OPERATIONS SKILLS FOR THE 21ST CENTURY

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INTRODUCTION

Today's refiners are dealing with many issues related to the safety, reliability and environmental performance of critical process plants. A lot of these issues are driven by the skills of human resources. The focus of this paper is how to maintain and enhance the skills of the plant engineers and operators who run these plants.

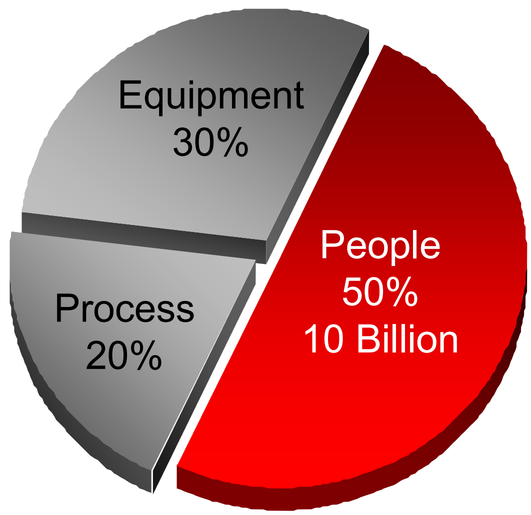
Currently we are going through a period of transition as a new generation of engineers and operators enter the refining industry. In countries with mature economies and slow growth rates, this transition is largely due to a wave of retiring expertise. In countries with developing economies and high growth rates, the transition is due to the rapid addition of new process plants and the corresponding shortage of expertise. In both cases, there is a looming shortage of skills which are typically gained over many years of experience. These skills are critical for avoiding operational errors that can negatively effect plant performance.

The looming skill shortage poses a significant challenge for refinery management, particularly for complex process plants that generate substantial value for the refiner. An example of such a complex refinery process plant is the FCC unit, which is featured in the discussion.

U.S. process plants lose over $20 billion per year from abnormal situations and $10 billion (50%) is directly attributable to human error as shown in Figure 1. These losses are caused by insufficient employee knowledge, and operator and maintenance worker errors.

The traditional approach for improving workforce skills includes on-the-job mentoring by a journeymen or classroom training led by an expert in the technology. The advent of high power personal computers and high speed internet has facilitated a new generation of powerful training tools. These new tools are representative of actual plant situations, utilize proven adult education techniques and allow refiners to better prepare their engineers and operators for the 21st century. These include modern training simulators, troubleshooting tools, web-based-training and operations monitoring tools.

Figure 1
Errors and Inefficiency Cost Money
Abnormal Situations Management Consortium



INCIDENTS STILL HAPPEN

Refineries have long suffered from disruptive incidents. Some of these incidents are high profile, especially when casualties or emissions violations are involved. Many more are low profile, which nonetheless cause equipment damage or processing outages. About half of these incidents are caused by process equipment failures or related process issues. The other half are due to human errors.

Refineries are complicated process plants which require intensive maintenance to operate reliably. Consequently many of the human errors which cause disruptions originate with maintenance workers and supervisors. The remaining human errors generally originate with plant operators and the engineers who supervise them (operations personnel). This paper will focus on errors which originate with operations personnel. Although similar types of human errors occur throughout refineries, the examples which folow are based on UOP's unique experience with operating FCC units. UOP has designed more than 200 FCC units beginning in the 1940's and has commissioned nine new units in the past three years. Today, UOP is actively engaged in monitoring and advising more than 150 operating FCC units throughout the world.

The FCC unit is one of the most important conversion units in the modern fuels refinery. In most refineries it is the major contributor to the gasoline pool and also a major producer of olefinic LPG. Generally, FCC units are highly profitable, and most refiners attempt to keep the plant running continuously for four to six years. A shutdown of the FCC unit frequently requires a reduction in crude processing and a reduction in feedrate to other conversion units, impacting the refinery's overall profit margins.

Therefore it is critical that operations personnel have the skill set to handle abnormal situations quickly and efficiently. The following case studies demonstrate situations where human errors by operations personnel caused significant disruptions.

