

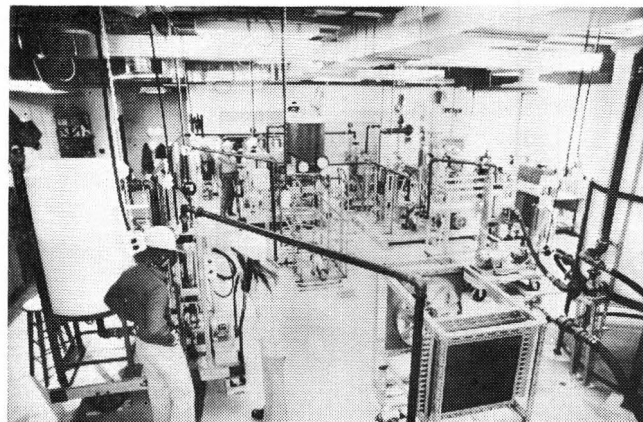
LESSONS IN A LAB

Incorporating Laboratory Exercises Into Industrial Practices

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A QUESTION FREQUENTLY asked by the academic community is how extensively or to what depth should laboratory exercises duplicate the industrial scene? In typical professional BS engineering programs, a certain amount of laboratory practice is included in each curriculum; however, that amount varies usually with the attitude and philosophy of the faculty. It is apparent that reduction of the laboratory program to a minimum in many professional BS engineering curricula and the substitution of math, computer and system/process simulation in its place has stimulated the formation of programs in engineering technology. These latter programs in technology are justified to legislatures, school administration and the industrial employers because they include the laboratory exercises in hands-on-training with industrial-type equipment. The use of both bench scale and larger items of equipment to demonstrate and train the four-year Bachelor of Technology students appears to satisfy the employers of the BT engineering graduates.

In the area of a two-year engineering technology curriculum, a strong laboratory program is an absolute necessity. If the graduate technician is to be capable of performing the tasks for which he/she was hired, then the academic training should have contained a strong industrial oriented laboratory experience on real industrial equipment or equipment that is a very close approximation. Another important feature of an academic-type industrial laboratory experience is that the instructor should have had industrial experience himself: the longer his length of service, the more vital the applied training to the student.



View of laboratory looking northwest.

At Nashville State Tech, we have attempted to develop laboratories that would incorporate as many of the previously discussed training philosophies that could be attempted in our academic environment. Particularly, the Chemical Engineering Technology laboratory has been designed, installed, tested, checked and finally operated in the concept of an industrial pilot plant. The present lab equipment was assembled essentially by six classes of students who had a variety of experiences in that assembly and checkout. While previous papers and publications have described the general philosophy of the ChE Technology lab and its intended program [1, 2, 3], this paper will discuss those experiences with reference to the orientation of the training involved in the actual assembly and testing.

In any pilot plant facility, the system is re-designed and assembled into a specific configuration based upon the actual chemical plant or process. It is intended, after the pilot plant is checked and tested, that the operation should proceed in a manner as the original plant. The efforts of the ChE Technology laboratory program was directed towards the assembly of a simulated pilot

plant in order to test, check out, maintain and operate a system in a similar to, or equivalent to, an ordinary chemical process in the manufacture of a product. Since Nashville Tech is not a competitive company, our product from the loop system, here described, is also our raw material. The operations in the laboratory should be the same in the transport of fluids, the heating and cooling processes and the separation and blending operations normally found in any chemical plant system. Our first activities in performing these tests are described in this article.

PROGRAM DEVELOPMENT

NASHVILLE STATE TECH began its function in the fall term of 1970. All Engineering Technology curricular areas were engaged in planning, in the program development, and in the acquisition of hardware for the various laboratories.

The ChE laboratory was to be unique in that it would provide hands-on-training by the assembly of the facility by the students themselves. In addition, the laboratory was to be different from others by being a total process system. In the laboratory and "pilot plant assembly," the stream-stream blender unit was temporarily removed from the system to avoid damage during piping flow checks. All of the equipment and piping shown was assembled by the various classes of second-year students. Figure 1 is a view of the laboratory looking northwest. Our first major assembly was the evaporator system. It was a standard philosophy in purchasing equipment that it should be sent unassembled (at reduced cost) so that the students could receive on-the-job training in following commercial assembly blueprints. In all classes, the use of a level and square was stressed in the equipment assembly. None of the different student classes had any trouble continuing the assemblies that

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were started by a previous class since all components and parts of these various assemblies were fitted properly into the desired configuration.

