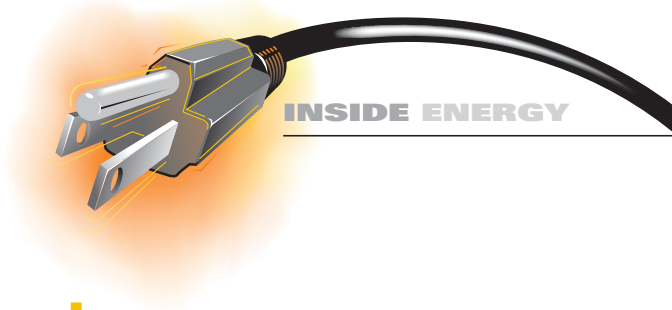


Refinery Expertise Preservation

New technologies and processes are pivotal in bridging the knowledge gap between this generation of workers and the next for many companies in the refining industries.

Some skeptics have expressed doubt about the reality of the problem refiners face in an aging workforce. But industry leading operating companies, think tanks, and government groups are increasingly recognizing that after decades of turmoil (over the past 20 years, the industry has lost a half-million workers to layoffs and mergers) there is a serious shortage of qualified and knowledgeable personnel ranging in age from 30 to 50 years.

In the oil-and-gas industry alone, the average age of the domestic worker is 50, and according to the *Journal of Petroleum Technology*, 60% of plant engineers will retire by 2010. And younger workers previously relied upon to take the reins are becoming alarmingly scarce.

With the negative image fostered by layoffs and downturns, the industry is experiencing a persistent shortage of new graduates combining strong technical abilities with "soft skills," such as communications, teamwork, and management. Only 5% of U.S. undergraduates earn engineering degrees, compared with 20% in Japan, Germany, Korea, and France, and 45% in China.

Changing roles

Beyond the challenge of retaining and recruiting employees, refiners must also equip current employees to adopt new roles and levels of responsibility. Like the rest of the world, the refining industry is entering a new economy with new competitive standards. Traditionally, refining companies competed primarily on productivity and price. A new economy, however, requires additional competitive standards: quality, variety, customization, convenience, and timeliness.

In response, traditional roles of people responsible for operating the refinery have changed, and become much broader. New refinery workers have increased responsibilities and skill requirements that are not necessarily job-specific—they are both more competitive and more technically sophisticated, and have the ability to impact the bottom line directly by their actions.

Refiners fight to retain expertise

Many industry-leading companies are implementing programs to recruit and transfer knowledge to a new generation of workers:

- ChevronTexaco currently has a task force studying the problem and looking for ways to increase knowledge sharing, recruit young college graduates, and retain critical talent.
- PetroCanada has begun to investigate strategies to give older workers more incentive to stay on for a few extra years or return part-time after retirement.
- Shell has announced plans to recruit and hire more than 1,000 new engineers and scientists by the end of 2006.

In addition, Marathon Oil, Sun, and Amerada Hess, among others, have publicly acknowledged the issue, and are taking steps to address it.

According to BP's general manager of public affairs, Hugh Depland, "This has been an issue BP is following and it has been a concern to us. We're concerned that as our workforce ages, we need to be able to replace these people."

AT A GLANCE

- U.S. engineer shortage
- Less petro-chem interest
- New engineering roles
- Software captures knowledge

Crude switch operations

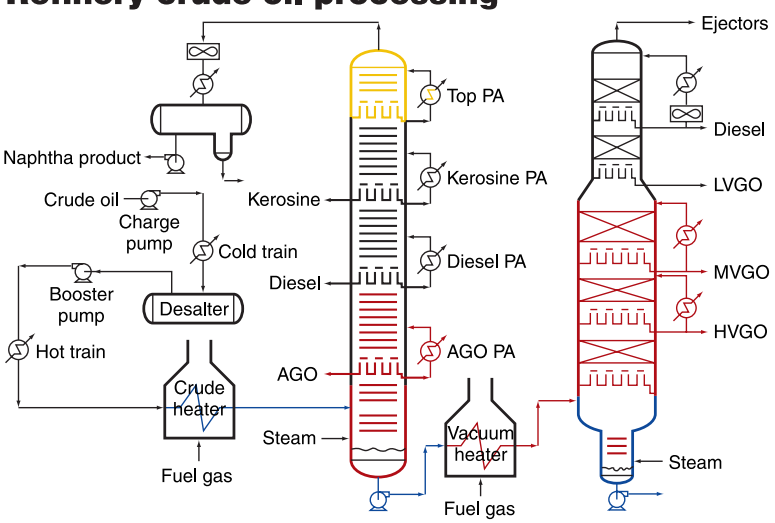
	Time to complete Percent of total
Review procedures	3%
Make necessary lineup changes	5%
Bring desalter to specs	5%
Rebalance preheat train exchangers	10%
Change firing rate on atmospheric tower furnace	5%
Rebalance pumparound flows/heat balance √ Begin at bottom pumparound and work way up tower	15%
Rebalance overheard heat balance √ Check all sidestream products online quality specs √ Confirm quality specs with lab	10%
Advise downstream unit supervisors/operator of progress	2%
Rebalance ejectors (vacuum) for new heat balance	5%
Repeat for vacuum tower	40%

This checklist defines the steps an operator should follow in the crude change procedure.