Case 1 – Regenerator internals damaged by high temperature

The regenerated catalyst slide valve suddenly closes due to a malfunctioning slide valve actuator. Lift steam continues to run, clearing the catalyst out of the riser. The spent catalyst slide valve is on level control, and gradually closes. However the board operator, reluctant to stop feed and thinking he can recover from the upset, does not stop feed. Raw oil is lifted up the riser and soaks the catalyst in the stripper. The reactor temperature drops dramatically. Several minutes later the regenerated catalyst slide valve suddenly opens, also due to the malfunctioning slide valve actuator. The spent catalyst slide valve then begins to open. Oil soaked catalyst enters the regenerator, causing very high temperatures, resulting in damage to internal equipment and a thick plume of smoke visible from the stack. This scenario or similar scenarios caused by low reactor temperature have occurred many times and is one of the most expensive losses from the refinery insurer's viewpoint.

Case 2 – Catalyst losses from the regenerator during startup

The unit was starting up following a planned turnaround. Catalyst was being loaded into the bubbling bed regenerator. The diplegs were sealed and catalyst loading continued. As the catalyst level approached the normal operating level, catalyst losses from the stack increased dramatically. In an attempt to reduce the catalyst losses, the operators reduced the main air rate, but the losses increased. The operators then increased the main air rate higher than during catalyst loading and the losses stopped. This scenario or similar scenarios have also occurred many times at various refineries. If the main air flowrate is too low and/or the catalsyt level is too high, maldistribution or gas bypassing can occur, resulting in stagnant regions of the bubbling bed. Diplegs located in a stagnant region will not discharge, the corresponding cyclone will flood and stop working, and high catalyst losses will result.

Case 3 – Damaged wet gas compressor

The wet gas compressor was shut down due to problems with auxiliary equipment. Feed was stopped and catalyst circulation was stopped. The main air blower continued to run and the regenerator was kept hot with torch oil. In order to keep the reactor hot for a quick restart, catalyst circulation was restarted at a slow rate, which entrained air from the regenerator into the reactor and downstream equipment. A few hours later, the wet gas compressor was repaired and restarted. As the compressor was started, a detonation occurred within the compressor casing, resulting in extensive damage. The established practice for catalyst circulation without feed is to flush the system with fuel gas and purge the entrained air out to the flare, keeping the partial pressure of oxygen below the explosive limit. The operators did not start the fuel gas purge when the catalyst circulation was started.

Case 4 – Catalyst losses from the regenerator during shutdown

The unit suffered a partial power outage. Feed was stopped and catalyst circulation was stopped. The operators continued to run the main air blower at the same flowrate as prior to the feed outage. Suddenly catalyst losses from the bubbling bed regenerator increased. This scenario occurred at the same refinery several times previously during sudden feed outages. This unit normally operates with a high regenerator superficial velocity with marginal cyclones. When feed is pulled, the reactor and regenerator pressures automatically decrease, resulting in an even higher regenerator superficial velocity. The resulting higher entrainment rate was sufficient to overwhelm the cyclones which flooded, resulting in catalyst losses. The correct course of action is to reduce the main air flowrate when the regenerator pressure drops.

THE NATURE OF HUMAN ERRORS

Fortunately, none of these incidents resulted in casualties. In fact, most refinery incidents which result in feed outages are not caused by fires or explosions.

All of the previous scenarios could have been prevented if operations personnel had properly executed long established emergency procedures. So why do such errors continue to occur?

Operations Worker Errors

There have been a number of studies which have explored the nature of human error. One of the best was a 1994 IEEE paper by R.W. Chu and others. Operations worker errors are essentially a failure to respond rapidly and properly to changing plant conditions.

Unit specific incident reports frequently cite errors which occurred during the execution of a compensatory or corrective response. However, operations personnel often cite more difficulty with their ability to recognize the root cause of a problem, or develop a solution to the problem in a timely manner, which then results in an error.

Failure to recognize a problem can be a result of poor cybernetic design such as too much or too little information, alarm overload or poorly designed DCS graphics. A similar problem occurs when the human interface or final control elements located in the field are poorly maintained.