The first major commercial installation was the 40 HP boiler unit in fall of 1972. Unfortunately, the steam piping was not a part of the facility. It was not until March 1976 that steam was available in the laboratory. There is still one problem area in the operation of the "pilot plant." Insufficient cooling water for the condenser on the evaporator is available; the only sources are the two water taps in the sinks. As one can visualize, there have been several exciting moments when the condenser temperature has risen too high for proper evaporator operation.

ON-THE-JOB TRAINING

IT IS AN ACCEPTED practice in the chemical industry that a small but essential production unit is constructed and operated before a full-scale plant is built. Although there are some exceptions in other industrial systems, these "pilot plants" are an accepted part of the chemical complex. At the Nashville Tech "pilot plant system," our first experience dealt with process piping and sub-systems cleanout. We prepared a 10 percent trisodium phosphate solution in our large tank, approximately 400 gallons, and proceeded to operate our pumps individually for a degreasing operation. It was immediately apparent that not all of the piping was leak tight; in fact, there were few fittings that did not leak. As the students quickly learned, we not only cleaned the system, but we had to tighten the process piping. At system shutdown, we all learned a bitter lesson; there were no drain valves on the low points in the piping. It required a week of disassembling and reassembling to correct this small detail.

Process instrumentation and control are offered jointly with the pilot plant laboratory. Students have assembled manometers and recorders in the necessary mobile frames for the past four years. Other groups electrically wired these units for power and added the wiring for

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the instrument to measure the desired variable. All of these instrumentation units have been placed in the pilot plant system when required. As a part of this instrumentation course, techniques in calibration and rate of response were (and continue to be) demonstrated and practiced. The experiences of the students were most useful in designing a liquid level assembly for one of the process tanks after a near overflow during a checkout exercise.

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the complexity of a process system during installation, checkout, testing, maintenance and operation. On the morning of the first actual attempt to go "operational," a first-year student was teamed with a second-year student to give training to both; the first year to learn and the second year to teach and supervise. The operation worked well as long as the laboratory facility was able to perform.

On schedule, the Loop System pump No. 1 was started and we found the entire evaporator unit leaked. This was remedied rapidly by some of the fastest pipe wrench action ever seen in the lab. Next, one of the students noticed that the steam condensate tank was not emptying; in fact, the pump would not start. We then discovered that there was an improper electrical connection for the condensate tank pump, no fuses for the auxiliary pump control switches, and no designations or names on the switches for turning on or off. After a lapse of two hours, we resumed only to discover that no pumps were pumping and our condensate pump controls had burned out. Somehow, a 208-volt line had been wired to a 110-volt solenoid. The lab exercise was terminated at this time. Several days later, after installing the correct solenoid, our exercise was started again.

MAKING THE SYSTEM WORK

SINCE OUR EVAPORATOR had filled up rather than operating properly during this brief operation, the pump motors had to be operated singly to determine the pump rotation. All operated, but backwards. The direction of the centrifugal pumps was easy to detect, but the gear pump required dismantling to determine the rotation of the pump in relation to that of the motor. It too was operating backwards. Simple remedies were made by reversing two leads of the 208-volt AC power system. Now the evaporator was a part of the operating system. One of the flow measuring instrumentation units was installed in the main liquid line to determine the amount of fluid bypassing the evaporator; it did not operate, nor did the included recorder. Electrical checks were performed, wire checks were made, a circuit ring-out was made, but still no operation. After two hours of frustration, one of the students grabbed the wires and discovered that one terminal was not crimped to a lead wire; in fact, none of the wires in one set were crimped.

