

*A program on . . .*

## HAZARDOUS WASTE MANAGEMENT

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**T**HE NEED FOR environmental professionals is escalating. The 1987 Bureau of Health Professionals report, "Evaluating the Environmental Health Work Force," [1] identified 50,000 environmental professionals in the U.S. and projected that by 1992 there will be a need for 100,000. Paul Busch, immediate past president of the American Academy of Environmental Engineers [2], estimates that 22,500 environmental engineers will be needed from 1990 to 1995 "just to meet the problem of hazardous waste clean up." Each year, less than 10% of the hazardous waste engineers

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that are needed are graduating from our universities [3]. Summit VI, a top level interaction between industry and AIChE (as reported by Mathis [4]), identified the environment and ecology as the number-one growth area for chemical engineers and suggested curriculum changes and more intense training to meet the growing need. Some educational programs have begun to emerge, but not in chemical engineering [5, 6].

The chemical and manufacturing industries are working vigorously to maximize recycle and to minimize waste. Major corporations are establishing their own landfill standards, with their own cradle-to-grave accounting systems and certification of both professionals and facilities. Consulting companies which perform the same services for small industries are thriving.

A new breed of professional, a "chemical control engineer," is emerging. This individual must be technically educated and trained in regulations, but with the focus on management rather than on science or design, and he or she must have such skills as:

- Risk assessment capability
- Computer experience
- Ability to maintain community involvement
- Material use control procedures
- Chemical management systems
- Land use planning
- Knowledge of health issues
- Transportation awareness
- Liability awareness

The boards of major corporations must be informed about these issues on a regular basis. Career path professionals in hazardous waste management will therefore have high rank and pay [7].

Chemical engineers are uniquely qualified to train for this opportunity. A solid background in mathematics, chemistry, and physics, with economics, process control, separations, and a thorough training in logical

thinking and organization, is characteristic of the chemical engineering BS degree. Waste minimization in the chemical industry involves optimization of unit operations, the classic tool of the chemical engineer.

However, within the confines of an ABET-accredited chemical engineering degree, it is not easy to provide the additional education necessary to allow the BS chemical engineer to become a "Chemical Control Engineer." Thus, at Wayne State University we have created a new concept in graduate education, called the "Graduate Certificate in Hazardous Waste Management," which is designed to provide auxiliary education not only to chemical engineers, but also to all conventional science and engineering majors who have the prerequisite mathematics and chemistry background.

This program is a major departure for the chemical engineering faculty. As discussed below, the courses attract a substantial number of non-chemical engineers and as a result constitute the largest service teaching that we have ever undertaken. The chemical

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engineering profession is uniquely qualified to lead this new effort, but expansion of the traditional tools of chemical engineering will be necessary.

In order to determine the content of the Graduate Certificate program, an interdisciplinary team consisting of faculty and an industrial advisory committee was assembled. A brief description of their backgrounds is given in Table 1.

The goal of the certificate program is to prepare admissible students to take and pass certification examinations. At the present time, WSU administers the Hazardous Materials Manager Certification Examination (CHMM) developed by the Institute of Hazardous Materials Management, and the Certified Hazardous Waste Specialist Examination developed by the National Environmental Health Association. The examinations are dynamic in nature and hence the courses must also be dynamic, to reflect the continual changes in technology, law, policy, and regulations. Thus, both the course outlines and topics vary from time to time. A poll of various governmental agencies and industry has shown enthusiastic support for this program. The student response to the certificate program has also surpassed all expectations; nearly half of the student body has requested that the program be expanded into a full Master's program in Hazardous Waste Management. The faculty developed and approved the curriculum for the MS degree, and authorization to begin awarding degrees in January of 1990 was granted by the Wayne State University Board of Governors.

The program's courses are available as electives to both undergraduate and graduate students in our regular university degree programs, and they have attracted many new students into full-time and part-time programs. Professionals already working in the field may require one or two courses prior to attempting the certification examinations; even certified managers require continuing education to retain governmental or industrial acceptance. Thus, the courses have wide applicability.

