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FINAL PERFORMANCE REPORT

**Purdue University
School of Health Sciences
West Lafayette, IN 47907**

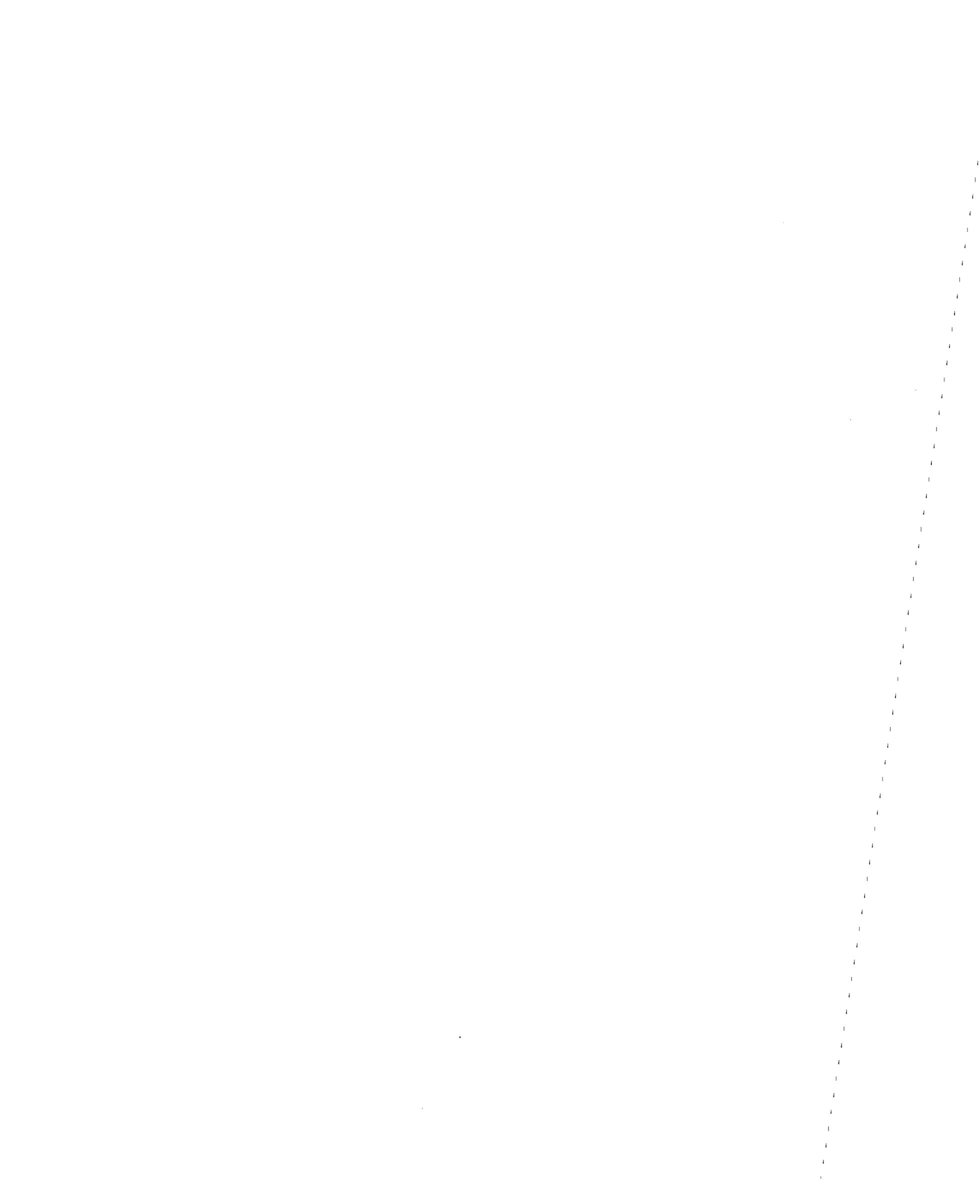
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ABSTRACT

With support from NIOSH, the Purdue University Graduate Program in Industrial Hygiene expanded and developed during the grant period. The program prepares students for advanced careers in Industrial Hygiene and Occupational Safety and Health, and contributes to the supply of highly skilled professionals in these fields, regionally and nationally. During the period of performance of this grant, the program increased its student enrollment, added several courses to its curriculum, created a new advisory council, and developed several new faculty and faculty student research projects. A plan to evaluate the impact of the program on industrial and commercial workplaces in the State of Indiana was also initiated.



