension. The variation in the aerosolization rate between different microorganism species can be due to variations in size and surface characteristics.

**EVALUATION OF THE BUTTON SAMPLER FOR THE MEASUREMENT OF OUTDOOR AEROALLERGENS** *Adhikari, S. Cho P. Pal, H. Wang, S. Lee, A. Kelley, H.G. St. Clair, G. LeMasters, S. Grinshpun, T. Reponen*

Accuracy in the sampling of outdoor aeroallergens is a critical issue when assessing the incidence of respiratory allergy and asthma. Recent laboratory studies have demonstrated that Button Personal Inhalable Aerosol Sampler is highly efficient for bioaerosol sampling and has low sensitivity to the wind direction velocity. The aim of the present study was to evaluate the performance of the Button Sampler for sampling of outdoor pollen grains and fungal spores in field conditions in Cincinnati, Ohio, USA.

Two identical Button Samplers were installed on a rooftop side by side with a 24-hour intermittent Rotorod Sampler and a weather station. One Button Sampler was oriented to southwest (the prevalent wind direction in Cincinnati) and the other one was oriented to northeast.

The combined data from all three samplers operated in the Fall showed that the total pollen concentration ranged from 0 to 170/m<sup>3</sup>. Results on fungal spores from two Button samplers correlated well (r<sup>2</sup>=0.906). Positive correlation (r<sup>2</sup>=0.575) was also observed with the pollen data. This finding supports the laboratory results on the independence of the performance of the Button Sampler on wind direction and velocity. The Button Sampler demonstrated on an average 3 times higher concentration than the Rotorod for

the total concentration of fungal spores and pollutant grains. This difference was more pronounced with *Aspergilli/Penicilli*. The results indicate that Button Sampler is efficient for collecting outdoor aeroallergens, and is especially beneficial when collecting smaller fungal spores.

THE INFLUENCE OF EXTERIOR LEAD-CONTAMINATED DUST AND SOIL ON POST-INTERVENTION INTERIOR DUST LEAD LOADING S. Clark, M. Chen, W. Menrath, R. Buncher, P. Succop, University of Cincinnati, Cincinnati, OH; P. McLaine, W. Galke, S. Dixon, National Center for Lead-Safe Housing, Columbia, MD

To aid in understanding the contribution of exterior dust/soil lead to post-intervention interior dust lead, a subset of housing in the Evaluation of the HUD Lead-Based Paint Hazard Control Grant Program was selected for collection of exterior entry and street dust, obtained by a vacuum method, and composite building perimeter soil core samples. Although interior dust wipe lead samples were collected by Evaluation grantees at several times, both pre- and post-intervention, exterior dust samples were not collected and soil samples were collected by only a few grantees. Results from 500 dwelling units revealed a wide range of exterior dust and soil lead levels both within and across the 12 contributing grantee sites. Minimum and maximum geometric mean dust lead loadings, by grantee, were: 126 and 14,400 ug/sq ft for exterior entry dust; 325 and 4,750 ug/sq ft for street dusts and for soil lead mean concentrations ranged from 383 and 2,710 ppm. Exterior entry dust lead concentration was about five times as high as street dust lead concentration suggesting that lead in dust near housing was a source of lead in street dust. Geometric mean exterior dust lead loading was more than five times higher than window trough dust lead loading and at least an order of magnitude higher than interior entry dust lead loading. Soil was not present for almost one-half of the housing units and although statistical analysis revealed several paint factors contributing to soil lead, a pathway from soil lead to dust lead was not detected. Statistical modeling revealed statistically significant pathways from both exterior entry and street dust lead to interior dust lead loading on entryway floors, other interior floors, window sills and troughs. The inclusion of measures to mitigate the role of exterior sources in lead hazard control programs needs consideration.