#### DESCRIPTION OF THE PROGRAM

The need for training in hazardous waste control technology, laws, policy, and regulations clearly implies more than the minimum coursework in any single

**TABLE 1**  
**Hazardous Waste Management Graduate Certificate Program Participants**

<i>Industrial Advisory Committee</i>	<i>Faculty</i>	<i>Course</i>
James Carlson <i>Director, Hazardous Waste Management Chrysler Corporation</i>	Ralph Kummeler, PhD <i>Director: Chairman of Chemical and Metallurgical Engineering</i>	CHE 751, 726
Del Rector <i>Deputy Director, Michigan Department of of Natural Resources</i>	James Dragun, PhD <i>President Dragun Associates, Inc.</i>	GEL 515
Myron Black <i>Director, Environmental Affairs Dundee Cement</i>	Tim Lang, PhD <i>Chief Manufacturing Chemist Environmental Operations GM Tech Center</i>	CHE 551, 554
James Dragun, PhD <i>President, Dragun Associates, Inc.</i>	Carol Miller, PhD <i>Associate Prof., Civil Engineering</i>	CHE 558
J. Chu, PhD (deceased, April 1989) <i>Ass't. Director, Hazardous Waste Manage- ment, General Motors Research Center</i>	Jeffrey Howard, PhD <i>Assistant Professor, Geology</i>	GEL 515
Rick Powals <i>Vice President, Petrochem, Inc.</i>	Joe Oravec, BS <i>Academic Serv. Officer, Chemistry</i>	CHE 554,556
	Robert Powitz, PhD <i>Director, Environmental Health and Safety</i>	CHE 551,557
	James McMicking, PhD <i>Associate Prof. Chemical Engineering</i>	CHE 553, 751
	Daniel Crowl, PhD <i>Professor, Chemical Engineering</i>	CHE 657
	Khalil Atasi, PhD <i>Head, Applied Tech. &amp; Evaluation Detroit Water and Sewerage Dept</i>	CHE 559
	A. L. Reeves, PhD <i>Prof., Occupat. &amp; Environ. Health</i>	OEH 832,632
	Devon Schwalm, MS <i>Hazardous Materials Coordinator Environmental Health &amp; Safety</i>	CHE 726,727

traditional discipline. Hence, WSU chose to recognize a group of credits as a "Certificate Program," where "certificate" simply refers to university-level recognition and is totally separate from the externally-administered examinations.

Our program consists of a minimum of thirteen credits, distributed as follows:

#### REQUIRED

- **CHE 551.** Introduction to Industrial Waste Management (2 cr: no credit toward a graduate engineering degree)  
*The first required course in the sequence is an overview of the program, including topics on solid waste management, site selection, thermal processing, biological waste disposal, hazardous chemical spill clean-up, and hazardous chemical transportation.*
- **CHE 554.** Law and Administration Issues in Industrial Waste Management (2 cr: no credit toward a graduate engineering degree)  
*The second required course covers management guidelines, Superfund issues, the Solid Waste Disposal Act, identification concepts, standards, reports, permits, and rules.*
- **CHE 556.** Transportation and Emergency Spill Response (3 cr)  
*This course covers marine, rail and tank truck transport methodology, planning and regulations, and emergency spill response, with field experience.*
- **CHE 751.** Public Issues of Hazardous Waste, (2 cr)  
*This course is devoted to current issues in hazardous waste management and is presented by nationally recognized leaders in industry.*

Students will also be required to take an additional four credits from among the following courses.