SIGNIFICANT FINDINGS

During the period of this grant, the following significant advances were made in developing and enhancing the graduate program:

1. Student enrollment was considerably increased
2. The graduate curriculum in Industrial Hygiene was expanded with several new graduate courses added
3. New faculty were added to the program.
4. Faculty - student research was expanded and enhanced.
5. An advisory council was created and has begun functioning
6. A program of outreach to local industry was initiated.



PROGRESS REPORT

1. Background

Although graduate study in IH has been offered at Purdue for over 15 years, the program has considerably developed and expanded in the last few years. Since the start of NIOSH support 3 years ago, student enrollment has increased, several courses have been added to the graduate curriculum, new student and faculty and research projects have been started, research funding has been obtained from the National Institutes of Health and ASHRAE and support for graduate students has been obtained from the Department of Energy and the American Industrial Hygiene Association Foundation.

The faculty of the program has recently been strengthened by two important developments: 1) Dr. Gary Carlson, a noted toxicologist doing research related to occupational health, transferred from the School of Pharmacy to the School of Health Sciences, joining the core faculty of the program, and 2) The University has created an additional faculty position in Industrial Hygiene. A faculty search has been conducted and we are currently negotiating with the final candidate.

The program has been further strengthened, since the last review, by the development of several new courses, the expansion of a seminar series in research and professional practice, and the creation of an Advisory Council. With the expanded core faculty, the program now meets the minimum core faculty requirement for accreditation by the American Board of Engineering Technology (ABET); and an accreditation site visit has been scheduled for October, 1996.

Purdue is the only institution in Indiana which offers graduate degrees in Industrial Hygiene. Regionally, the nearest other graduate programs are at the University of Cincinnati, the University of Illinois (Chicago), the University of Michigan (Ann Arbor), and Murray State University (Murray, KY). Indiana University offers a Master's degree in Public Health Management with some IH courses; Indiana State University offers a Master's Degree in Safety Sciences.

The importance of the program regionally is underscored by an analysis presented in our original application for NIOSH support, submitted three years ago. We pointed to the extensive industry and agriculture in Indiana (major production in iron, steel, oil products, automobiles, automobile parts, farm machinery, and pharmaceuticals), a large number of employees in industries associated with toxic air emissions, and an occupational fatality rate similar to the national average. Despite these indicators, the number of Certified Industrial Hygienists (CIH's) per 10,000 manufacturing employees was among the lowest of all states. Similar conditions exist today, although the number of CIH's in Indiana has increased about 20% over the last three years, along with a similar increase nationwide.

In this report, we also note additional statistics supporting the need to target the training of occupational safety and health professionals to Indiana: 1) Indiana incidence rates for occupational injury and illness are higher than national statistics in almost all industry categories (Appendix A, and

2) The number of members of the American Industrial Hygiene Association per 10,000 manufacturing employees in Indiana is among the lowest of all states (Appendix A).

The Purdue program is well suited to contributing to the supply of occupational safety and health professionals in Indiana and the region. Many of our students come from the region and seek positions in the region upon graduation. In addition, recent graduate student projects have focused on workplace hazards in Indiana industry. While satisfying the needs of the existing job market, activities of the Purdue program can also promote the increased use of graduate trained occupational safety and health professionals throughout the region.

From 1992 to 1995, 66 companies, primarily located in Indiana and the surrounding region, contacted the School of Health Sciences to recruit Industrial Hygiene students for internships and full time positions (See Appendix B). Although historically, many of these companies have recruited B.S. students, graduate students have also used the contacts and interviews set up by these companies. These companies provide a pool with which we can work in placing program graduates.