PERSONAL LEAD EXPOSURE DURING INDOOR LEAD-BASED PAINT ABATEMENT M. Trunoy, S. Grinshpun, K. Willeke, K. Choe, University of Cincinnati, Cincinnati, OH; W. Friedman, U.S. HUD, Washington, DC

Millions of U.S. homes still have lead-based paint (LBP) and require abatement. In this study, the personal lead exposure of abatement workers was assessed during active LBP removal and final cleaning procedures performed indoors. Personal aerosol monitoring was performed during LBP abatement of wooden surfaces in a room-size Environmental Test Chamber (volume = 24.3 m<sup>3</sup>). Short-term task-specific lead exposures were determined for dry scraping, dry non-HEPA machine sanding, and wet scraping. The exposure assessment was also performed for different work practices applied for the final cleaning. The air sampling was done with the Button Personal Inhalable Aerosol Sampler (operated at 4 Lpm) and the standard closed-face 37-mm cassette (2 Lpm). The filters were analyzed for lead using Flame Atomic Absorption Spectrometry (NIOSH 7082 method). Statistical analyses indicated that lead concentrations obtained with the Button Sampler were up to 50% higher than those obtained with the 37-mm cassette. The regression coefficients for the data varied from 1.08 (for final wet cleaning) to 1.50 (for dry scraping). Microscopic analyses have shown that the sampler's regression coefficient increases with increasing percentage of large (> 20 mm) inhalable particles.

The geometrical means of the short-term lead exposure of workers measured with the Button Sampler for different active abatement methods were: 820  $\mu\text{g}/\text{m}^3$  for wet scraping, 5860  $\mu\text{g}/\text{m}^3$  for dry scraping, and 8,330  $\mu\text{g}/\text{m}^3$  for dry sanding. These concentrations are significantly higher than the half-facepiece air purifying respirator protection level of 500  $\mu\text{g}/\text{m}^3$  (based on a respirator protection factor of 10). No definite conclusion can be drawn at this time, because in various field situations adequate protection may be provided, since the actual respirator protection factor may significantly exceed 10 and large airborne

particles released during active lead abatement have limited penetration through the respirator's face seal leaks and no penetration through the respirator filter material.

## APPENDIX D

### INDUSTRIAL HYGIENE PUBLICATIONS 1997 - 2002

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- Succop, P Clark, S, Tseng, C-Y, Bornschein, R and Chen, M (2001) Evaluation of Public Housing Risk Assessment Data, *Environmental Geochemistry and Health* .
- Talaska, G., Maier, A., Henn, S., Booth-Jones, A., Tsuneoka, Y., Vermeulen, R. and Schumann, B. (2002) Carcinogen biomonitoring of human exposures and in laboratory research: validation and application to human occupational exposures, *Toxicol. Letts*. In Press.
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- Willeke, K., and Macher, J.M. (1999). "Air Sampling", in *Bioaerosols: Assessment and Control* (J.M. Macher, Editor), Chapter 11, pp 11-1 to 11-25, American Conference of Governmental Industrial Hygienists, Cincinnati, OH.
- Xue, W., Siner, A., Rance, M., Jayasimhulu, K., Talaska, G. and Warshawsky, D. (2002) Metabolic activation of 7H-dibenz[c,g]carbazole via o-quinone Part 2: Covalent adducts of 7H-dibenz[c,g]carbazole-3,4-dione with nucleic acid bases and nucleosides, *Chem. Res. Toxicol.*, IN Press.
- Xue, W., Schneider, J., Mitchell, K., Jaeger, M., Nanayakkara, V., Talaska, G. and Warshawsky, D. (2001) Trans-3,4-Dihydrodiol-anti-1,2-epoxy-1,2,3,4-tetrahydrodibenz[a,j]acridine involvement in dibenz[a,j]acridine DNA adduct formation in mouse skin, *Chem. Res. Toxicol.*, In Press.

