a = cross-sectional area of the drain piping

$$C = \left(\frac{2\alpha}{d}\right)^2 \left[\frac{1}{2g}\left(1+\frac{fL}{d}\right)\right]^{1/2}$$

D = upper diameter of the conical tank

d = inside diameter of the drain piping

f = Moody friction factor

g = acceleration due to gravity

g_c = conversion factor

H = liquid height above the drain pipe outlet at any time

h = liquid level in the tank at any time

h_ℓ = head loss in the piping

h_o = elevation of the tank bottom above the drain pipe outlet

L = equivalent length of the piping

P = pressure

q = liquid flow rate out of the tank

R = upper radius of the conical tank

r = radius of the liquid level at any time

t = time

V = liquid velocity

Y = height of the conical tank

Z = vertical elevation

Greek Letters

α = R/Y

Θ = angle formed by the cone with the vertical axis

π = number pi (3.14159...)

ρ = liquid density

Subscripts

f = final condition

o = initial condition

1 = liquid surface in the tank at any time

2 = drain pipe outlet

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ChE book review

HAZARDOUS WASTE MANAGEMENT

by Charles A. Wentz

McGraw-Hill Book Company, 1221 Avenue of the Americas, New York 10020; $46.95 (1989)

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The nation's need for educated and trained professionals in hazardous materials and waste management is enormous and growing [1,2]. In a recent survey paper, my colleagues and I concluded that universities were beginning to respond to the need, albeit slowly [3]. We were able to identify 113 universities offering credit courses related to hazardous waste management (HWM), and 52 universities providing non-credit short courses at the professional level, for a total of 130 universities providing some kind of HWM education. This new area of knowledge is being studied by a very wide array of practitioners, from traditional chemical and civil engineers and chemists to environmental scientists, environmental health professionals, and medical technologists. It appears that a whole new graduate profession is emerging, since there is plenty of conventional chemical and civil engineering to be accomplished, but the additional role of interdisciplinary management must be implemented. There is a clear need for such new managers at (almost) the entry level, and the career path leads up to the vice-presidential level when environment, health, and safety aspects are combined.

In this context, the pioneering text, Hazardous Waste Management, by Charles A. Wentz, fills an enormous need as the first teaching textbook on the market. I expect this book to enable virtually all chemical, civil, and applied science departments to introduce a survey course in HWM. The author is particularly well-qualified to have undertaken this task, having a rare blend of industrial, university

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tries) was presented. We demonstrated the "thickening" characteristics of agar and presented examples of edible seaweed products. The session concluded with a tour of the laboratory in which seaweeds are cultured and grown.

EVALUATION OF THE SESSIONS

Unfortunately, we did not survey the students before or after conducting our first pilot quarter. However, we did so for the second quarter. As noted above, an application/questionnaire was given at the initiation/conclusion of these sessions. Some overall observations follow.

First, on the original application, only six students indicated a serious interest in pursuing a career in science or engineering (no one mentioned the word "engineering"). On the concluding questionnaire, only six students did *not* indicate the pursuit of science or engineering as a career goal. Moreover, from their responses on the final course evaluation form and on the separate application form for a summer internship program (completed by fifteen students), it appeared that the students were more focused on technical interests. While we cannot say if there was an earlier unexpressed interest in the topical issues presented, it is clear that these ninth (and some tenth) grade students were sufficiently sophisticated to decide that genetic engineering of seaweeds was exciting and that investigating the use of biopolymers in concrete was not exciting—or the reverse. Moreover, some students expressed an interest in having demonstrations and experiments with animals and in further pursuing research on the topics we had discussed. (Note: Other than showing an animal to the high school students, demonstrating experiments by using live animals is illegal in Massachusetts.)

At the conclusion of our second quarter pilot program we devoted the last session to a buffet, followed by the awarding of certificates. (An award was made to students who missed three or fewer sessions.) Two faculty members who had graduated from this school spoke briefly, as did the dean of the college of engineering. The students seemed to be pleased both with the special awards session and with the opportunity to complete a course evaluation form. In general, throughout the pilot project we treated the students as adults and found that they acted like adults.

FUTURE PLANS

Our future plans call for bringing together high school science teachers and university professors to plan the introduction of applications of modern biotechnology into high school science courses. In our first summer session, we anticipate that high school science teachers will wish to learn more about modern biotechnology, and especially its social applications. Thus, a series of informal lectures and hands-on participative demonstrations will be given by professors who are well-established in selected areas of modern biotechnology. Further, since the professors will need to gain an understanding of what high school science teachers believe is appropriate for presentatin to high school students, the high school teachers will present informal seminars dealing with their experiences in introducing the newer aspects of science and technology into their courses.