Besides addressing regional needs, Purdue's program is unique in several key ways:

The program collaborates with a strong graduate program in Health Physics producing graduates who have been exposed to both disciplines. There is increasing need for such individuals in dealing with "mixed waste" at nuclear waste sites. Because diseases of interest in relation to these sites may be associated with both chemical agents and ionizing radiation (e.g. leukemia) exposure assessments must include both IH and HP and may be facilitated by individuals with background in both areas. Significantly, both the Health Physics and Industrial Hygiene graduate programs at Purdue are designated sites for Department of Energy fellowships for graduate study.

Purdue is one of few schools with both undergraduate and graduate programs in IH and HP. It may be the only school with a combined undergraduate major in HP and IH. Thus we are in a unique position to promote and facilitate the interaction between undergraduate and graduate education in these areas.

Purdue faculty pursue several research areas which are found at few other occupational safety and health programs nationwide. These include: Pulmonary Deposition of Aerosols, Exposure Assessment for Ultraviolet Radiation, Bioaerosols in agricultural operations, and Bioassays for Indoor Air Quality.

The interdisciplinary environment at Purdue is unusually strong with ties to many other University schools and departments. In their fields, these schools are among the highest ranked and most prestigious in the nation. Faculty from across the University have actively participated in molding the environment for the IH program.

The graduate coursework in Industrial Hygiene is rich and diverse, on a par with much larger programs, with courses in Aerosol Science, Nonionizing Radiation, Exposure Assessment, Advanced Control Engineering, and Ergonomics, as well as electives available in Health Physics, Environmental Engineering, Audiology, Human Factors, and other relevant subjects.

NIOSH support has played an important role in the recent development of the program. Most importantly, the traineeships have enabled us to increase our enrollment which has provided a "critical mass" for seminar courses, group projects, and overall peer support. NIOSH support has also enabled us to advertise the program, greatly increasing the number of inquiries and applicants, giving us a better pool of students from which to choose. NIOSH funds have been used to facilitate student research projects, to obtain curricular materials such as books and computer programs for new courses, to purchase materials to improve our Industrial Hygiene laboratory courses, to bring Industrial Hygiene and Occupational Health seminar speakers to campus, and to provide support for travel of students to professional conferences.

NIOSH funds have also provided salary support to key faculty participants, and provided support for them to attend professional meetings. These meetings help faculty keep up to date on both scientific and educational issues in Industrial Hygiene

The program continues to receive a high level of support from the School of Health Sciences, the Dean of the Schools of Pharmacy, Nursing and Health Sciences and the University administration. The three core faculty are tenured with rank of Associate Professor or Full Professor and are supported with State funds. Purdue funds directly support the NIOSH training program by providing salary support for the core faculty and associate faculty, supplements to student stipends, tuition and stipends for teaching assistants, funds for laboratory equipment and supplies, and supplementary funds for travel to conferences and meetings. In the years 1992 - 1995, the University provided approximately \$30,000 for the upgrading of Industrial Hygiene and Health Physics teaching laboratories. The approval of cost-sharing agreements for faculty from four different Purdue departments is another indication of University support for the program.

2. Training Objectives

The overall objective of this training program is to provide graduate education which prepares students for advanced careers in Industrial Hygiene and to contribute to the supply of highly skilled Industrial Hygiene professionals. We achieve these objectives by 1) providing a thorough core curriculum in the basic and applied sciences related to Industrial Hygiene, 2) developing critical thinking through thesis research and other independent student work 3) complimenting classroom instruction with laboratory exercises, internships, and student projects, 4) utilizing guest speakers and seminars to provide information and discussion on state-of-the-art issues in Industrial Hygiene and Occupational Health, and 5) emphasizing the development of oral and written communication skills in coursework and student projects.