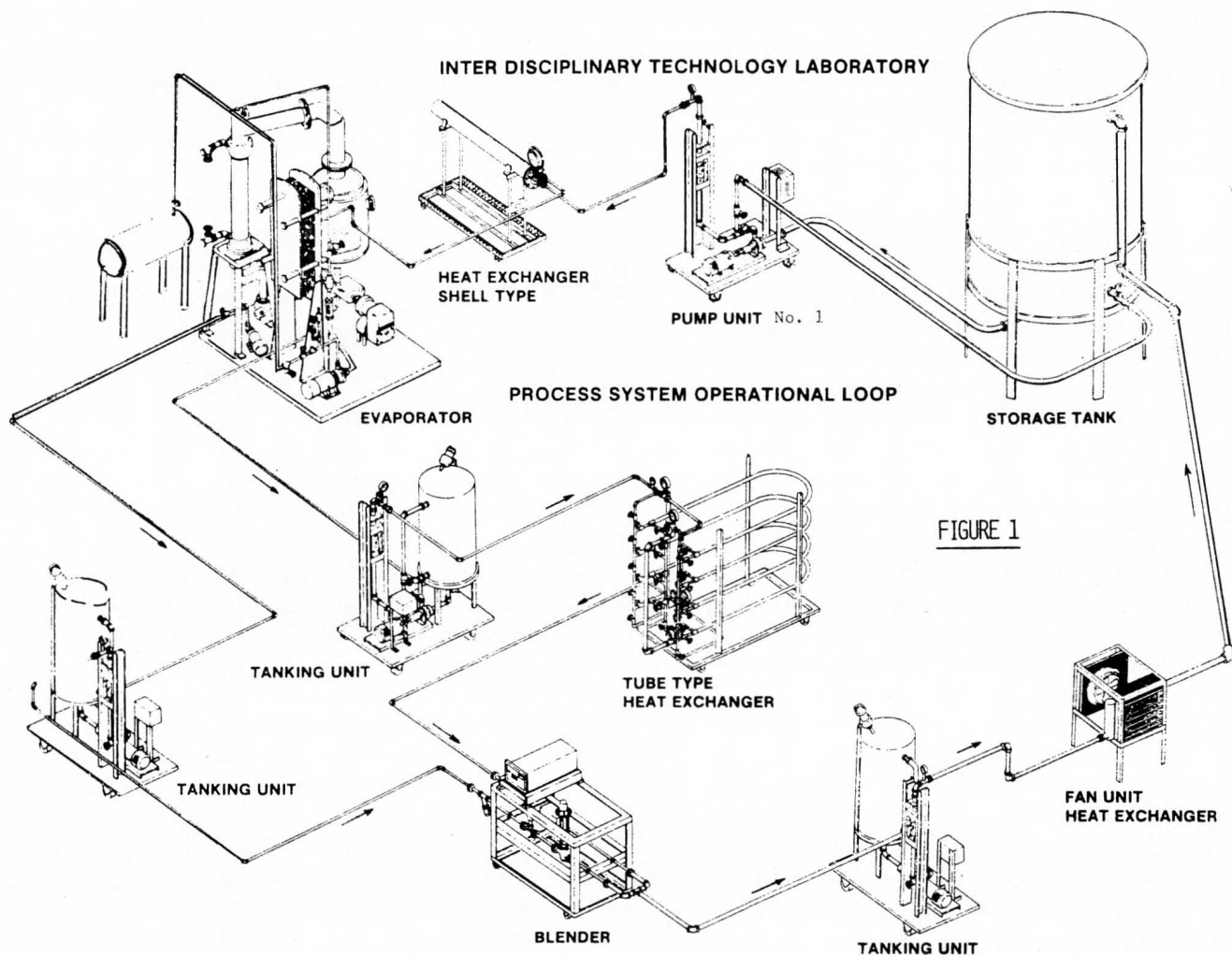


FIGURE 1

After immediate repairs, we had a magnetic flow meter that worked. Unfortunately, the recorder was not calibrated so that our readings at first were not too accurate. During all of these attempts to operate the pilot plant, the students all agreed on one question—"What actions are taken when this happens in an industrial plant?" Both of the instructors just smiled and said, "The same thing that you are doing here, trouble shooting the cause and making the necessary repairs or alterations to make the system work."

