Consider classroom training for plant operators

Course materials are specially focused on the safe, environmentally sound and efficient operations of a processing facility

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There are many reasons why operator training is important. One survey found that the three top objectives for operating plants are to improve safety, increase process knowledge, and improve plant profit. The most important is safety, to ensure that operators can properly respond to abnormal situations. This includes handling situations that the operators may never have actually encountered before. The training method is similar to the program used for airline pilots who train for many possible situations that rarely, if ever, occur. In short, plant operators must have a deep thorough understanding of the process to enable them to safely handle abnormal situations and to identify potential hazards. The following case history discusses how a major Gulf Coast refinery implemented a training program on fired heater operations for process operations to meet plant goals.

Importance of training. Operator training can and should be done in a variety of ways. Some types of refresher training may best be done online. Training on a specific unit is usually best done via on-the-job where an experienced operator trains a less-experienced operator. Process simulators are the better training method for process upset conditions that would be difficult to experience with actual operating equipment. Training on general theory and best practices is often best done in the classroom where students and instructors can interact and discuss principles that can be applied to their processes. The focus of this article is classroom training.

Improved performance through knowledge sharing. Sustaining and improving the performance of process plant operators is a key element of operational excellence. This is accomplished in many ways including, for example, proper procedures, documentation, audits, mentoring/coaching, automation and controls, maintenance and training (both off- and on-the-job). There are many elements of operational excellence including safety, efficiency, productivity and environmental compliance. It is critical that operators are adequately trained to meet the demands of operational excellence.

Plant operators must be able to quickly and accurately troubleshoot and diagnose process upsets and equipment problems. Failure to do so can lead to lost production, off-spec product generation, equipment damage and, possibly, catastrophic events.

Related to troubleshooting is process optimization, which involves maximizing production while minimizing costs and meeting environmental regulations. Under optimization programs, process operators should be trained both to handle problems and to look for ways to improve unit operations even when nothing appears to be wrong. Proper training can sensitize operators about what to look for and what adjustments to make depending on the situation.

Training partnership. The BP Texas City refinery (Fig. 1) is one of the largest and most complex refineries in the world. Located on a 1,200-ac site, it has a crude oil capacity of 460,000 bpd and more than 2,000 direct employees. BP’s unit specific operations training department partnered with the process burner company to develop a general one-day training course for fired-heater operations.

This course is one component of a more comprehensive operator training program that BP developed. The training program also includes a classroom-lead process fired heater simulator and unit-specific fired heater training conducted by the BP unit train-
ing coordinators. BP’s unit specific operations training department developed its desired course outline, learning objectives and outcomes including a student learning assessment. A pilot course was developed by the process burner company and delivered to a cross functional group of BP personnel, including training personnel, engineers and operations supervisors. The materials were fine-tuned to meet BP’s requirements before rolling it out to the Texas City site operations organization.

One of the benefits for a plant partnering with an experienced training organization is the accumulation of industry-wide best practices. The process burner company personnel have worked in numerous refineries worldwide. They have seen a wide range of both problems and best practices. This experience is invaluable for training because it exposes a particular plant to potential issues that even their experienced operators may rarely, if ever, have seen before.

Most training courses are accredited by the International Association for Continuing Education and Training (IACET), which means that continuing education units (CEUs) are given to students who can demonstrate that they have met the course requirements, which includes successfully passing a post-course examination. One of the accreditation requirements mandates student privacy where test results can only be given to others with written permission from the student. BP decided to forego CEUs for this training because they wanted to see all test results. BP also elected to make the course requirements more stringent than those required by the IACET accreditation.

**Customized operator training.** The objectives for the course are to:

- Improve overall understanding
- Define common fired heater terminology
- Follow proper and safe operating procedures
- Increase heater thermal efficiency
- Reduce pollutant emissions
- Provide tools for troubleshooting problems.

Table 1 lists the agenda developed for the course to meet these objectives. The primary thrusts of the training are safety, reducing pollution emissions, maximizing thermal efficiency and providing troubleshooting tools. All points are addressed throughout the course.

For example, while Section 3 specifically addresses combustion safety, it is designed to provide the foundation for other discussions on safety in later sections. Detailed theory and equations are kept to a minimum because the course is designed for operators; so, the information must be practical and easily applied to daily operations.

Sixteen classes were conducted in 2007, with an average class size of 13 to ensure good interaction between students and instructors. Each student received a color copy of the slides used during the training. Fig. 2 is an example of a typical slide, which has a picture of actual equipment and a drawing showing more details of free-standing diffusion (raw gas) burners. One copy of the *John Zink Combustion Handbook* was provided to each class for use as a reference. This book is used as a text in other training classes. Although this title includes practical information, it is designed primarily for engineers rather than operators. Each student also received a laminated flowchart, designed for use in the plant, for setting the oxygen and draft levels for natural draft and balanced draft heaters.