3. Curriculum Development

In the last three years, the following new courses have been developed:

a. Advanced Topics in Exposure Assessment

This course addresses the goals and methodologies of assessing exposure to health hazards in the workplace. It was developed by Drs. Rosenthal and Zimmerman based on an analysis of current

literature on Exposure Assessment strategy and on case examples of exposure assessment in industrial settings. The topics covered include the characterization of industrial processes for exposure assessment, homogeneous exposure groups, exposure assessment for epidemiology, biological markers of exposure, pharmacokinetic models of exposure and dose, statistical issues in exposure assessment, and case studies in exposure assessment. The course emphasizes critical and analytical discussions of readings in the scientific and professional literature. Students participate in the learning process through presentations, class discussions and a semester project. Instructors: Dr. Rosenthal and Dr. Zimmerman

b. Advanced Topics in Ventilation and Control Technology

This course addresses several key topics in the engineering control of workplace hazards which are not covered in the introductory course. The role of engineering control in the philosophy and hierarchy of industrial hygiene control is presented and critically discussed. The effectiveness of personal protective equipment (PPE) is addressed through critical readings of research in which PPE has been evaluated in the workplace (e.g. using workplace protection factors and program protection factors) are discussed. The effects of humidity, temperature and ambient pressure on ventilation systems are discussed. Students carry out a ventilation design problem using computer software ("Heavent") and compare their solutions to those done by hand or spreadsheet. Several readings on "Pollution Prevention" are read and analyzed and the interface with Industrial Hygiene is discussed. Finally, the students do an extended case study of an industrial process, based on the book "Case Studies in Industrial Hygiene" by Jimmy Perkins and Vernon Rose. Instructors: Drs. Zimmerman and Rosenthal

c. Fundamental Principles of Epidemiological Studies/ Environmental Epidemiology

This course "Fundamental Principles of Epidemiological Studies" was first taught in 1994 with the aim of providing students with the analytical tools to read and critique studies in occupational epidemiology. The course covered the basic principles of cohort and case control studies with presentation of quantitative measures of association and their statistical uncertainties. Univariate, stratified and modeling approaches are presented. Sources of bias and confounding were discussed. Students read and present papers, and carried out analyses manually and with computer software "EPI-INFO". Plans are underway to expand this course to a 2-credit course entitled: "Environmental Epidemiology", to be offered in Fall, 1997.

d. Industrial Hygiene Practicum

This course was developed by Assistant Professor Stuart Kline, an associate faculty of the program, in response to the need for practical training in Industrial Hygiene activities at the workplace. In this course, students work in the Purdue Department of Radiological and Environmental Management with hands-on participation in many of the Department's activities. Students do Lab Safety Audits, Biohazard audits, bioaerosol sampling and analysis, chemical exposure monitoring, asbestos sampling (using filters and real time instruments), observation of asbestos remediation sites, quantitative respirator fit testing, IAQ investigations, and HAZCOM activities. Students also spend time at Purdue's Treatment Storage and Disposal Facility where they

observe facility operations and do exposure monitoring. Students meet periodically with Mr. Kline and his staff to discuss and evaluate their work. In 1993-94 two graduate students participated in this practicum. We plan to increase student participation in the future.

e. Instruction in Ergonomics

Since 1992 we have provided graduate students with coursework in Ergonomics. We first developed our own course with the aid of Occupational Physician Thomas Ryder, a graduate of our Masters IH program. This course was well received and well attended by both graduate and undergraduate students. When Dr. Ryder left in 1994 our students took a course provided by the Industrial Engineering Department, which included Ergonomics. Since then, we have registered graduate students in an advanced undergraduate course in "Industrial Ergonomics" offered in the School of Technology.

f. Graduate seminar series

Our seminars continue to supplement course instruction using both local and outside speakers, many of whom are nationally recognized experts in their fields. In the years 1993- 1995 Thirty-five (35) seminars related to Industrial Hygiene were presented in the School of Health Sciences. Additional seminars have been presented in Health Physics in the School of Health Sciences, and in Epidemiology, Toxicology, and Environmental Engineering in several other seminar series throughout the University.