Research performed by the Abnormal Situation Management Consortium (a research and development consortium of 11 companies and universities concerned about the negative effects of industrial plant incidents; www.asm-consortium.com) found that 42% of abnormal situations studied among member companies could be attributed to people and work context factors. The greatest contributors to this figure were inadequate or missing procedures, inadequate or incorrect actions, or failure to follow instructions or proper procedures. According to ASM, these unexpected disruptions are thought to cost 3-8% of capacity, and $10 billion in annual lost production in the U.S. petrochemical industry alone.

Detailed view of the atmospheric distillation and vacuum distillation units affected during the crude change procedure.

Refinery crude oil processing



Drilling into technology

For nearly 30 years, distributed control systems (DCS) systems have provided the framework for managing plant processes. A drawback of these traditional systems is that much of the knowledge about the system's operation—critical process parameters, symptom/fault information, and maintenance schedules—doesn't reside within the system itself, but in the minds, notebooks, and files of the facility's operators, technicians, and engineers. When these people leave an organization, much of the knowledge leaves with them. Newer technology provides ways to systematically capture process knowledge in a useful, accessible format.

Let's look at a real-world example of how technology might impact a typical refinery operation, like switching feed to the crude unit.

In the case of a crude change, the operations personnel on duty at the console would drill down through the displays to focus on the operating areas where the crude change physically takes place, in this case the atmospheric distillation and vacuum distillation units.

Drilling down into the graphic, the operator sees a detailed look at the units affected during the crude change procedure (see "Refinery crude oil processing" graphic). The crude switch operations procedure is embedded in the system and is automatically displayed on the console, as part of the automated process operations system (see "Crude switch operations" graphic).

The checklist defines the steps in the crude change procedure and gives the operator the ability to drill down into each task for more detailed procedures and recommendations. For example, PA (pump around) can be a challenge during manual switch over, so the console operator may drill further into the steps listed to be certain the steps are communicated to the field resources, and followed correctly.

In this basic example, the process knowledge embedded in the automation system enables operations staff to better communicate with the field and coordinate the procedures more precisely with each resource involved. It also provides access to knowledge and experience in well-documented and accessible procedures associated with current plant operations.

And in the event of trouble, the system has embedded procedures to help operations resources deal with unexpected problems safely and quickly (see "Crude switch common problems" graphic). As the crude change procedure is implemented, the system displays a quick reference list of problems common to this type of procedure, again with ability to drill down into

each for suggested actions to be taken.

By capturing safe operating procedures and experiences of similar operating conditions (historically contained primarily in the minds of more experienced workers), the system effectively augments tools available to operators, allowing them to focus on tasks at hand in a safe, reliable, and consistent manner.

Crude switch common problems

Common processing problems

- High crude-side pressure drop
- Desalter upsets and poor desalting
- Rapid crude column condenser corrosion
- Crude column naphtha-jet fuel section fouling
- Low diesel product yield
- Vacuum heater coking
- Vacuum column fouling (top section)
- High vacuum column operating pressure
- Low heavy gas oil product draw temperature
- Low heavy gas oil product yield
- High metals feed to the cat feed hydrotreater
- General corrosion problems

Operating changes to process difficult crudes

Variable	Atmospheric tower	Vacuum tower
Temperature	Higher	Higher
Pressure	Lower	Lower
Flash-zone oil partial pressure	Lower	Lower
Residue stripping efficiency	Higher	Higher

Embedded procedures help operations resources deal with unexpected problems safely and quickly.

Information flow

As the aging workforce retires, solutions that embody knowledge capture and sharing provide means to retain learned information, so that the next generation of workers does not live in a "trial-by-fire" environment.

Therefore, leading companies in all industries are turning to knowledge management applications built on platforms that support email systems, Web portals, and interactive workspaces to rescue expertise from retiring workers.

The evolving role of technology in the refinery does not necessarily mean a reduction in human involvement. Instead, the increased complexity in work calls for a proportionate increase in the quality of technical and human components.

Many refiners are achieving improved results by significantly increasing the number and quality of the mental "tools" available to operators, along with concentrated training on effective tool use. When dealing with huge volumes of data, it becomes more important to weed out extraneous noise and focus intently on critical information. Adding ability to embed work practices and procedures in the way operators perform their jobs day-to-day can greatly improve ability of less experienced operators to respond appropriately—in normal operations or during an unexpected incident. **ce**

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How Honeywell retains knowledge

Honeywell is well known in the process industries as both an operating company and supplier of technology solutions. With over 100,000 people in 95 countries, Honeywell also faces significant challenges resulting from an aging workforce.

To address this issue, Honeywell has implemented knowledge management and organizational learning processes throughout the company's divisions and business units aimed at identifying, capturing, and effectively transferring critical knowledge and skills.

One such program, known as the Knowledge Retention process, uses Six Sigma Plus tools to establish a repeatable, sustainable method for assessing the risk of critical knowledge deficiency and transferring that knowledge that would otherwise be lost through attrition. The Knowledge Retention process provides guidance in:

- Determining critical areas for knowledge retention;
- Identifying specific areas of concern by function/job classification;
- Developing plans to retain knowledge from the experienced workforce; and
- Proactively addressing workforce continuity by institutionalizing processes ensuring both ongoing continuity and knowledge retention of workforce.

Provided as a prototype, the process is flexible enough to be adapted for specific business needs in different areas of the company.