# DESIGNING A CHEMICAL ENGINEERING LABORATORY AT A MINIMAL COST

by

GREGORIO C. GERVASIO*

## Introduction

Today, with the prices of everything escalating rapidly, the words "minimal cost" seem to be out of context. What may be expensive 20 or 25 years ago may be considered cheap today. For example P500,000 worth of facilities may be considered expensive 20 years ago but is relatively cheap today. The Unit Operations Laboratory of the Mapua Institute of Technology except for the two new units, was put up for less than P100,000 in the early 60's when the rate of exchange is P4.00 to $1.00. It is now reportedly assessed at around P3,000,000.

Putting up a Unit Operations Laboratory is not a sound business proposition. Considering the investment involved, the pay out period could be more than 20 years. But hearing in mind that the obligation of the school is to impart to the students the necessary knowledge to better equip them in their chosen career, then the establishment of a laboratory no matter how small is a must for any school.

Planning a unit operations laboratory involves:

a) Determining the type and sizes of equipment to be purchased.

b) Where and how to get them, and

c) How to arrange them properly.

A long range plan should be adopted with a master plan laid out to consider future expansion of facilities. A five year program of acquisition of equipment is reasonable. When purchasing equipment, no attempt should be made to complete the set-up within a year's time. Such a move will be too expensive to get the approval of the school's board. It may also lead to the acquisition of unnecessary equipment which may turn out to be too unwieldy to use.

For space requirements, a floor area of around 250 to 300 square meters should be set aside if possible.

It should be emphasized here however that the kind of laboratory which can be set up depends on how much funds are available.

## Determining What Equipment To Purchase

In determining what equipment to purchase, a study of what experiments can be conducted should be made. Investigations in relation to some of the unit operations such as fluid flow, heat transfer, filtration, evaporation, distillation, absorption and extraction, drying, humidification and dehumidification may be considered.

*Research and Development and Technical Services Manager, Colgate-Palmolive Phils. Inc.

The set-up can be made sophisticated to include computerized controls but can be made in a very simple manner to suit the budget. Since the topic is putting up the facilities at minimal cost, then the discussion shall be concentrated on the simplest set-up.

### ☐ 1. Fluid Flow

For schools with limited facilities, fluid flow experiments may be jointly conducted in the hydraulics laboratory. Later on, a simple set-up can be made to demonstrate fluid flow experiments. The unit can consist of a waterproofed concrete storage tank for the water, a set of pipes, valves and fittings, a centrifugal pump, a galvanized receiving tank, and a platform scale. Different size orifices can be fabricated from steel washers. A simple pitot tube made of brass is relatively cheap. A discarded steam jet ejector can be reconditioned to make a decent venturi. Manometers to measure pressure at different points can be made by the students. Provisions can be made on the piping to allow installation of a meter long glass pipe in the future to demonstrate laminar and turbulent flow.

Such a set-up can be put up for approximately P25,000.00. On the other hand, if an elaborate set-up is desired, P200,000.00 will not be enough. Just consider, if a dial type instead of a beam type platform scale is used, the comparative cost is P2,700.00 for a beam type against over P20,000.00 for a dial type.

The participation of the students in assembling the set-up should be encouraged. Not only do the students gain valuable experience in properly handling the tools but they take pride in the accomplishments. Labor cost is also minimized.

### ☐ 2. Heat Transfer

For a set-up to demonstrate heat transfer, a solar water heater will be ideal. It will be in keeping up with the times in this energy conscious era. A radiator, finned tubes or plain pipes with heat absorbing background connected to a water source and a receiver can be installed in a sunny area. Heat absorption can be determined with ordinary thermometers whereas the flow rate can be determined volumetrically. This type of experiment may even inspire students to design an effective solar water heater for commercial purposes.

### ☐ 3. Filtration

An experiment using a plate and frame type filter press with washing and non-washing plates offers a simple way of understanding filtration. Stock units with different materials such as steel, cast aluminum, reinforced plastic or stainless steel. A reasonable size plate and frame filter press is one with a plate area of one square foot and consists of 2 end plates (non-washing), 3 washing plates, 2 non-washing plates and 6 frames. The set-up should include a pump, a feed tank with a slow speed agitator and a receiver. Should heating be desired such as in the processing of oils, the feed tank can be provided with a set of steam coils. If washing is planned, a tank for wash water should be included.

For ordinary experiments, a suspension of calcium carbonate in water as the material to be filtered will serve the purpose.

☐ 4. **Evaporation/Distillation/Absorption/Extraction**

For experiments on these unit operations, the all glass quick fit (QVF) set up appears to be the cheapest. The QVF assemblies are stock items and are readily available. The parts are standard sizes. A possible way of limiting the initial cost is to order basic matching parts such as a reboiler, condenser, column, valves and other pipings which can be assembled to fit the experiments to be conducted. The disadvantage, however, is the inconvenience of dismantling and assembling of the parts and possible breakage during handling or storage if not handled carefully. Surprisingly, these glass parts are tough and durable when handled with normal care.