4. Student Enrollment

Student enrollment has increased considerably. Since NIOSH support began, three years ago, 15 graduate students have enrolled in the program. This may be compared to a total enrollment of 19 graduate students for the first thirteen years of the program (1980 - 1992) before NIOSH support was provided. Eight students have been graduated with M.S. degrees during the period of performance of this grant. Five students have received NIOSH traineeships. One of these received her M.S. in May, 1995; a second is scheduled to defend her thesis in Fall, 1996. Three NIOSH trainees are currently enrolled.

5. NIOSH trainees

a. Diane Schumacher

Ms. Schumacher entered the program in August, 1993. Her undergraduate training was in Chemistry from Michigan State University. She received her M.S. degree in Industrial Hygiene from Purdue in May, 1995. Her thesis is entitled: "Brine Shrimp Lethality Bioassay: Determining the Bioactivity of Ambient Air Particulates". Ms. Schumacher presented her work in several forms, first as a seminar at Purdue University, second as a poster presentation at a meeting organized by the Chicago local section of the American Industrial Hygiene Association, and finally as a student poster presentation at the national meeting of the American Industrial Hygiene Conference and Exposition

in Kansas City. In 1994 and 1995 Ms. Schumacher received a graduate student scholarship from the American Industrial Hygiene Association Foundation.

b. Michelle Byrum

Ms. Byrum entered the program in August, 1994. Her undergraduate training was in Chemistry and Environmental Health from East Carolina University. Her masters thesis project is entitled: "Field Comparison of Inhalable and Total Dust Samplers in Poultry Processing Plants". Her findings were presented at the 1996 meeting of the American Industrial Hygiene Association as a student poster. In the summer of 1995, Ms. Byrum worked on an Internship with the Eli Lilly Company in Indianapolis. She will defend her thesis in Fall, 1996.

c. Raymond Modglin

Mr. Modglin entered the program in September, 1995. His undergraduate training was in Radiation Health Engineering at Texas A&M University. He did an Industrial Hygiene internship in summer, 1996 with United Air Lines in Indianapolis. He has finished most of his coursework and is currently working on thesis research investigating ergonomics of cashier work in the retail industry.

d. Rose Felten

Ms. Felten entered the program in September 1995. Her undergraduate work was in Environmental Sciences at Purdue University. She has finished most of her coursework and is currently working on thesis research in the toxicology of acrylonitrile. In the summer of 1996, she served as an Industrial Hygiene intern for Great Lakes Chemical Company in West Lafayette, Indiana.

e. Mark Powley

Mr. Powley entered the program in September, 1996. He has a B.S. in Environmental Health Sciences from Wright State University and served as an Industrial Hygiene intern at the Hobart Brothers Chemical Company in 1995.

6. Faculty Developments

Several faculty developments have strengthened the program.

Dr. Rosenthal was awarded tenure in 1993. Dr. Zimmerman was promoted to Associate Professor in 1995. In 1994, Dr. Zimmerman received a University-wide award for excellence in teaching. In 1994, Dr. Rosenthal received a 3 year research award from the National Heart Lung Blood Institute for his study "Aerosol Probes of Lung Injury in a Chronic Disease Model". In 1995, Dr. Gary Carlson transferred from the School of Pharmacy to the School of Health Sciences and joined the core faculty of this program. A new full time tenure track faculty position in Industrial Hygiene has been created by the University and we are currently negotiating with the final candidate determined by the search.

In 1993, Dr. Paul L. Ziemer returned from a leave of absence, during which he was Assistant Secretary of the Department of Energy, to resume as Head of the School of Health Sciences. Dr. Ziemer, a nationally known leader in Health Physics and Environmental Health, has had extensive research and teaching experience and participates as an Associate Faculty of this training program.

7. Faculty and Student Research Projects

In the last three years, several new research projects have been initiated: Dr. Zimmerman and graduate student Diane Schumacher have worked on applying a bioassay technique to screen air samples for toxicity. Dr. Zimmerman and graduate students Michelle Byrum and Karen Lutgring have been investigating bioaerosol and dust levels in poultry operations (funded by ASHRAE). Dr. Rosenthal and graduate student Rao Papineni investigated the size distribution of droplets in exhaled breath with implications for disease transmission via aerosol. Dr. Rosenthal has initiated new studies in using aerosols to detect lung disease (funded by National Heart Lung and Blood Institute). Current graduate students projects include investigation of ergonomics of cashier workers, characterization of metal working fluid aerosols, effect of protective clothing on heat stress, and histological assessment of lung injury.