Inconsistent or inaccurate information can lead to the wrong conclusion, and therefore the wrong action. In many cases, fear of taking the wrong action may prevent the operator from taking any action at all. Inadequate procedures, insufficient knowledge of the procedures, and failure to properly execute the procedures are well known causes of error.

Management decisions including too few experienced people on shift, ineffective communications and poor training can compound errors.

Maintenance Worker Errors

Maintenance worker errors are slower moving, but can also be very disruptive. Maintenance worker errors are frequently caused by insufficient knowledge of the equipment or insufficient maintenance instructions.

Management decisions including pressure to restart the unit as quickly as possible, pressure to control maintenance costs, insufficient spares or inadequate procurement logistics often compound the problem.

Stress

Both maintenance worker and operations worker errors can be compounded by excessive workload and insufficient sleep. These last two factors are frequently cited as contributing to human errors near the end of a long turnaround.

CHALLENGES OF THE 21ST CENTURY REFINERY

Demographics

In countries with mature economies such as the U.S., Western Europe and Japan, the oil, gas and petrochemical industry has increasingly lost experienced personnel to mergers, restructuring and retirement. Due to cost containment and increased automation, many of the people with the institutional knowledge necessary to operate the facilities under the most trying conditions are not being replaced. This results in complex facility operation being performed by personnel who may not have had the requisite training needed to deal with crisis situations. This lack of experience increases the potential for loss when normal operation processes fail. (from Risk Management Magazine. June 2005).

In countries with emerging economies such as China and India, there are very large populations which continue to grow. There is also an emerging middle class in many developing countries, causing increased demand for motor fuel. Most new refining capacity worldwide is going into emerging markets.

Historically, refiners in the Middle East have relied on ex-patriots for technical expertise. There is a growing trend in these countries to develop expertise from among the local workforce.

Consequently many refineries throughout the world are staffed by a younger generation of operations personnel. These workers lack the experience necessary to deal with complex operations such as startup, shutdown and emergencies. The world-wide pool of experienced operations personnel is flat or declining, even as the industry is expanding. This means that new human resources will have to be developed into technical experts more quickly.

Aging facilities & long run lengths

Along with an aging population, we also have aging facilities, especially in the United States. The last new refinery in the United States was built in 1976. Most refineries in the United States are now over 40 years old and still rely on much of the original equipment.

This is significant because the frequency of equipment failure increases rapidly as the equipment approaches end of design life. In addition to this, run lengths have increased. Campaigns of three or four years used to be the norm for FCC units. Today 5, 6 and even 7 year campaigns are common. The increased maintenance intervals deprive equipment of routine maintenance. This increases the probability that a critical piece of equipment will come down suddenly.

Increased complexity and automation

Modern refineries are very complex, requiring a high level of expertise for proper operation. Examples in the FCC unit include:

- Highly integrated heat exchanger systems for increased efficiency
- Highly efficient rotating equipment such as axial main air blowers and power recovery expanders
- High speed slide valve actuators
- Environmental pressure to control stack emissions during normal operations as well as during startups and shutdowns
- Environmental pressure to startup the unit without excessive flaring

Refineries are also becoming increasingly automated. Examples in the FCC unit include:

- Intergrated process control and antisurge systems for the main air blower and wet gas compressor
- Emergency interlock systems, which safely shut down the reactor-regenerator system during common abnormal events
- Advanced process control systems, which relieves the operations worker of routine process control duties. Ironically, these very systems, which are designed to increase the profitably of the unit, deprives the operations worker of the learning associated with responding to routine emergencies.

These advances in automation coupled with complications associated with thermal cycles and the high cost of turnarounds has pushed refiners to run their FCC units continuously for 5 to 7 years. During these long campaigns, operations personnel do not experience shutdowns and startups. The operations personnel are therefore deprived of the learning garnered during the period of operation which is most challenging, and when incidents often occur.