The students were introduced to each course by a BP manufacturing department leader and the unit specific operations training project manager. Both provided context expectations and motivation for the class. The students then took a closed-book pre-test consisting of 15 questions that required fill-in-the-blank answers. No multiple choice or true-false questions were used where students might be able to correctly guess the answers even though they may not have actually known the answer prior to the lesson.

The classes were designed to be highly interactive, emphasizing the Socratic teaching style where the instructor asks the students lots of questions and instructs based on the responses. For example, Fig. 3a depicts three burners firing horizontally in a process heater (not a BP facility). The students were asked to determine what might have been wrong with the burners. Then they were
shown a picture of the back of the burners (Fig. 3b), which shows that the air registers were closed on the two burners with bright yellow flames.

Throughout the course, numerous pictures, animations and short video clips were shown of process heaters that had problems. The students were asked to determine the problems and recommend solutions. This format exposed them to many potential problems that they may never have encountered. However, the operators could possibly encounter or avoid the event by taking the proper actions. For example, video clips of burners flashing back were shown during the class. These clips were taken at the John Zink test facility under highly controlled conditions. The clips exposed students to the sights and sounds of flashbacks in case they should encounter this event in their own heaters.

The course was designed to show operators both good and bad heater operations. Many examples were provided covering a variety of problems found in actual operating heaters in many plants. Fig. 4a shows an example of improperly adjusted burners in a process heater (not a BP facility). Both the furnace draft and excess O₂ were well out of desired specifications. The flames were irregular and not producing the desired heat flux pattern on the floor. Fig. 4b shows the same burners in the same heater, after being properly adjusted. These adjustments can be easily made by operators once they have been properly trained.

Fig. 5 is a schematic of a flame rollover in a cabin heater. Burners are firing up along the wall, but the flames are rolling over into the process tubes, which is very undesirable and can cause a premature shutdown. Possible causes and solutions were discussed for this event and other related problems. Students practiced troubleshooting exercises in the classroom using the tools that they had learned. The operators also discussed the problems with their colleagues and instructors.

An important element of the class is that it was designed to be fun. While there is no doubt that a lot of new material was covered over the course, humor and games were used to help engage the students. For example, as a review for the post-test, students were divided into two teams that competed in a game of ZJeopardy (Fig. 6). The winning team members received a prize, so the competition was often fierce.

**Course results.** The students taking this course ranged in experience from a few months to more than 30 years. Very experienced operators still benefited from this training because they gained a deeper understanding of the reasons for various procedures. For example, a burner that is pulsing or huffing is unsafe and must be corrected immediately. The operator may know to reduce the fuel flow to the burner, but they may not know why or what could happen if the wrong action is taken. Knowing the why behind the procedures helps operations personnel to better handle abnormal operations that they may never have encountered before.

The post-test questions were identical to the pre-test questions, so a direct comparison could be made between what students knew before and after taking the course. After 16 classes and over 200 students, there was a sizeable improvement between pre-test
and post-test scores as a result of the course. The average pre-test score was 33% and the average post-test score was 94%. Students were given anonymous course evaluations and asked to rate their interest in and the benefit of each topic using a Likert scale ranging from 1 to 5 where 1 = none and 5 = great.

The overall average rating for all topics was 4.3. One student wrote, “Learning was made fun and interesting.” Another wrote, “I know more about heaters than when I came to class!” Fig. 7 shows a summary of the total student evaluations for the course. The blue bars show interest in the content and the green bars show how much the student benefited from the class. The vast majority of students found the course interesting and beneficial. The course materials were continuously revised based on student feedback. For example, students in the earlier classes felt there was too much material, so duplicate and superfluous information was deleted in later classes.

**Training for improvement.** Operator training is critical for the safe, environmentally sound and efficient operation of a plant. Partnerships between plants and external training organizations can effectively help meet some operator training requirements. Specific objectives should be developed so the materials and learning experiences can be designed to meet those objectives. Certain training types are better suited for classroom environments with a limited number of students to promote interaction and engagement. An assessment tool, such as a post-test, should be used to quantify learning and to ensure that key concepts have been grasped. Ideally, the training should be fun to fully engage the students, particularly operators who may not be as comfortable in the classroom as degreed engineers. Course evaluation is important to adjust the presented materials and methodologies to continuously improve the content and instruction methods.

**LITERATURE CITED**


**Fig. 7** Overall ratings by students on their interest in and benefits of each course section.