- **GEL 515.** Soils and Soil Pollution (3 cr)  
*The properties and classification of soils are covered. Knowledge of soil properties is used to understand the removal of pollutants from soils and groundwater.*

- **CHE 553.** Thermal Processing of Hazardous Waste (2 cr)  
*This course covers thermal processing technology, including combustion fundamentals, incineration equipment, waste heat boilers, air pollution control equipment, and facilities design.*
- **CHE/CE 558.** Land and Ocean Disposal of Hazardous Waste (2 cr)  
*This course covers industrial landfills, biological processes, land disposal techniques, ocean disposal techniques, and the disposal of ashes.*
- **CHE/CE 559.** Biological Waste Disposal (2 cr)  
*This course, taught in conjunction with Civil Engineering, considers environmental requirements, activated sludge, anaerobic systems, stabilization ponds, dewatering experiments, and activated carbon systems.*
- **CE 619.** Ground Water (4 cr)  
*Aquifers, aquitards, saturated and unsaturated flow, sources of contamination, artificial recharge, development of basins, and efficient utilization are discussed.*
- **CHE 657.** Safety in the Chemical Process Industry (3 cr)  
*This course covers the fundamentals and practical experience necessary for safe operation of a chemical process plant, including case studies conducted under an industrial supervisor.*
- **OEH 832.** Principles of Toxicology (4 cr)  
*Qualified students (those with a biological background) gain exposure to toxicity of industrial chemicals, absorption of gases and dust, laboratory studies of toxicity, inhalation data, and experimentation methodology.*
- **CHE 726.** Waste Management Internship (1-3 cr)  
*Students earn credit by working in WSU's Environmental Health and Safety hazardous waste program, or other environmental control programs in local industry.*
- **CHE 727.** Hazardous Waste Laboratory (2 cr)  
*This is a structured laboratory experience in waste characterization, analysis, disposal techniques, and waste minimization.*

A "B" average in these 13 credits is required for recognition by the university. Individual courses may

Number of Participants

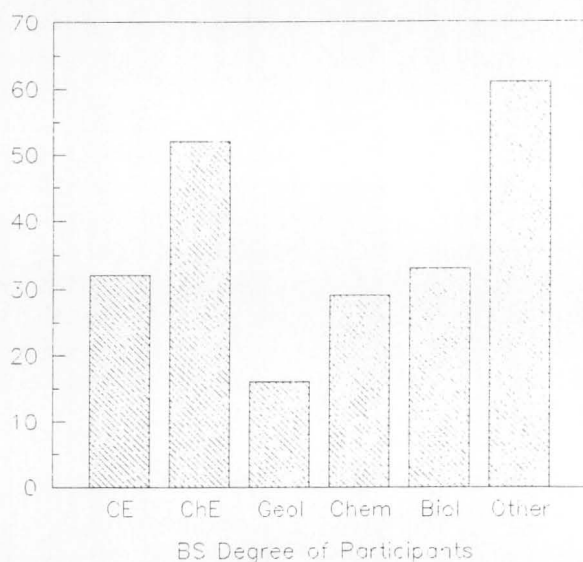


FIGURE 1. Academic degree of participants

Number of Participants

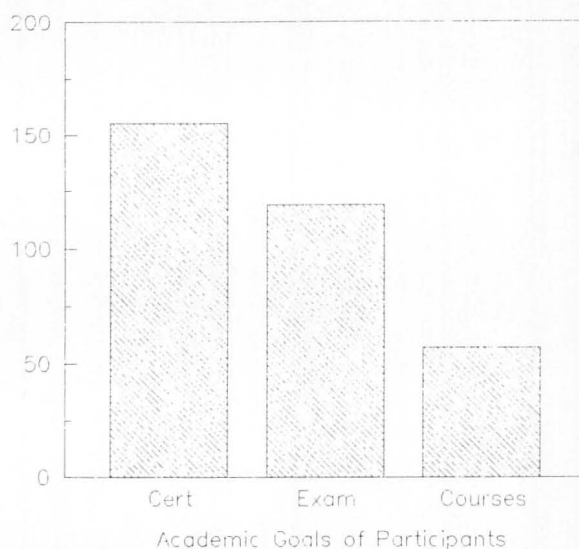


FIGURE 2. Academic goals of participants



be taken as elective credit toward undergraduate or graduate degrees as well as by non-matriculated students.