Limits of traditional training

A report by the Abnormal Situations Management Consortium found that concerns over current training practices are ubiquitous among plant personnel. Some key findings regarding current training practices are:

- Emphasis on informal “hands-on” and “on-the-job” apprenticeship training
- Strong initial training for field operators, moderate training for console operators, and weak training for all other operations personnel
- Difficult organizational obstacles to effective training execution or on-the-job learning

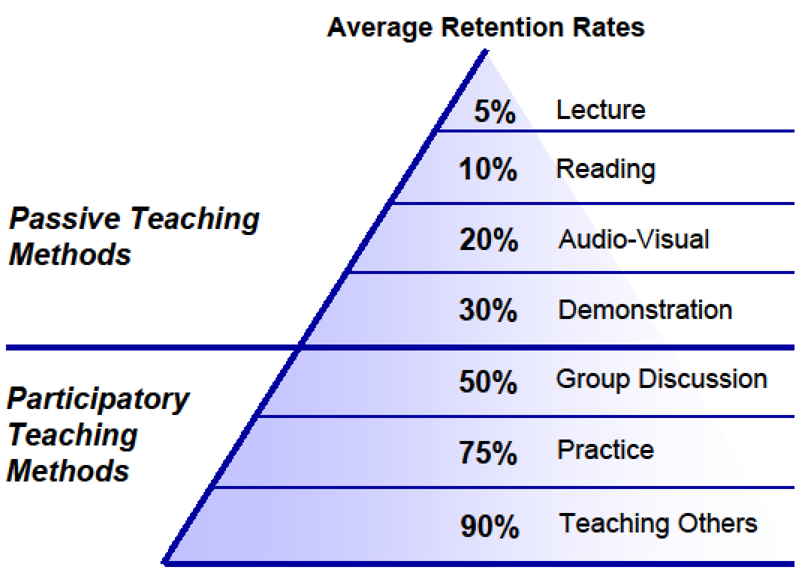
Traditionally within the refining industry, field operator training occurs on the job using the journeyman-apprentice system. This system is still in wide-spread use today and is very effective, with an emphasis on "hands-on" training. It's an excellent system for teaching remedial tasks such as turning valves, starting spare pumps and collecting samples. However, the quality of the training depends on the expertise and mentoring skills of the journeyman. Both the good and the bad habits of the journeyman can be passed on to the apprentice.

The journeyman-apprenticeship system is less effective at teaching console operators complex tasks such as responding to a wet gas compressor failure or responding to a sudden change in feed quality. This is because it takes a long time to encounter abnormal situations, most of which occur infrequently. The journeyman-apprentice system is also less effective at teaching console operators how to safely start up or shut down the plant, which also occur infrequently. The challenge is to regularly train the operations personnel on probable, yet infrequently encountered operating scenarios so they act instinctively.

KNOWLEDGE, SKILLS AND BEHAVIORS

The adage 'practice makes perfect' is important to remember when designing training programs for new personnel. Studies of various types of teaching methods confirm this as described in the National Training Laboratories learning pyramid shown in Figure 2.

Figure 2:
Effective Teaching Methods



*** Adapted from National Training Laboratories, Bethel, Maine**

Participatory teaching methods like practice and group discussions are much more effective than passive teaching methods such as classroom lectures or reading. By far, the best way for an operator to learn critical skills would be to start up, shut down or handle emergencies on an operating unit, and then teach others the intracacies of the procedures and the necessary responses to upset conditions. Such an experience should result in 75+ % retention of key skills. However, it is difficult to practice responding to situations which occur infrequently, and when they do occur, are handled by more experienced personnel. Given the inability of personnel to practice dealing with emergency situations on an operating unit, there needs to be a way for personnel to develop their skills outside of the operating control room.

There are three key parts to competency development that play equally large roles in developing skilled operations personnel. These elements are knowledge, skill and behaviors. Knowledge serves as the foundation on which skills and behaviors are built.

Knowledge development refers to the acquisition of facts about the plant and its operation. Examples of facts include process chemistry, process variables, control schemes, cause and effect diagrams, operator responsibilities, and operating goals under normal and abnormal situations. Knowledge development does involve some theoretical learning, and is essential for all levels of operations personnel in order to further develop skills and behaviors.