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**APPENDIX E**

**NIOSH TRAINING GRANT PROGRAM GRADUATES & PLACEMENT**  
 Academic Year 9/1/97 – 6/30/02

Occupational Health Nursing

Name #	Date Entered Program (MO/YR)	Date Degree Awarded## (MO/YR)	Degree Awarded ### (e.g., MS/PH)	Date of Certificate of Completion ** (MO/YR)	Current Employment Status (Job title/employer)	Current Business Address (Or last known address)
Brown, Michelle	9/01			Post-master's 6/02	Cambell Food Co.	Napoleon, OH
Campbell, Linda	9/97	8/01	MSN / Community Health		DHN/Riuz Food Prod., Inc.	Riuz Food Products 501 S. alta Ave Dinuba, CA 93618
Christianson, Jane	9/98	6/01	MSN / Community Health		Occupational Health Coordinator/TriHealth	Formica Corporation at 10155 Reading Road, Evendale, Ohio
Chen, Jie*	9/99	6/01	MSN / Community Health		Applying for PhD Program	University of Cincinnati College of Nursing PO Box 210030 Cincinnati, OH, 45221
Craig, Elaine	9/98	6/01	MSN / Community Health		CNS/University Hosp. .	234 Goodman, Cincinnati, OH, 45219
Downing, Shelley	9/00	12/02	MSN / Community Health		Pending graduation	
Geary, Michael	9/00	12/01	MSN / Community Health		Farm Implement Mfg.	Pennsylvania
Gibson, Mikal	9/00	12/01	MSN / Community Health		DHN case management	
Helsingier, Coleen	9/95	9/99	MSN / Community Health		Case Manager	Concentra Managed Care, Inc. Cincinnati
Kelly, Cynthia	9/96	6/02	PhD Nursing		Assistant Professor	Northern Kentucky University
Lockett, Janice	9/95	6/98	MSN / Community Health		Assistant Professor	Cincinnati Technical Institute
Moeller, Judith	9/95	6/98	MSN / Community Health		Case Manager	
Nester, Robert	9/95	6/99	PhD Nursing		Research Scientist	OSHA, Washington, DC
Perng, Shoa Jen	9/97	6/02	PhD Nursing		Professor of Nursing	Hualien, Taiwan, ROC
Randolph, Jo Ann	9/95	6/00	PhD Nursing		Nursing Professor	Northern Kentucky University
Rebhan, Catherine	9/95	12/97	MSN / Community Health		Case manager	
Richter, Sharon	9/99	6/01	MSN / Community Health		Manager, Occupational Health & Safety	Moving, address not available at this time.
Shearman, Victoria	9/96	6/01	MSN / Community Health		CNS Employee Health	Children's Hospital Med Center, 3333 Burnet Avenue, Cincinnati, OH 45229-3039
Sorenson, Paul	9/98	6/00		Post-Master's certificate FNP	Case Manager	Bethesda Care

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- NOTE:** Please only report data for the **time period specified above** and do not eliminate any of the columns.
- # = Please specify by asterisk those Program graduates that did **not** receive NIOSH financial support.
  - ## = Report only degrees awarded at **your** institution.
  - ### = Please also specify specialty area as noted on degree.
  - \*\* = This column should be used **only** for Occupational Medicine residency graduates and other Certificate program graduates to specify issuance dates of certificates of completion of residency or other specified programs.