Since we are primarily an agricultural country, experiments in using agricultural products can be conducted. For example, for distillation, fermented molasses to obtain alcohol may be tried; for extraction, oil bearing seeds may be used.

☐ 5. **Drying**

A drying equipment can be locally fabricated. A tray type cabinet dryer can be constructed at a minimal cost. Made of galvanized sheet and insulated with styrofoam for low temperature application or with fiber glass for high temperature application, such unit can serve the purpose. The heat source can be one or two units of electric heating elements. Air flow can be supplied by a small blower with necessary ducting to provide recycling of air if desired.

Drying of grains or of wood panel will suffice for the experiments.

A more sophisticated model is an aeromatic dryer which incorporates the principle of fluidization drying. Since the material to be dried is fluidized, an intimate contact between the material to be dried and the drying air is achieved thus speeding up drying rate.

☐ 6. **Humidification/Dehumidification**

Experiments on these unit operations can be conducted in cooling towers. It is most likely that schools have some type of cooling towers for their mechanical engineering laboratory or for airconditioning. If none is available, a natural or induced draft cooling tower may be constructed using wooden slats or honeycomb construction of the contact surfaces.

## Determining Unit Size

When sizing a unit, the quantity of feed needed to conduct an experiment should be taken into consideration. The materials cost has gone up rapidly that even for a simple demonstration, the cost of materials to be used can run to several hundred pesos.

If units of 20 or 25 liters capacity are available, these are preferred. It should be noted that to conduct, say a distillation experiment, it will take some time to reach equilibrium conditions and collect enough distillate. Such an experiment can easily use up 200 liters of feed.

In other experiments like solid-liquid extraction, the cost of solvent may well be over P10.00 per liter. If 100 liters are required then the solvent cost alone can reach over P1,000.00.

Where steam is needed, a 7.5 to 10.0 H.P. packaged type boiler should be adequate. Space requirement as well as fuel consumption will be minimal. It should be borne in mind that the laboratory fee is too small to even cover the cost of materials.

## Planning The Equipment Layout

Each unit should be provided with ample space around to avoid crowding and to facilitate student movement. This will allow students to take measurements with ease. Furthermore, with ample space, assembling or disassembling and maintenance of the units can be conducted with ease.

When grouping the units, try to have those that will need steam supply near and in line with each other. Such layout will reduce the steam piping cost and insulation, and will present an attractive appearance. A main steam line can run along the entire length and taps are provided for each unit.

Similarly, units which use water can be grouped together. Criss-crossing pipelines should be avoided. There is nothing more attractive in an installation than a symmetrically arranged piping layout. It adds to the orderliness of the place.

Adequate drainage facilities should also be provided along the floor to maintain cleanliness.

## Possible Sources of Equipment

Standard stock items like the QVF quick fit glass assemblies are represented in the Philippines by Otto Gmur Inc. Others like platform balances are readily available. If the school is not too fussy about using second hand equipment, it is quite possible to acquire a few pieces by diligent inquiries from various companies or surplus dealers.

1. Most companies have, in one way or another, discarded pieces of equipment not necessarily unusable but discarded due to obsolescence or increased capacity requirements. Other companies may even have brand new units which become unusable due to change in plans. Multinational companies can be a rich source of equipment which may even be obtained as a donation or just for the price of scrap metal.

2. Dealers of army surplus carry a number of measuring instruments. It may be possible to obtain from this source, thermometers, gauges or even rotameter. These are not junk materials and can be reconditioned and calibrated.

3. From time to time, chemical magazines have a section of surplus equipment

listing. Listed are tanks, pressure vessels, reactors, mixers, dryers, filters and many others. It is quite possible to find a piece of equipment that will fit the need.

4. Local fabricators have managed to upgrade the quality of their products. By contracting a good fabricator, some pieces of equipment can be made to specifications. The quality is just as good as an imported one and at a cheaper price.

5. Students can assist in the fabrication of manometers, orifices or other simple apparatus for measurement.

## Preparing A Long Range Plan

Having discussed the different types of equipment that can be put up, the optimum unit size, the ideal layout and possible sources of equipment, the next step is to prepare a long range plan to present in detail the program for gradual acquisition of these units. The plan should tie in with the available funds from the school allocated for this purpose. Without such a plan, the completion of a unit operations laboratory will be difficult, depending on the changes in the teaching staff, or the laboratory may not even be completed at all.

The long range plan can start with a first year acquisition of a fluid flow set-up and a heat transfer set-up. In the second year, a packed tower for absorption experiments and a dryer may be planned. If in the third year the acquisition of a boiler is possible, then other units requiring steam can be scheduled for acquisition. With such a plan, at least a realization of having an equipped Unit Operations Laboratory is possible.

Summarizing, a decent Unit Operations Laboratory at a minimal cost can be put up by diligently pursuing a master plan, by diligently searching various sources for the different pieces of equipment, and by resourcefulness and innovativeness in adapting what is available. Lastly, the students potential capabilities in setting up such units should not be overlooked.