8. Advisory Council

An advisory committee has been set up as described under the program plan presented in the original grant application. The advisory council includes representatives from government, industry, academia and labor. The council has met twice since it was initiated.

9. Plans to evaluate program impact on the region

In the next project period, we plan to begin an outreach program to assess our impact on industry, government and labor groups in the region. Initially we will send a brochure about our program and a questionnaire to industrial establishments throughout the State of Indiana. The questionnaire will ask about the establishment's: 1) existing Health and Safety program, 2) Industrial Hygiene personnel and resources, 3) projected employment needs for Health and Safety professionals, 4) knowledge and/or opinion of the Purdue IH programs, 5) major health and safety concerns. A similar survey will be prepared for government and labor organizations. An emphasis will be placed on increasing awareness of the skills and capabilities of graduate trained Industrial Hygienists.

Several sources can provide the mailing list for the survey. Ward's Business Directory (Omaha, NB, 1995-96) lists 3,144 Indiana Companies. The Indiana Business Directory provides company listing by city and product. The "Disclosure SCC Data Base" (Bethesda, MD, 1993) provides company listings (on CD-ROM) by geographical location, industry and other qualifiers.

This survey will serve several purposes: 1) to assess our impact on the region, 2) to increase our impact on the region by increasing awareness of our program and the need for Industrial Hygiene activities in general, 3) to begin to assess the overall occupational safety and health needs in the State

of Indiana, and 4) to provide a pool of contacts from which to develop internships, student projects and employment opportunities. Associate faculty member David R. Black, who has extensive experience in survey research, will serve as a consultant for this project.

10. Program Contributions to the field of Occupational Safety and Health

Program faculty and students have continued to contribute to the field of occupational health and safety through diverse research in such fields as agricultural industrial hygiene, aerosol sampling methodology, biomarkers of lung injury, industrial toxicology, respiratory physiology, and assessment of nonionizing radiation. The program continues to meet regional needs for Occupational Safety and Health. Several recent graduates have taken positions in Indiana and neighboring states. Recent research has focused on dust and bioaerosol problems in Indiana agricultural buildings. The program has begun to further assess regional needs for Industrial Hygiene training and personnel through a pilot survey of local industry. In addition to meeting regional needs, the program continues to make distinct contributions through research in pulmonary aerosol deposition, bioaerosols and nonionizing radiation. Interdisciplinary research activity has involved interactions with the Departments of Agricultural Engineering, Veterinary Clinical Sciences, and Foods and Nutrition. Interdisciplinary teaching and research activity has involved interactions with various Schools and Departments including Veterinary Pathobiology, Industrial Engineering, Statistics and Industrial Technology.

11. Conclusions

Through support of NIOSH, the Purdue Graduate Industrial Hygiene Program has developed and expanded considerably. The student enrollment has increased. New courses in key areas have been added to the curriculum to keep up-to-date with changing issues and needs in the field of Occupational Safety and Health. Advances have been made in student-faculty research, interdisciplinary interactions, faculty development, development of an advisory council, and local outreach. The program has continued to address regional and national needs in supplying highly qualified professionals in the areas of Industrial Hygiene and Occupational Safety and Health.