## APPENDIX F

### OCCUPATIONAL HEALTH NURSING PUBLICATIONS

1997 -- 2002

- Anderson, D., Bankston, K., Stindt, J., & Weybright, D. (2000). Interdisciplinary shared governance: A partnership model for high performance in a managed care environment. *Seminars for Nurse Managers*, 8, 1-12. (September)
- Baik, S., Oakley, L., Hoebeke, R., & Dunham, N. (2001). Understanding managed care: Practice implications for NPs. *Clinical Excellence for Nurse Practitioners: The international journal of NPACE*. 5(4), 1-8. (May)
- Beery, T. (2000). The evolving role of genetics in the diagnosis and management of heart disease. *Nursing Clinics of North America*, 35, 963-973. (December)
- Brehm, B. (2000). Book review: Women afraid to eat. *Journal of the American Dietetic Association*, 100, 126-1267.
- Bliss, T; Kinel, L.; Auyang, E.; Baker, J.; Everitt, J.; Mangharam, J.; Pasternak, E. & Rice, C. *Residual Pesticides in Housing and Bedding at Migrant Labor camps in Northwestern Ohio*. A poster presentation at the American Industrial Hygiene Conference & Exposition, Atlanta, GA, May 1-15, 1998.
- Brehm, B., Seeley, R., & D'Alessio, D. (2001). *Effects of a low carbohydrate, ketogenic diet on body weight and cardiovascular risk factors* (abstract). *Journal of the American Dietetic Association*, 101(9), Supplement, A-84.
- Burton, Mattie Presentation "Integrating Business Theory into Nursing Management". Nursing Leadership and Management Conference. Ohio State University, October 3, 2000.
- Burton, M. (1999). Presentation: "Herbal Medicine: What your client didn't tell you" Annual Conference of Kentucky Association of Not-for-Profit Homes and Services for the Elderly, Louisville, KY.
- Burton, M & Wilburn, B (1998) Poster presentation "School-based mobile clinics" 23<sup>rd</sup> National Primary Care Nurse Practitioner Symposium, Keystone, Colorado.
- Davis, LS & Nester, R. (2001). *Demonstrating productivity through evidence-based research methods, using Bureau of Workers' compensation case studies*. A workshop presented at the Applications of Human Performance & Disability Conference, March 26-29, 2001, Cairo, Egypt.
- Daraseh, N, Genaidy, A. & Davis, LS. (2001). *Relationship between work & individual factors and health outcomes measures*. Paper presentation at the Applications of Human Performance & Disability Conference, March 26-29, 2001, Cairo, Egypt.
- Davis, LS; Genaidy, A; Daraseh, N & Burton, M. (2001) "Organizational factors contributing to work-related musculoskeletal disorders in nursing personnel". Scholarship Roundtable Series for Faculty and Graduate students, May, College of Nursing, University of Cincinnati.
- Driscoll, K. (1998). *The application of genetic knowledge: Ethical and policy implications*. *AACN Clinical Issues*, 9, (4), 588-599. (Has a section on protection in the workplace.)
- Dyehouse. "Brief intervention for reducing alcohol consumption following unintentional injury." A paper presented at the 23<sup>rd</sup> Annual Midwest Nursing Research Society Research Conference. Indianapolis, Indiana, April 11, 1999.
- Dyehouse, J.M., Sommers, M.S., & Howe, S.R. (2001). Abstinence of non-dependent drinkers after brief intervention in 12 months post unintentional injury (abstract). *Alcoholism: Clinical and Experimental Research*, 25 (S5), 55A.
- Finkelman, A. (2001). *Problem-solving, decision-making, and critical thinking: How do they mix and why bother?* *Home Care Provider*, 6(6), 194-199.
- Fitzwater, E. (1999). Tips on caring for yourself as you care for other. Electronic article. Available online at Netwellness Consumer Health Information site. <http://www.netwellness.org/health-topics/aging/faq11.cfm>.