Skill development refers to mastering the ability to respond in an automated manner to shifting plant conditions. Operations personnel often have only several seconds to a few minutes in which to react and in many cases do not have time to refer to operating manuals for what steps to take. In many refineries the turnover of operations personnel, particularly unit engineers, is extremely high and it is not uncommon to have a unit engineer which has never actually been part of a unit shutdown or restart.

Behavior development is more intangible, but refers to the motivation, role expectations and values instilled in the person. For example, corporate culture, safety practices and performance incentives can all be used to drive behavior development.

Over the years UOP technical experts have been involved in hundreds of troubleshooting investigations and have experieced dozens of refinery operation philosophies. One key observation is that the refiners with the best on-stream availability all share some common characteristics. They have an intense focus on safety, there is a commitment to maintenance, which is driven by the needs of the operations personnel, and when incidents occur, there is a culture of collaboration. These are all examples where the behavior of the operations personnel has been directly influenced by management.

This combination of knowledge, skills and behaviors is needed to ensure optimum workforce performance.

KNOWLEDGE TRANSFER

TRADITIONAL KNOWLEDGE TRANSFER

UOP has been developing and supplying technology to the refining and petrochemical industry since 1914. The traditional process for transferring this knowledge from UOP to the refiner is as follows:

Basic Engineering

Basic engineering packages contain specifications for all equipment, piping and control schemes. This package on its own is detailed enough for a contractor to develop a detailed engineering package. The basic engineering package is generated by process design, mechanical design and control systems engineers and is a key component of knowledge transfer.

Due to the critical nature of certain equipment, UOP also provides engineering support to review the detailed design and ensure that all specifications have been understood and adhered to.

In the case of an FCC unit, the catalyst and additive specifications are also reviewed by a process specialist to ensure they match the basis of the original design.

As part of the basic engineering package a general operating manual is also provided which includes the basics of the technology, along with generic operating and emergency procedures.

Classroom Training

As part of a new unit startup, UOP has traditionally offered an instructor led technology training course for the refinery's personnel. The format of this training consists of classroom presentations, general discussion, and question and answer periods. Training is focused on process fundamentals and operating procedures. In addition to refinery specific training, UOP provides a yearly calendar of instructor led process technology and engineering courses open to all technology users.

Commissioning Support

The degree of commissioning support varies among technology suppliers. UOP standard commissioning support consists of equipment and piping and instrument checkout to ensure that the unit has been built in accordance with the basic engineering package. One of the key methods of knowledge transfer occurs during commissioning through the daily interaction between the refinery's operations personnel and the UOP operations specialists. This provides the valuable component of "on-the job" training.

Enhanced Knowledge Transfer

With the influx of new operations personnel the traditional methods of knowledge transfer may not be sufficient for bringing refinery staff up to speed given today's complex technologies. Refining organizations can no longer rely on seasoned employees only requiring an incremental increase in their knowledge base to effectively run a new process unit. In order to bridge the growing gap in overall operations knowledge additional tools are required. These tools can provide enhanced knowledge transfer across the plant life cycle and can help reduce the number of errors and improve responses to incidents.

Technical Support

The basic engineering support described above is still critical, but it can be enhanced to further support the design and commissioning of the unit. Examples of where enhanced support can be provided include

- Mechanical expert participation in 3D CAD model review
- Process expert participation in HAZOP review
- Detailed startup/shutdown/emergency procedures based on as-built P&ID's

Training & Advanced Tools

Instructor led training still forms the fundamental building block of an enhanced knowledge transfer program, but it can be improved over basic training by focusing more on the areas of troubleshooting, startup, shutdown, and emergency procedures. Additional courses such as advanced process techology, advanced skill engineering (e.g. rotating equipment, fired heaters, energy management), and process engineering design seminar can be used to increase the overall skill level of on-site personnel and help refinery staff in dealing with operations and maintenance issues.