An industrial/governmental advisory committee has been recruited, with representation from the basic chemical and automotive industries, hazardous waste operators, consultants, and regulatory agencies. This committee evaluates the program at yearly intervals and suggests revisions in course content for compatibility with current regulations and state-of-the-art technologies.

### CURRENT STATUS

The Graduate Certificate program was initiated in the fall of 1986 with the offering of "Introduction to Industrial Waste Management." There was no formal survey of the students at that time; however, records indicate that the class was composed mainly of undergraduate chemical engineering students. Since the course was given during the day and was not heavily publicized, this was expected. In winter 1987, "Law and Administration in Industrial Waste Management," "Land and Ocean Disposal of Hazardous Waste," "Public Issues of Hazardous Waste," "Waste Management Internship," and "Hazardous Waste Laboratory" were added to the curriculum. Beginning with that semester, classes were offered in the evening and were publicized to attract graduate and post-degree students. "Transportation and Emergency Spill Response," "Thermal Processing of Hazardous Waste," and "Biological Waste Disposal" were added in subsequent semesters.

In the fall of 1988 there were approximately ninety new students in the program, including students in both the regular graduate and undergraduate programs and those enrolled in the Hazardous Waste Management Graduate Certificate program. An off-campus program began in winter 1989 with fifty students. From a modest beginning of 8-10 students per year prior to the introduction of the Graduate Certificate Program, the class has now grown to 140 students per year.

### STUDENT PROFILE

For future use in planning, a survey was taken of the winter and fall, 1987, and fall 1988 classes to determine the background and the goals of the students in this program. The total number of students surveyed was 223. Figure 1 shows the baccalaureate degrees of the students in the categories of civil engineering, chemical engineering, geology, chemistry, biology, and other (health management, other engineering, law, business, and liberal arts).

Figure 2 shows the goals of the participants in three basic categories: Graduate Certificate conferred by the University, Certification and Examination by an external agency, and Selected Courses. It should be noted that several participants selected more than one category.

Figure 3 indicates the general areas in which the participants are classified relative to their work or study situation: Hazardous Waste Generators, Hazardous Waste Haulers and Disposers, Environmental Regulators, Students, and Consultants.