- Fitzwater, E., & Gates, D. (2002). *Testing an intervention to reduce assaults in nursing homes: A pilot study*. *Geriatric Nursing*, 23(1), 1-7. (March)
- Fitzwater, E & Gates, D. (2000). Violence in home health care. A focus group study. *Home Healthcare Nurse*, 18, 596-605.
- Fitzwater, E. & Gates, DM. "Violence against caregivers in nursing homes: Expected, tolerated and accepted?" Ohio Healthcare Association Conference, Columbus, OH, May 4, 1999.
- Fitzwater, E. & Gates, D.M. "Violence against caregivers working in nursing homes. A focus group study." A paper presented at the Gerontological Society of America, Philadelphia, November 23, 1998.
- Fontana, J., Colella, C., Baas, L.S., & Ghazi, F. (2000). T'ai Chi Chih as an intervention for heart failure. *Nursing Clinics of North America*, 35, 1031-1046. (December)
- Gates, D., Fitzwater, E. & Telintelo, S. (2000). Using simulations to assess skill performance. Manuscript submitted to *Nurse Educator*, summer.
- Gates, D., Fitzwater, E, Deets, C. (2000). Testing the reliability and validity of the assault log and violence prevention checklist. Manuscript submitted to the *Journal of Nursing Measurement*, Summer, 2000.
- Gates, D. "Workplace Violence: What really Works". Ninth Annual National Worker' Compensation and Occupational Medicine Seminar, San Diego, Ca, March 29, 2000. Invited speaker.
- Gates, D., Fitzwater, E. & Meyer, U. (1999). Violence against caregivers in nursing homes: Expected, tolerated accepted. *The Journal of Gerontological Nursing*, 25, 12-22.
- Gates, D.M. (1997). Predicting occupational health nurses' intentions to provide violence prevention education. *American Journal of Health Behavior*, 21, 197-206.
- Gates, D.M. & Fitzwater, E. "Violence against caregivers in nursing homes: Expected, tolerated and accepted?" A paper presented at the American Public Health Association, Chicago, November 8, 1999.
- Gates, D.M. "Violence against caregivers in nursing homes: Expected, tolerated and accepted?" A paper presented at the American Conference of Governmental Industrial Hygienists (ACGIH), "Hazard Control Technologies in Healthcare: Collaborative Strategies for the Next Millennium, Colorado Springs, August 3, 1999.
- Gates, D.M. & Fitzwater, E. "Violence against healthcare workers: Expected, tolerated and accepted?" a paper presented at the University of Kentucky, Lexington, KY, April, 16, 1999.
- Gates, D.M. "An action plan to prevent and control workplace violence." A paper presented at the American Occupational Conference, Boston, April 26, 1998.
- Gates, D.M. (1999). Reviewer for two chapters in *Community Health Nursing*, "Health Promotion" and "Occupational Health Nursing".
- Gates, D. (2001). *Stress and coping: A model for the workplace*. *AAOHN Journal*, 49, 390-398. (August)
- Gates, D., Fitzwater, E., & Telintelo, S. (2001). *Using simulations and standardized patients in intervention research*. *Clinical Nursing Research*, 10(4), 387-400. (November)
- Gibbs, C & Burton, M. (1999). *Lung cancer*. *ADVANCES for Administrators in Radiology*.
- Kelly, Cynthia. Paper presentation "Heart Healthy Behavior Study: Using Rasch Analysis for Rating Scale Development" October, 2000 at the First Annual Pilot Research Symposium, University of Cincinnati, Cincinnati, OH.
- Kelly, Cynthia. Presentation, "Rasch Rating Scale Methods" Scholarship Roundtable, November, 2000, College of Nursing, University of Cincinnati, Cincinnati, OH.
- Kenner, C., & Dreyer, L. (2000). Prenatal and neonatal testing and screening: A double edged sword. *Nursing Clinics of North America*, 35(3), 627-642. (September)
- Kennerly, S. (2001). Fostering interaction through multimedia. *Nurse Educator*, 26, 90-94. (March/April)
- Kennerly, S. (2000). Perceived worker autonomy: The foundation for shared governance. *Journal of Nursing Administration*, 30(12), 1-7. (December)

