ChE laboratory

PIPING LAYOUT AS A LABORATORY PROJECT

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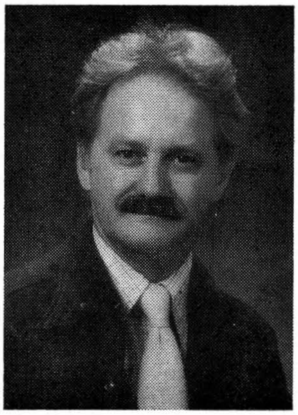
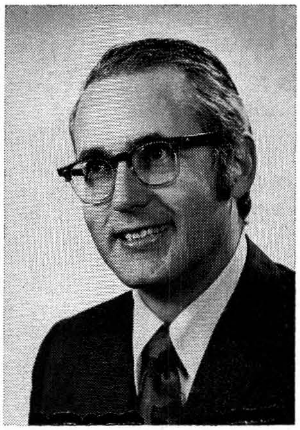
PRACTICAL CONSIDERATIONS in equipment layout, safety, piping, reading blueprints, appreciating specifications and model building,—yes, it would be nice if we had room in our curriculum for all these. Recently, we discovered how. We provide the students with a partially built model; give them 7 hours to decide if the model has been built correctly and why the equipment is placed where it is and wind up with a 5-hour project to install "some piping on the model." This activity is scheduled as one of our 12 hour laboratory projects that students may elect to take instead of a traditional unit operations experiment. This laboratory is very popular with the students.

Robert Dunn was Senior Technician at the Welsh College of Advanced Technology, Cardiff, Wales, where he was part time lecturer and technician. He has been Chief Technician in the ChE Dept. at McMaster University since 1965. His special concerns are to develop laboratory experiments and experiences that acquaint students with the practical side of engineering and provide insight into the fundamental principles. He is an avid wilderness hiker, fisherman and outdoorsman. **(L)**

D. R. Woods is a graduate of Queen's University and the University of Wisconsin (Ph.D.). For the past three years he has been attending all undergraduate lectures along with the students to try to discover what needs to be done to improve student's problem solving skills. His teaching and research interests are in process analysis, and synthesis communication skills, cost estimation, separations, surface phenomena and developing problem solving skills. He is the author of "Financial Decision-Making in the Process Industry." He received the Ontario Confederation of University Faculty Association award for Outstanding Contribution to University Teaching. **(R)**

OBJECTIVES

THE OVERALL OBJECTIVES for the laboratory are to provide an opportunity and a vehicle through which we can consolidate theoretical and practical considerations for the selection of pumps, pressure vessels, heat exchangers and distillation columns; to introduce factors used for equipment placement and layout, and piping; to develop skill at translating information on drawings into three dimensions and to develop psychomotor skill at model building. More specifically these objectives are:

- **To give the students some idea of what process equipment looks like,**
- **To give the students some idea of the information given on equipment specification sheets,**
- **To familiarize the students with some of the working techniques for building models,**
- **To help students visualize the three dimensional layout of equipment,**
- **To help students realize what factors influence the layout of equipment,**
- **To provide actual model building experience,**
- **To help students learn how to translate information from a diagram into three dimensional space,**
- **To give the students practice at laying in pipe on the model,**
- **To train the students to identify good and bad features of piping layout on the model, on plant visits and as shown in photographs.**

CONTENT TO ACHIEVE THE OBJECTIVES

THIS LABORATORY WAS developed around the Model Builder's Training kit [1] and manuals [2, 3] developed by the Engineering Model Associates. This kit includes all the components needed to build a 3/8″ = 1 ft scale model of a single rectification column. The unit consists of the column, overhead condensers, reboiler, distillate accumulation drum and four pumps. All the drawings needed are given in the Training Manual [2]. To build the complete model would require about 200 hours. Since the laboratory time is very limited we prefabricated all the process vessels, the structural steel work, prepared the plot plan and glued all the vessels on to the plot plan. This required about 140 hours. Thus, in the terms of model building we supplied the basic model. No piping was laid out on the basic model when it was given to the students.