In addition to instructor-led training, advanced tools now available for refiners include:

- High fidelity training simulators that provide simulated experience starting up, shutting down and handling emergencies on the unit
- Decision tree based troubleshooting tools that help diagnose the root cause of unit upsets
- Web based training, which is a cost effective, flexible tool to teach process fundamentals to a large group of people and ensure all employees are speaking the same technical language
- Operations monitoring tools to facilitate data handling, standardize unit calculations and provide a remote link to the technology suppliers' experts

21ST CENTURY TOOLS

Some of the UOP training tools that are currently available are highlighted in Table 1. While they are available as stand alone tools, it is the combination of these tools, at the right time in the technology transfer process that allows for the successful merging of knowledge, skills and behaviors.

Table 1:
UOP Training Tools

	Knowledge	*Skills*	*Behaviors*
Classroom training	x	x	x
Web Based training	x		
UOP training simulators		x	
HPS custom simulators		x	
Expert systems troubleshooting	x	x	
Residency Programs	x	x	x
Start-up support	x	x	x

Classroom Training

Classroom training combines knowledge, skills and behavior development, using traditional lectures, Q&A, case studies and process simulation. Courses are developed and presented by technical experts utilizing adult learning methodologies. Topics include process fundamentals for technology courses and advanced operations and troubleshooting as well as engineering disciplines. A key training course to fully develop engineering skills would be the 40 day engineering design seminar. This type of course can quickly bridge the gap between university learning and key skills required as a refinery engineer. It teaches the basic engineering design skills to perform key calculations and evaluations. Classroom training utilizing technical experts as trainers is a key part of an effective training program due to the high degree of interaction between students and instructors. It is also customizable to the required skill level.

Web Based Training

Web based training has proven a cost effective flexible training tool that allows a large group of personnel to gain the process technology basics at their own pace and without time away from the office. It is important for operations personnel as well as management to have basic technology knowledge. By incorporating interactive, high quality graphics & animations, as well as quizzes and learning assessments, retention is improved compared to simply reading a book, or listening to a lecture. Web based training is self-paced, and can be used for stand alone technology training, as pre-work for instructor led training, or refresher training. The key topics included in UOP's web based training are process overview, equipment, chemistry, catalyst, process variables, process flow and process control.

Expert Systems Troubleshooting Tool

Expert Systems is a computer based tool to troubleshoot operating issues. It was developed by UOP technical experts with years of operating knowledge and is based on decision tree diagnostics. This tool can be used as a training tool as well as a troubleshooting tool in case of an upset condition. Significant background and reference material is included, so that the user can gain a deeper understanding of the subject matter. The system provides rapid troubleshooting of operating problems, increased self-reliance and confidence of the user and helps prevent future operating problems.

An FCC example using Expert Systems is to help diagnose the cause of increased catalyst losses. There are many possible reasons for increased catalyst losses, so a decision tree approach can help close in on the most likely cause.

Expert Systems were originally developed as a troubleshooting and training tool for UOP's technology services groups and continues to be an important part of the UOP career development program.

Training Simulators

The use of training simulators enhances the effectiveness of a training program by giving participants an opportunity to apply knowledge and practice skills learned in the classroom. The "hands-on" experience provided by training simulators gives the participants an added level of confidence, security and knowledge to function competently during the actual pre-commissioning, startup, steady state operation, emergencies and long-term operation of the process unit. As a result of using the training simulator, operator skill levels can be dramatically improved. These improvements can be sustained when the training simulators are utilized as a core component of the refinery's in-house training management system. Training simulators are available based on the most common flow scheme of a process unit or can be customized to accurately reflect the refiner's exact configuration.

Built using the Honeywell UniSim® simulation platform, UOP Training Simulators are based on typical designs of UOP process technology. Unlike other training simulators, UOP embeds proprietary reactor models, operating philosophy and engineering expertise directly into the training simulator software. The simulators include realistic exercises that reproduce actual emergency situations and allows the operator to experience in a matter of weeks what would typically take years to expeience. An added feature of the UOP Training Simulators is the ability to score the responses of the operations personnel to upset conditions.