- Hern, M., Chung, H.S., Lindell, A. R., & Kim, C.J. (2000). Linking hands online: The Korean connection. *Reflections on Nursing Leadership*, 26, 16-19. (July-November)
- Hur, K.H. (2000). Nursing diagnoses and interventions used in home care in Korea. *Nursing Diagnosis: The Journal of Nursing Language & Classification*. (July-September)
- Jones, Susan. A poster presentation, "Photonovels: Tools to Promote Health in the Occupational Arena" at the American Occupational Health Conference, San Francisco, CA, April 24, 2001.
- Jones, Susan. A poster presentation, "Development of an Interdisciplinary Rural Health & Safety Academic Course: A Collaborative Approach" at the 2<sup>nd</sup> Annual Teaching Symposium, Lexington, KY, September 21-22, 2000.
- Jones, Susan. A poster presentation, "Empowering Rural Adolescents in Risk Reduction" at the 2<sup>nd</sup> Annual Research Day, Kappa Theta Chapter, Sigma Theta Tau, Bowling Green, KY, March, 2000.
- Jones, Susan. A poster presentation, "Developing Photonovels as Educational Tools in the Prevention of Agricultural Injury and Illness" at the 4<sup>th</sup> International Symposium, "Rural Health in a Changing World", Saskatoon, Saskatchewan, Canada, October, 1998
- Jones, Susan. A poster presentation, "Lessons Learned from a Women-Focused Partnership for Farm Safety" at the Fourth World Conference on Injury Prevention and Control, May 20, 1998 in RAI Amsterdam, The Netherlands. Co-authored with Dr. Robert McKnight, College of Medicine, University of Kentucky and presented by Dr. McKnight.
- Jones, Susan. A poster presentation, "A Community-Based Nursing Education: Promoting Agricultural Health & Safety in Country Stores" at the KY Nurses Association Annual Convention, Louisville, KY, October 23, 1997.
- Jones, Susan. A poster presentation, "Health Promotion in Country Stores" at the Thirteenth Congress of the International Association of Agricultural Medicine and Rural Health, University of Iowa, Iowa City, Iowa, September 7-9, 1997.
- Jones, Susan. A poster presentation, "Health Promotion in Country Stores," at the Summer Conference of the National Institute for Farm Safety, Indianapolis, IN, June 25-27, 1997.
- Jones, Susan. Paper presentation, "Assessing Factors Contributing to the Use of Respiratory Protection of Workers in Swine Confinement Buildings" at the Pilot Research Project Symposium, University of Cincinnati, October 13, 2000 and at the 3<sup>rd</sup> Research Day, Kappa Theta, Sigma Theta Tau, Inc., Bowling Green, KY, March 30, 2001.
- Jones, Susan. Paper presentation, "Empowering Rural Adolescents in Risk Reduction" at the 12 Annual Rural Nursing Conference, Estes Park, CO, September 14, 2000.
- Jones, Susan. Paper presentation, "Empowering Rural Adolescents in Risk Reduction Through the Use of Photo Novels" at the 127<sup>th</sup> American Public Health Association's Annual Conference, Chicago, IL, November 8, 1999.
- Jones, Susan. Coordinated and presented one part of session, "Working with Amish/Mennonite Communities: Lessons Learned" at the 43<sup>rd</sup> Annual Maternal and Child Health Conference, Louisville, KY, September 13, 2000.
- Jones, Susan. Paper presentation, "Development of an Interdisciplinary Rural Health & Safety Academic course: A Collaborative Approach" at the 1999 National AHEC Conference, Louisville, KY, August 10, 1999.
- Jones, Susan. Paper presentation, "Development of an Interdisciplinary Rural Health & Safety Academic Course: A Collaborative Approach" at the 12<sup>th</sup> Annual Meeting of the North American Agromedicine Consortium, Raleigh, NC, September 27, 1999.
- Jones, Susan. Paper presentation, "Incorporation of Agromedicine Curricula Content into a Medical Residency Program: A Collaborative Approach" at the 1999 National AHEC Conference, Louisville, KY, August 11, 1999.
- Jones, Susan. Paper presentation, "Photonovels: Education resources to Prevent Agricultural illnesses and Injuries" at the National Institute for farm Safety's Summer conference, Sheraton Fontainebleau Hotel, Ocean City, MD, June, 1999.