Looking ahead, we also plan to initiate some of the key recommendations from this summer study program into a pilot program to be initiated during the following academic year. This pilot program will involve the introduction of key recommendations from the summer study sessions into the high school classrooms and laboratories. We also anticipate that the professors will give demonstrations and will involve students in "show-and-tell" type experimental themes coupled with measurement orientations (*i.e.*, we wish to integrate quantitation into all demonstrations). Further, the pilot program will include regularly scheduled monthly meetings with the professors and the high school teachers in order to assess progress and to discuss problems. □

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teaching and research, consulting, and governmental experience to supplement his BS, MS, and PhD in chemical engineering, and his MBA. Thus, he has real design and management experience in waste treatment technologies and has taught the material in the classroom to engineering students. Moreover, he has organized countless professional meetings dealing with the HWM area for AIChE.

The text covers the entire field in 450 pages. It begins with the basic definition of hazardous waste in general terms and provides an historical background for the field, both in the United States and Europe. The latter is an important perspective because European concerns predate ours in many respects. Several important case studies are provided to place the field in its political context and to provide introductory technical insight. Next, the process of risk assessment is introduced with case studies. Then the author provides two chapters which discuss the driving force behind the HWM area: federal legislation.

The background begins with the Rivers and Harbors Act of 1899 and includes explanatory pages on the Atomic Energy Act, the National Environmental Policy Act, the Occupational Safety and Health Act, the Air Quality and Water Quality Acts, the Solid Waste Disposal and Resource Recovery Acts, the Toxic Substances Control Act (TSCA), the Resource Conservation and Recovery Act (RCRA), the Comprehensive Environmental Response, Compensation, and Liabilities Act (CERCLA), and the Superfund Amendments and Reauthorization Act (SARA) among others. The final chapter of the introductory portion of the book provides a detailed technical and legal definition of hazardous waste.

The author then shifts to the technical side of the field. First, he focuses on waste minimization, which is perhaps the most important future concern in HWM. This chapter treats the managerial portion of waste minimization, including policy, benefits, priorities, and tracking and auditing systems. This chapter does not treat the engineering design aspects of waste minimization, the heart of which is chemical engineering, because the pedagogical aspects of this discipline have not yet been developed and are rightfully the subject of another book. Next, Wentz covers chemical, physical, biological, and thermal treatment of hazardous waste in two excellent chapters which incorporate both descriptive material and fundamental design equations. Consistent with earlier portions of the text, these chapters provide a legal standard context and case studies.

In logical order, Wentz turns to the transportation of hazardous waste. Included are federal regulations, DOT and EPA procedures, definitions of shippers and carriers, and the regulation of each. Record-keeping, reporting, and manifesting are treated with examples and the uniform manifest. State and local regulations, with emphasis on notification, routing, emergency response procedures and equipment, and right-to-know laws, are covered.

Finally, the text treats land disposal, groundwater contamination, injection well disposal, process siting and site remediation. Again, the author has achieved comprehensive coverage of hydrology, groundwater chemistry, contamination, design of monitoring wells, regulations, siting, and classification of wells, with design equations and case studies. The Superfund law, the Hazard Ranking System (HRS), and National Priority List (NPL), together with containment and treatment technologies and vitally important financial strategies, play a role in the final chapter.

Wentz has packed the text with important information needed by the practitioner, and he definitely achieves his stated goal in the preface "to integrate a broad field into a single book that deals with all phases of this important subject." He provides appendices of listed wastes and a surprising depth of coverage despite the comprehensive nature of this teaching text. The problems at the end of each chapter could be more extensive, but are certainly at the right level for the senior undergraduate or beginning graduate student for whom the text is intended. A solutions manual is available.

This subject has and will continue to move quickly, so much of the illustrative data in the early chapters is already dated, but the need for this book should warrant frequent updates. It is clearly a survey text, so that one should not expect in-depth coverage of every topic; we continue to need other texts, but Wentz has given us a start.

At Wayne state University, we offer several dozen hazardous waste management courses as part of our regular chemical and civil engineering degree programs, but chemical engineering also administers a Graduate Certificate Program [4] and a full MS in Hazardous Waste Management [5,6]. Most schools offering an extensive HWM program have a survey course as the entry point [3]. For our introductory course, we have adopted Wentz's Hazardous Waste Management as the required text, but cannot cover the text in a two-credit semester offering. One of the highest compliments that I can pay to the text is that our civil engineering faculty also use it for their landfill course, which is well beyond the scope of our introductory course.

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