An FCC example of a preprogrammed response scenario is a change in feed quality due to a feed tank change. This type of change is something that the advanced process control system might not recognize, and it is up to the operator to recognize the change, and respond correctly by making appropriate adjustments to the unit operation. Scoring the scenario places emphasis on making the right changes at the right time.

Residency Programs

Many times there is a gap between what a refiner needs from their engineering personnel and the actual skill level and experience of a new graduate or early career engineer. In cases where there is a lack of in-house mentoring available, developing an effective training program for new or relocated personnel can be challenging. In these instances UOP offers refiners the opportunity to take part in a residency program. The UOP residency program is a long term training program which takes place alongside the UOP technical experts. This program offers multiple tracks of training, from engineering design, advanced skill engineering, and Technical Service, to Field Service training similar to the first two years of a UOP engineer's training. An engineer specializing in projects would focus on engineering design, and receive general engineering training and work with UOP engineers on new and revamp process unit designs. An engineer specializing in operations would focus on working with UOP Technical Service engineers on office based learning in conjunction with field troubleshooting, process optimization, data analysis, startup and turnaround activities.

The residency programs utilize a combination of the mentoring process, a team environment and continual feedback through assessments. The benefit of this program is that it is fast paced experiential knowledge transfer. The engineer is exposed to a large number of situations in a short amount of time.

Operations Monitoring Tools

On a day to day basis it is critical to transform data into actionable information. Improved data analysis will empower engineers to make better operating decisions. The collection and management of operations data can be cumbersome and tedious. Today, process engineers can spend more time gathering, organizing and processing data than they do determining how to best optimize operations. Advanced operations monitoring tools take on the data manipulation task and perform advanced calculations to help make better operating decisions and offer significant productivity gains. Linking this with direct access to the technology supplier allows for instant data evaluation in cases of plant upset or declining performance.

The UOP OpAware™ Operations Monitoring Tool has been designed to specifically address the data evaluation challenge. It involves secure remote data acquisition which is then reconciled and mass balanced using UOP proprietary calculations. The results are compiled in standard outputs and reports and can be compared against key performance metrics. Daily data updates and online access ensures that all personnel are using the same data at the same time. Simultaneous data sharing with UOP maximizes the possible support.

Combination of Tools

While each tool has powerful knowledge transfer capabilities, it is the combination of tools and training that can help overcome the workforce challenges of a modern refinery. Table 2 shows the recommended tools at each stage of the plant life cycle from process design, through construction & commissioning and on through continuing operations.

Table 2:
Complete Training Solution

	Design (-3 yr to -1.5 yr)	Construction/ Commissioning (-1.5 yr to 0)	Operations (0 to Ongoing)
Engineers			
Skills to gain	• Design engineering skills • Start-up and troubleshooting expertise	• Detailed understanding of procedures and technology	• Troubleshooting expertise • Refresher or new technology • Skilled in engineering, troubleshooting and operations
Tools	• Engineering & Tech Service Residency Programs	• Classroom training with Web based training • UOP Training Simulator • Field Residency Program	• Residency program • Classroom training • Web Based training • Expert Systems • UOP Training Simulators • Engineering Design Seminar
Operators			
Skills to gain	• Experience in operations and upset scenarios	• Skill development of operations before start-up	• New operator competency • Refresher assessments
Tools	• UOP Training Simulators	• UOP training simulator • HPS custom training simulator	• UOP Training simulator • HPS custom training simulator
All			
Skills to gain	• Understanding of technology basics	• Understanding of technology basics	• Understanding of technology basics
Tools	• Web Based Training	• Web Based Training	• Web Based Training

SUMMARY

There is a growing competency gap in the refining industry which may have an impact on the safety, reliability and profitability of critical process plants. The competenecy gap will likely persist as retirements and global growth continue.

UOP is in a unique position to aid in closing the competency gap using state of the art tools to transfer our knowledge to the refining industry. By combining the expert skills from engineering, research, operations and process optimization, the refiner can be assured of receiving the most effective training programs using proven adult learning methodologies. Incorporating modern training programs into the refiner's training management system will improve the operators' and engineers' ability to respond to upset conditions and quickly resolve issues that may arise.

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