- Jones, Susan. Paper presentation, "Developing Photonovels as Educational Tools for Mobilizing Rural Communities" at the 11<sup>th</sup> Annual Rural Nursing Conference, Greeley, Colorado, April 16, 1999.
- Jones, Susan. "Mobilizing a Rural Community to Promote Health and Safety Practices on the Family Farm" at the Fourth International Symposium, "Rural Health and Safety in a Changing World", Saskatoon, Saskatchewan, Canada in October, 1998.
- Jones, Susan. Paper presentation, "Preventing Occupational Injuries and Disease in an Agricultural Community: A Model Based on Empowerment of Farm Women" at the 30<sup>th</sup> Annual Conference of the Community Development Society, Kansas City, KA, July 20, 1998.
- Jones, Susan. Paper presentation, "Building Partnerships to Empower Women to Reduce Agricultural Injuries and Injuries" at the 2<sup>nd</sup> International Conference for Women in Agriculture, Washington, D.C., June 30, 1998.
- Jones, Susan. Paper presentation, "Promoting Agricultural Health and Safety in the Community" at the 10<sup>th</sup> Rural Nursing Conference, Greeley, CO, April 2-3, 1998.
- Jones, Susan. Paper presentation, "Photonovels: Tools for Community Learning" at the 5<sup>th</sup> Annual Conference, Australian and New Zealand Association of Occupational Health and Safety Educators, Brisbane, Queensland, Australia, February, 1998. Co-authored with C.Koetke and presented by C. Koetke, Southeast Center for Agricultural Health and Injury Prevention, University of Kentucky College of Medicine.
- Jones, Susan. Paper presentation, "Health Promotion in Country Stores" at the 8<sup>th</sup> Nurse Educators Conference in the Rockies, Copper Mountain Resort, CO, August 6-9, 1997.
- Jones, Susan. Paper presentation, "Women and Health" at the Women Have Options: A Women's Health Symposium, Leitchfield, Ky. May 17, 1997.
- Jones, Susan. Paper presentation, "Pros and Cons of a Not-for Profit Organization to Address Agricultural Health and Safety Issues," at the ASH-NET Conference, Fresno, CA, April, 1997.
- Jones, Susan. Roundtable discussion, "Overview of The Kentucky Partnership" at the Kentucky Women in Agriculture: Breaking New Ground Conference, Louisville, KY, November 12, 1999.
- Jones, M.S. & Siegrist, B. (1999). Community-based education: Health promotion in country stores. *Nurse Educator*, 24(5), 16-18.
- Jones, M. S., Bussey, D. & Morgan, C. (2000). Community-based education at the campsite. *Journal of Nursing Education*, 39(6), 283-284.
- McClellan, V.H., Luchok, K.J. & Jones, M. S. (submitted for publication, 1999). Promoting farm health and safety practices in a rural community. *Journal of Agricultural Safety and Health*.
- Manharth, M. "Effectiveness of brief intervention in reducing driver citations following alcohol-related vehicular injury." A paper presented at the 23<sup>rd</sup> Annual Midwest Nursing Research Society Research Conference. Indianapolis, Indiana, April 11, 1999.
- Jones, M.S. & Goldy, D. (1998). Green tobacco sickness. *The Nurse Practitioner: The American Journal of Primary Care* 23(9), 15-16.
- Jones, M. S., Luchok, K.J. & McKnight, R.H. (1998). Empowering farm women to reduce hazards to family health and safety on the farm. *Journal for Agromedicine*, 5(2), 91-98.
- Jones, Susan (1998) Building Partnerships to Promote Safety and Health in Rural Communities. *Kentucky Agricultural News*, Spring/Summer, 30(1).
- McClellan, V.H. Luchok, K.J. & Jones, M.S. (2002). Promoting farm health and safety practices in a rural community. *Journal of Agricultural Safety and Health*.
- Meek, P.M., Nail, L.M., Barsevick, A.L., Schwartz, S., Whitmer, K., Beck, L., & Walker, B. (2000). Psychometric testing of fatigue instruments for use with cancer patients. *Nursing Research*, 49, 181-190.
- Miller, E.T. (2001). Editorial: Paving the way for future stroke care! *Rehabilitation Nursing*, 26(3), 82. (May/June)
- Miller, E.T., Deets, C., & Miller, R. (2001). Nurse call and the work environment: Lessons learned. *Journal of Nursing Care Quarterly* 15(3), 7-15. (April)

