INTRODUCING INDUSTRIAL PRACTICE IN THE UNIT OPERATIONS LAB

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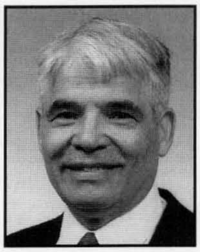
One of the major goals in an engineering laboratory course is a demonstration of the principles and theory which are presented in lectures and textbooks. In the chemical engineering curricula, laboratory classes are usually first scheduled in the student's junior year, and they include student preparation of extensive technical reports concerning the experiments conducted in the lab.

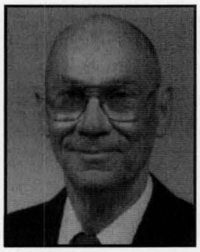
Feeling that the Unit Operations Laboratory could serve as an introduction to "good engineering practice" in industry, we tried to modify that course in such a way that it would introduce students to the industrial workplace. Based on our experiences from that effort, this article suggests changes in existing laboratory methods that will make the Unit Operations Laboratory course more closely simulate industrial work practices.

The following general premises for modification were used:

- Experiments should be performed to obtain, immediately, the results required for solving simulated industrial problems; they should not be performed simply to demonstrate the validity of principles or theory.
- Student engineers should be encouraged to know (or find out) how to obtain the required results within a specific time frame.
- Laboratory reports should accurately and concisely communicate the results of the students' work.



Thomas R. Marrero *received his BS from Polytechnic Institute of Brooklyn (1958), his MS from Villanova University (1959), and his PhD from the University of Maryland (1970), all in chemical engineering.*



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These premises led to a review of the existing procedures used in conducting experiments. Four key procedural items were considered: operating instructions, flow diagrams, practical problems, and laboratory report writing. In the following paragraphs we will show how each of these items was modified so as to introduce student engineers to industrial practice.

OPERATING INSTRUCTIONS

Operating instructions were written in "layman's" language and included all the data necessary for calculations. Since industrial operating instructions are usually written for technicians with, say, two years of college and/or several years of experience, they should *not* simply state, for example,

> *. . . turn valve A until you get 6 on the rotameter.*

That kind of instruction should be, and was, rewritten to state

> *. . . the globe valve just upstream of the exchanger on the cold water supply is used to manually control the cold water to the exchanger; slowly open this valve until the rotameter indicates your initial flow rate.*

The idea behind rewriting instructions in this manner is to encourage students to appreciate the why and how of each step. The latter instruction helps the student to focus on the function of each piece of equipment and to realize how each piece fits into the overall process. The revised operating instructions for all the experiments had a consistent format typical of an industrial operating manual. The procedures were organized into the following five major sections:

- ***Checkout*** Prior to actually conducting the laboratory experiment, students must make a first-hand inspection of the apparatus. Their objective is to become familiar with the process and its components, controls, and utilities (see Table 1). The students then generate a system flow diagram for checkout purposes.
- ***Start-up*** The start-up procedure takes the system from "cold" conditions, with utilities (water, air, electricity) essentially dis-

connected, to steady-state conditions. Operations that may be dangerous are noted and safety precautions are highlighted, as they would be in industry.

- ***Operations*** Steady-state operations are listed for the experiment. Limits on operating temperatures, pressures, and power are noted both for safety reasons and for equipment protection.
- ***Shutdown*** The system should be shut down in a safe and orderly manner and should be left in its original condition. This responsibility is assigned to one student (in industry the student becomes the group leader). During shutdown, component deficiencies should be written down or the instructor should be advised in order to make the appropriate repairs.
- ***Emergency Actions*** Certain operating instructions are given for cases when someone is injured or the process conditions go out-of-control. The student engineer is shown how to quickly and safely shut down the system. For example, in a steam-heating water experiment, the emergency action instruction would be to close the steam valve at its supply header.

TABLE 1
Example of Checkout Procedure Instruction

In checking out the system, ascertain the following:

1. The location of the supply water to the inlet valve
2. That the inlet valve is in fact closed
3. That the outlet water valve is open
4. That the flow meter is in working condition

TABLE 2
Laboratory Report Outline (2-page limit for text)

1. *Title Page*
2. *Introduction (3-4 sentences)*
   Experimental assignment
   Purpose (experiment and practical problems)
3. *Summary*
   Specific answers to requested information (tabulate or graph)
4. *Results and Discussion (several paragraphs)*
   Experimental
   Practical problem
5. *Conclusion (2-3 sentences)*
6. *Recommendations (2-3 sentences)*
   Indicate deficiencies in equipment

APPENDIX
1. Original data
2. Sample calculations, including assumptions taken
3. Physical data from references used
4. Assessment of the quality of data collected

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FLOW DIAGRAMS

Prior to our revision of the operating instructions, students were given flowsheets. We feel, however, that an experiment is sometimes best understood through the construction of one's own process flow diagram, so we required that the students themselves draw the diagrams of the experimental apparatus or of the system for which the experimental information was to be applied. The "checkout" diagram did not have to be "professional," but it had to reflect an understanding of the system. We required that the laboratory report be neat and accurate and that the flow-diagram symbols be the same as used in industry; for this purpose we supplied the students with the proper equipment and instrument symbols.

PRACTICAL PROBLEMS

In addition to the usual laboratory demonstrations of engineering theory, we added practical problems to the experiments. Each experiment was redesigned to require specific data that would help solve a practical industrial problem. For example:

Convective Heat Transfer Experiment

Production department ABM wants to speed up reactor washing by heating the wash water from ambient (70°F) to 150°F. Obtain the heat transfer film coefficient using our wash water and specify the surface for this exchanger. The heat exchanger must operate with water flows of 5 to 20 GPM and steam at pressures of 5 to 40 PSIG.

A test heat exchanger is available in the pilot plant (laboratory).

REPORT WRITING

In previous years, laboratory reports were often lengthy documents of twenty-five or more pages. Unfortunately, much of the student's effort was expended in simply copying theory and procedures into that report, so we decided to reduce the report writing requirement by a factor of about ten! We devised a descriptive outline of the required report and gave it to each student during the first lab lecture. As a result, the reports now have a fixed format with a firm two-page limit on the number of "text" pages (see Table 2).

The revised format requires that the original data sheet for experimental observations and calculations be included, and that it had to be prepared by the students in advance. This forced the students to determine exactly what data were needed and how the data would be converted to the needed results.

The revised report also requires a brief discussion of the practical problem. The problems were slightly different for each group of students, which had the effect of minimizing plagiarism and making the reports more meaningful. The reports also contain a succinct statement regarding experimental observations applied to a practical problem.

CONCLUDING REMARKS

The procedures used in a typical Unit Ops Laboratory course were modified to more closely reflect actual industrial practice, and included some applied problems and industrial-type instructions. These modifications were implemented with minimal cost. ❐