After an hour of relatively calm performance, by both the system and the operating personnel, it was discovered that the flow rate of pump No. 1 was gradually decreasing. In the supply line between the pump and supply tank, a strainer was originally installed. Its purpose was to prevent any collected sediment and/or debris from entering the pump. This strainer was cleaned at least twenty times with some recovery of flow, but the overall condition did not improve satisfactorily.

Again, the process system operation was terminated because of completion of the daily scheduled lab exercise.

During the next lab period, an observer was stationed to observe the interior of the tank. The normal tank level for these initial test exercises was five feet from the bottom with an NPSH* of six feet. After an hour of operation (tank level stabilized, from the input/output flows), the observer reported that a vortex had formed and gradually increased in size as the pump speed and flow rate also increased. After observing this vortex and having the flow rate decrease to 25 percent capacity, the regular shut down procedures were started and the system gradually returned to zero flow conditions.

A new problem arose when the students reported that there was little or no information on anti-vortex baffle plate. Since the tank is manu-

*Net Positive Suction Head (Pump Inlet Pressure)

factured of polyethylene, by necessity the plate had to be hot-welded to the tank bottom. Author Hallman had that privilege, but not by choice. The plate worked; no further problems in vortexing were encountered, and the flow rate remained steady at the maximum value of 80 gpm.

PIPING PROBLEMS

IT SHOULD BE NOTED that piping leaks were encountered frequently during all check outs and systems operations. All piping in the process laboratory and an air supply line were installed by the second-year ChE Technology students as a part of the unit operations laboratory; the air line was installed by the 1976 graduating class. It has been a learning experience for both instructors and students in teaching and learning to properly measure and thread pipe of various sizes. Although a pipe threading machine was available for the larger sizes of pipe (1½" and 2" diameter), the small pipe sizes (1" diameter and less) were always threaded by hand; the larger pipe was threaded by machine, after the students had the opportunity to hand thread those larger diameters. In the manipulations of assembling the piping system, the assortment of pipe fittings, valves, and associated items gave the students the experience and actual training in choice, selection, and determination of pipe and piping equipment. It is interesting to note that not all of the mistakes and errors were made by the students; one commercially purchased assembly had a check valve installed backwards; this improper assembly caused several hours of lost time and many heated tempers, because the system did not contain any piping unions which could be used for the disassembly of the system. The students learned that pipe unions were made to be installed in the event a system must be cleaned, revised, or removed.

The Spring Quarter, 1976, ended with the graduation of the students and their employment in various companies. The lab was approximately 85% complete in its assembly. The 1977 class has finished all of the assembly required, both sub-unit and the instrumentation/control systems, and have installed all in the loop. We have operated the total loop system for several hours at a steady state flow (about 30 gallons/minute) without serious malfunction. Our only problems have arisen due to excessive pressure drop and dirty filters. As the quarter ends on the 1977 class of

graduates, all have expressed the same opinion: that the laboratory was an exercise in patience, fortitude and real training, coupled with entertainment.

In several visitations by ChE professors of other colleges and universities as well as the chemical engineers employed in our local industry, the general comment has been the same; they wished their employees could have had some training on the Nashville Tech ChE loop.

CONCLUSIONS: BY APPLICATION

THE USEFULNESS of these past seven years in the operations of the ChE Technology laboratory has been demonstrated by the applications being used by the graduates. One of the 1976 graduates has been assigned the task of designing the process piping system for an actual pilot plant; he has attributed his assignment particularly to his experiences in the assembly and checkout of the Nashville Tech system. Other graduates are employed in system design, pollution/environmental controls, pilot plant operations and production. Each graduate, in visits to the school, has expressed his gratitude for the laboratory training experiences. Many present and potential employers have commented favorably on the philosophy of the laboratory training. It is apparent that we have developed one method of providing a student with the opportunity to practice in school some of the industrial practices he will use in his own career. Future planning contains our same philosophy: change, modify, test and operate the laboratory as before; give to the student what he/she will require to perform the job for which he/she will be hired. □

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