To blend together the experience with the model and the objectives, we prepared four sets of notes and worksheets. Details are summarized in Table 1. First of all, these summarize background information and data about model building and plant layout. Next they provide leading questions that force the students to ask themselves questions in sufficient depth that they achieve the objectives. The students can answer the questions directly on the worksheets. Some worksheets ask that the students fabricate pipe and put it on the model. Indeed, the laboratory activities can be divided into two main types: understand the fundamental reasons for the layout given, and actually put in the pipe. The first topic is the focus for worksheets 1, 2 and 3, and takes about 7 hours, and, in the view of the students, is a "super review of all we have had and then some!" The topics start with individual pieces of equipment, consider horizontal and vertical layout of each, build up to the pipe rack and the placement of equipment about it, and end up considering overall site layout. The second major activity has three parts related to the actual model construction. The students bend wire to represent a piping system given on an isometric drawing. Then they learn how to lay in a pipe when the isometric drawing is not given. Indeed, the drawings that are supplied provide insufficient details; engineering judgment is needed to determine the piping route for most pipes. Figure 1 shows two students discussing with the instructor the location of one of the pipes. Thirdly, to provide insight to the students as to how to create the basic model we review how we went about fabricating the process equipment, constructing the structural steel and

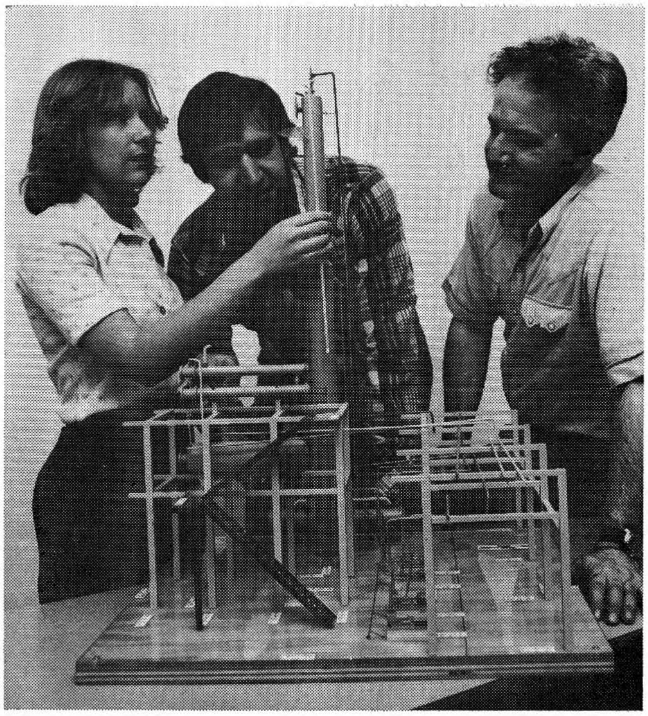


FIGURE 1: Students Suzanne Norman and Steven Cosic adjust piping while Bob Dunn (right) looks on.

making the basic model. The purpose of this last exercise is to give the students sufficient appreciation of model building that they could set up a model shop, could interact effectively with an existing model shop and are aware of the strengths and weaknesses of modelling.

The role of the instructor is similar to that played in any other laboratory: to be available when the students get hopelessly stuck, to provide enthusiasm for the activity when and if student enthusiasm wanes, and in some activities to share experience. We make available extensive resources that range from a collection of reprints of pertinent articles [4-13], to model building literature [14-19], to trade literature [20-25], to text books [25-29], to photographs of plants that illustrate piping layout. These photographs are taken from advertisements in, and covers of such maga-

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TABLE I
Notes and Worksheets

NOTES	WORKSHEETS	STUDENT ACTIVITY
SET 1		
Principles for building models, the information base, the criteria for layout equipment.	Set of questions pertaining to the drum: its function, the drawings, the specifications, the design principles used, design alternatives and decisions made, and horizontal layout.	Analyze complete flow diagram to discover what is happening on this unit. Identify model components and flow diagram.
Tables of recommended horizontal and vertical distances needed.	Similar questions pertaining to the heat exchangers, the pumps and the distillation tower.	Answer questions about specifications, design and horizontal layout, based on experience, courses, resource texts or instructor. Compare drawing of drum with model to discover any mistakes or omissions.
SET 2		
Articles on NPSH and reboiler piping design considerations. Comments on vertical layout considerations.	These provide an opportunity for the student to consider notes, implications and model details as they pertain to the vertical placement.	Answer questions and do calculations related to NPSH; measure vertical distance and do some order-of-magnitude estimates.
SET 3		
Articles and notes about the pipe rack, its placement on site, the relationship between the pipe rack and the process equipment, and the placement of piping on the rack. Horizontal distances between process units, and other units on the plant site.	The students relate what they observe on the model to the suggestions given in the notes.	Compare model with theory. Will need these ideas later when they lay out the piping themselves. Discuss with technician how the model was made, what procedures followed, what difficulties encountered.
Description of the bending board and methods of fabricating piping networks.	Given two isometric drawings of piping for the model.	To fabricate the piping network given in one of the isometrics. The bending board, pliers, cutters, piping and pipe fittings are all supplied.
SET 4		
General suggestions from the model building books (2)(3) on tagging lines and laying them out.	Students are asked to select one pipe (in addition to the one fabricated from the isometric) and lay in the pipe.	To read the diagrams, determine where the pipe goes, make decisions as to placement of pipe when diagrams leave off the details, fabricate the pipe including supports, fittings and valves and incorporate this onto the model.