Number of Participants

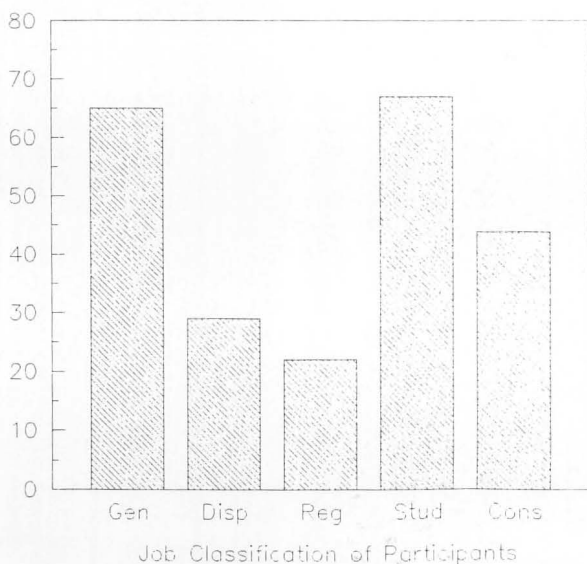


FIGURE 3. Job classification of participants

Number of Participants

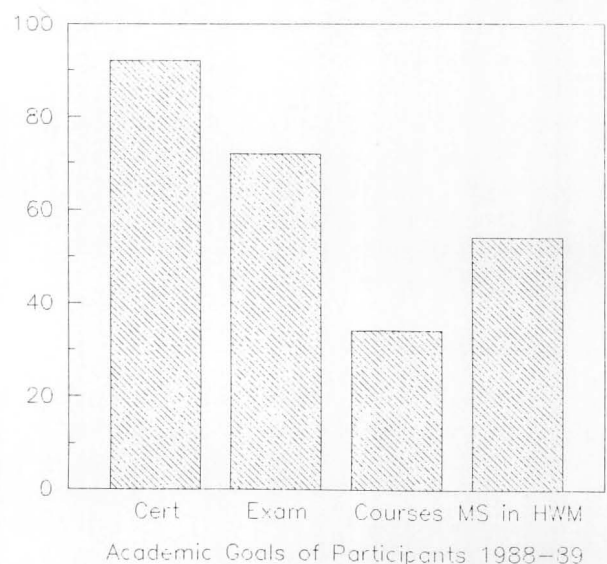


FIGURE 4. Academic goals of 1988 participants

**TABLE 2**  
**Curriculum: Master of Science in Hazardous Waste Management**  
*Prerequisite/Corequisite: Graduate Certificate in Hazardous Waste Management*

<u>REQUIRED COURSES:</u>	<u>Credits</u>		
Introduction to Industrial Waste Management	2 (S/U) (no graduate credit)	Industrial Waste: Control, regulations, and treatment	4
Thermal Processing of Hazardous Waste	2	Safety in the Laboratory	1
Law and Administration in Industrial Waste Management	2 (S/U) (no graduate credit)	Master's Thesis Research and Direction (CHE 899)	10
Transportation and Emergency Spill Response	3	- or -	
Land Disposal	2	Master's Thesis Research and Direction (CE 899)	8
Biological Treatment of Hazardous Waste	2	- or -	
Public Issues of Hazardous Waste	2	Master's Thesis Research and Direction (CM 899)	8
Hydrogeology	4	- or -	
Waste Minimization	2	Master's Thesis Research and Direction (OEH 899)	8
Safety in the Chemical Process Industry	3	Environmental Microbiology	3 or 5
Waste Management Internship	2	Biochemistry	3
- or -		Soils and Soil Pollution	3
Hazardous Waste Laboratory	2 (minimum)	Sanitary Chemistry	3
- or -		Anal/Inst Chemistry	3
Air Sampling and Analysis	3	Environmental Law	2-3
Principles of Industrial Toxicology	4	Transnational Environmental Problems	3
Design of Chemical Process Experiments I	3	Environmental Pollution	3
- or -		Radiation Safety: Principles and Practice	2
Probability Models and Data Analysis	4	Chemistry of Industrial Processes	3
		Epidemiology	2
		Applied Epidemiology	3
		Chemical Engineering Graduate Seminar	1
<u>Minimum Required</u>	29	<u>Total Electives</u>	5
(excess credit may be applied to electives)	(33 including noncredit requirements)	(Including overage from required selection)	
<b>ELECTIVES:</b>		<b>TOTAL CREDITS</b>	<b>34</b>
Unit Operation: Unit Processes in Environmental Engg.	4		(38 including noncredit courses)

## MASTERS PROGRAM

Student demand for more information led the faculty and the industrial advisory committee to develop a curriculum for a Master of Science in Hazardous Waste Management. Approximately 37% of the entering class of '88 expressed interest in the full MS program, as illustrated in Figure 4.

The Graduate Certificate is a prerequisite to admission in the Masters program, and all credits are directly applicable toward the Masters. The approved curriculum is listed in Table 2. A full discussion of all the MS courses is beyond the scope of this paper, but graduates will have solid backgrounds in biological and thermal processing, land disposal, hydrogeology, toxicology, laboratory techniques, waste minimization, and chemical process safety.

## CONCLUSIONS

It has become evident that industry must learn to design and operate plants to prevent spills and episodes, and to manage their chemical wastes properly. However, it is equally true that they must learn to cope with emergencies and to be able to deal with the public and regulatory agencies before, during, and after such problems.

A graduate certificate program such as the one offered by WSU provides a new avenue of education in this field. The uniqueness of this program lies in the fact that it is area-specific, flexible, and subject to frequent content review. Some changes have already been made, and others are currently under study by the faculty involved in the program, such as the development of the full Masters Degree.

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