- Miller, E. T. (2000). Partnering: A remedy for the emerging caregiving crisis. *Rehabilitation Nursing*, 25, 124-145. (July)
- Miller, E., & Spilker, J. (2002). Lessons learned: Why educational interventions may not work (abstract). *Journal of Stroke and Cerebrovascular Diseases*, 10(4), 196.
- Nakamura, Kumiko (2001) Secondary prevention of breast cancer in female Japanese citizens residing in the USA. *Journal of Cultural Diversity* (to appear in the June issue).
- Nester, R.M. (2001). A Chinese experience in nursing and health care. *District #10 News and Views*, 51(4).
- Nester, R.M. (2001). Presentation "Innovative Teaching Strategies". Advances in Nursing Education Technology Conference, April 6, Wright State University.
- Nester, R.M. (2001). Presentation "Chinese public health system". March 1, Miami Valley Hospital Dayton, OH
- Nester, R.M. (2001). Presentation, "Chinese health care". Jan 01, Sigma Theta Tau Wright State University/ CONH
- Nester, R.M., & Stalter, A. (2000). *Autism, Putting the pieces together*. Abstract submitted to Sigma Theta Tau Leadership conference, November 13, 2001.
- Nester, R.M. (submitted December, 2000). Nursing and health care: A Chinese experience. Manuscript submitted December to *American Journal of Nursing* for publication consideration.
- Nester, R.M. (2000). Presentation, "The occupational health nurse, your key to managing health care costs", October, Beijing, People's Republic of China (PRC)
- Nester, R.M. (2000). Presentation, "Factors associated with the intent to adopt a safety and health curriculum", October, Xi'an, PRC
- Nester, R.M. (2000). Presentation, "Hazards in the workplace: Creating a safe environment. Is health care hazardous to your health?" February, District #10 Town Hall Meeting Ohio Nurses Association
- Nester, R.M. (1999). Presentation, "OSHA: Current initiatives & issues" June, Organization for safety & Asepsis Procedures Annual Symposium Cincinnati, OH
- Nester, R.M. (1998). Presentation, "The Occupational Health Nurse and OSHA." October, 99<sup>th</sup> Semianual Conference Ohio Association of Occupational Health Nurses, University of Findlay
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## APPENDIX G

### **FACULTY AND FACULTY-TRAINEE PUBLICATIONS FOR THE PERIOD**

**September 1, 2000 – August 31, 2002**

#### **OCCUPATIONAL SAFETY/ERGONOMICS**

##### **Books and Book Chapters**

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- “Generic Design Guidelines to Manufacture Usable Consumer Products,” In Manufacturing Engineering Handbook (Editor: D.T. Pham), Springer-Verlag, Berlin, Germany, pp., 2000. (M. Govindaraju and A. Mital)
- Human Strengths: Terminology, Measurement and Applications, D. Van Nostrand, U.S.A., December 2000. (A. Mital and S. Kumar)
- “Planning and Control of Service Operations,” Chapter 9.5, Maynard’s Industrial Engineering Handbook, 5th Edition, McGraw-Hill (New York), May 2001. (Shell)
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- “Ergonomics and Manual Handling Systems”, Tool and Manufacturing Engineers Handbook, Volume 9, Material and Part Handling in Manufacturing, Society of Manufacturing Engineers, pp. 7-1 - 7-9, 1998. (A. Mital)
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