INCIDENCE RATES FOR THE UNITED STATES AND INDIANA
BY INDUSTRY DIVISION*
1992

<u>Industry Division</u>	<u>Total Case Incidence Rate</u>		<u>Lost Workday Case Incidence Rate</u>		<u>Non-Lost Workday Case Incidence Rate</u>	
	<u>U.S.</u>	<u>Indiana</u>	<u>U.S.</u>	<u>Indiana</u>	<u>U.S.</u>	<u>Indiana</u>
Private Sector	8.9	11.0	3.9	4.6	5.0	6.4
Agriculture, Forestry & Fishing	11.6	14.3	5.4	6.6	6.2	7.7
Mining	7.3	5.8	4.1	2.7	3.3	3.0
Construction	13.1	14.9	5.8	6.1	7.3	8.8
Manufacturing	12.5	15.3	5.4	6.1	7.1	9.1
Transportation & Public Utilities	9.1	9.5	5.1	5.5	4.0	4.0
Wholesale Trade	7.6	8.5	3.6	3.9	3.9	4.6
Retail Trade	8.7	9.0	3.4	3.2	5.3	5.8
Finance, Insurance & Real Estate	2.9	3.2	1.2	1.3	1.7	1.9
Services	7.1	8.3	3.0	3.6	4.2	4.7

From: State of Indiana Summary of Occupational Injuries and Illnesses
Volume 13, 1992

Indiana Department of Labor
Division of Research and Statistics
Indianapolis, IN

$$*Incidence Rate = \left(\frac{\# \text{ injuries and illnesses}}{\text{total employee hours worked}} \right) \times 200,000$$

TABLE 1. MANUFACTURING EMPLOYEES AND AIHA MEMBERS BY STATE

STATE	EST	EMP	EMP/EST	AIHAMemb	AIHAMem/EMP
DC	465	15859	34.1	83	52.3
AK	443	10758	24.3	35	32.5
NM	1313	37656	28.7	107	28.4
NV	1029	28863	28.0	56	19.4
UT	2106	101066	48.0	139	13.8
MT	1213	21034	17.3	28	13.3
MD	4217	225099	53.4	276	12.3
DE	679	69804	102.8	80	11.5
WY	501	8418	16.8	9	10.7
ID	1570	59058	37.6	50	8.5
WV	1633	84380	51.7	70	8.3
LA	3636	169837	46.7	139	8.2
TX	19529	948255	48.6	767	8.1
WA	7812	363379	46.5	268	7.4
VA	6127	437300	71.4	302	6.9
NJ	13919	670837	48.2	452	6.7
AZ	4177	189341	45.3	122	6.4
OK	3664	159360	43.5	102	6.4
ND	610	16510	27.1	10	6.1
PA	17641	1048656	59.4	618	5.9
CT	6545	373419	57.1	211	5.7
CO	4631	188523	40.7	104	5.5
FL	15365	524582	34.1	275	5.2
CA	48880	2186368	44.7	1134	5.2
MA	10736	597293	55.6	295	4.9
OH	17395	1124191	64.6	536	4.8
MN	7151	397810	55.6	187	4.7
IL	18142	1036621	57.1	478	4.6
MI	15805	973858	61.6	448	4.6
MO	7354	441843	60.1	198	4.5
NY	27813	1214314	43.7	541	4.5
TN	6943	505629	72.8	219	4.3
OR	6359	207393	32.6	81	3.9
AL	5836	368739	63.2	132	3.6
KS	3186	192489	60.4	65	3.4
NE	1827	97730	53.5	33	3.4
GA	9029	576352	63.8	188	3.3
IA	3507	230708	65.8	72	3.1
NC	11234	868534	77.3	269	3.1
NH	2264	109992	48.6	34	3.1
SC	4540	383156	84.4	116	3.0
KY	3818	272729	71.4	82	3.0
ME	2142	108435	50.6	32	3.0
IN	8763	642946	73.4	164	2.6
WI	9230	547786	59.3	139	2.5
VT	1224	47838	39.1	12	2.5
RI	2719	110759	40.7	24	2.2
AR	3369	216695	64.3	43	2.0
SD	786	30467	38.8	5	1.6
MS	3318	228630	68.9	25	1.1
Total	362195	19471299	53.8	9855	5.1

EST = # manufacturing establishments, EMP = # manufacturing employees
 EMP/EST = avg # manufacturing employees per establishment
 AIHAMemb = # AIHA members
 AIHAMem/EMP = # AIHA members per 10,000 manufacturing employees

Sources:

1. American Industrial Hygiene Association - Who's Who in Industrial Hygiene, 1994.
2. U.S. Bureau of the Census. County Business Patterns, 1989.