zines as *Chemical Engineering* and *Hydrocarbon Processing*.

THE MECHANICS

OUR LABORATORY course is a three-hour per week composite laboratory to provide experiments pertinent to all the senior level courses. Pairs of students spend four such afternoons on any one experiment. One professor coordinates the scheduling of the experiments with about six others responsible for developing, supervising and evaluating the 15 experiments that make up the course. Students select four out of the fifteen. The piping layout laboratory is one of the choices. So far we have handled only two students per model kit and we run two model kits simultaneously. Thus, one instructor can handle four students simultaneously.

Each pair of students receives the basic model, scale ruler, pliers, bending board, glue, a small cabinet of model parts, a parts catalogue [15] and piping materials. The basic model and the parts can be reused each year in that the parts are clipped on and not glued. Each student receives a set of 27 drawings pertinent to the model. These are given in the EMA "Design Model Training Manual." [2]

As the year progresses we leave on the model the piping synthesized by the previous groups (and remove for each new group the standard piping configuration that we prepared from the isometric).

A complementary activity to this laboratory is to ask students to visit the local boiler house or pumping station, sketch the piping layout in a section of the plant about 3 m x 3 m x 3 m and comment on the appropriateness of the piping and layout.

EVALUATION

THE STUDENTS ARE evaluated 20% on the psychomotor skills and quality of pipework added to the model and 80% on the project report. In the report, four aspects are worth equal marks. The students are to show that they achieved objectives 1 and 2 by providing answers to the approximately 100 questions asked on the worksheets. Next, for objectives 3, 4, 6, 7 and 8, they should summarize the practical suggestions that they have learned about building a model. The third aspect of the report considers Objective 5: plant layout. The students are expected to consult articles and books other than those cited in the bibliography and add additional information to the notes on recommendations for the horizontal and vertical layout of process equipment. Finally, to satisfy Objective 9, the students should summarize the good and bad practices illustrated for the model they built, and for a photograph they locate in the literature. This evaluation scheme works well.

The students are enthusiastic about this project; so enthusiastic that one might consider extending the activity and introducing it earlier in the program. We have noted with interest the imaginative uses being made of models as freshman projects [30]. Such use is very attractive to us because it would complement our existing freshman course in engineering graphics and design. The students could experience the strong tie-in between engineering drawings, the model and engineering practice. In addition such a project would be highly motivating. However, we believe that the distillation model and the materials we developed are inappropriate for use in the freshman year. Our hope is to develop a project to be handled similarly to the approach taken here but for a small self-contained process such as a flue gas desulfurization or sour gas scrubbing unit.

SUMMARY

BOTH FACULTY AND students have responded enthusiastically to the use of piping layout on a plant model as a laboratory project. In this project the students are given the basic model of a distillation column and the pertinent engineering drawings. They are expected to review the fundamentals used to design, select and lay out equipment, and to gain experience adding pipe to the model. Details are given of the objectives, the materials developed to make this project successful, the mechanics for incorporating this project into a traditional experimental laboratory course and the method used to evaluate the students. □

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ACKNOWLEDGMENT

We are grateful to the students for their useful comments on how we could improve this laboratory. Mr. Keith Day of EMA has been very helpful.

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ChE letters

ChE's IN THE RUNNING

Editor:

In response to the question on chemical engineering faculty who have run in a marathon (Winter 1979, p. 52), I ran in the Cheyenne Frontier Days Marathon in July, 1978. I am planning to run in at least two during this coming summer.

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