PlantMentor®

Advanced On-line Training and Certification for Technical Personnel

TABLE OF CONTENTS

FIGURES AND TABLES

EXPERIENCE IS A VERY PAINFUL WAY TO LEARN

Time and time again, petroleum refiners, petrochemical plants, and chemical plants have to relearn the lessons of the past through unit upsets, incidents, unplanned outages, and low production rates. Collectively, they have spent billions of dollars implementing advanced process control systems designed to reduce or eliminate the often devastating effects of these events. With each new technology implemented, the operational personnel – holding the "keys" to the unit, get further away from the "steering wheel."

Historically, process plants were run from large control rooms with hundreds of controls and analog gauges installed over a process map that was drawn or painted onto a wall. Controls and instrument repeaters appeared in the same positions relative to their actual positions in the field. The configuration enabled operations personnel to develop a deep understanding of the unit because they could:

- See most, if not all, of the unit in one view.
- See the impact of each control move or parameter change as it worked its way through the unit over time. If a temperature, pressure, or composition changed in one area of the unit, then personnel could quickly determine what other parameters were impacted and at what rate. The use of analog gauges facilitated easy understanding of the rate of change as well as the direction and magnitude.
- Easily gather around the process map in small or large groups to brainstorm control moves or troubleshoot off-specification situations.
- Readily train new personnel using the process map to develop a common mental model of the unit and its operation. New personnel, who would already be experienced in field operations, could easily relate what they were seeing in the control room to the actual unit.

The advent of distributed control systems (DCS) brought a new and unparalleled level of precision that enabled operations personnel to control process parameters to a far more granular level. The promise of DCS systems was automated process control, conducted to a far finer degree than humanly possible, with the control system recognizing and responding to impending adverse situations faster and more reliably than human operators could. With these advanced DCS systems, operations personnel can view, examine, control, and record each unit parameter and can quickly determine the status of simple systems from a single screen, but it is impossible to view the entire unit at once and the DCS system controls almost the entire operation of the unit. The deep understanding operations personnel gained by gathering in the control room around the process map and sharing knowledge and perspective was eventually lost over time.

While operations can now run process units longer and harder than ever before, they are now run closer to the boundaries of their operational envelope. As such, the impact of this "knowledge leakage" has manifested itself since the early 1990's through increasing numbers of unit upsets, incidents, reduced production, and unfortunate accidents. While reduced production results in internal repercussions such as lost revenue opportunities or increased costs, upsets, incidents, and accidents often result in unplanned shutdowns, environmental releases, damaged equipment, adverse media attention, or worse … Operations personnel, learning only from experience, tend to interpret their limited view of the unit incorrectly and make flawed troubleshooting or operational decisions when the control system encounters scenarios that are not programmed and when equipment or instruments fail. Sometimes they can relate an existing set of parameters they are seeing on their DCS screen to a previously experienced or similar scenario, but sometimes that cannot. Additionally, scenarios that manifest themselves with similar symptoms often have radically different root causes.

Simply put – Experience is a very painful way to learn.

The question unit Managers should ask is "How can I help my operations personnel regain the depth of knowledge they once had so they can troubleshoot and make operational decisions better?" The answer is "Deploy PlantMentor®"

PLANTMENTOR® PHILOSOPHY AND DESIGN

BUILDING OPERATOR COMPETENCY

Since its inception in 1988, RWD Technologies has accumulated hundreds of person-years of experience in process unit operations. During this time, RWD interacted extensively with all levels of unit operations personnel and has created and validated the model of operational performance competence depicted in Figure 0-1.

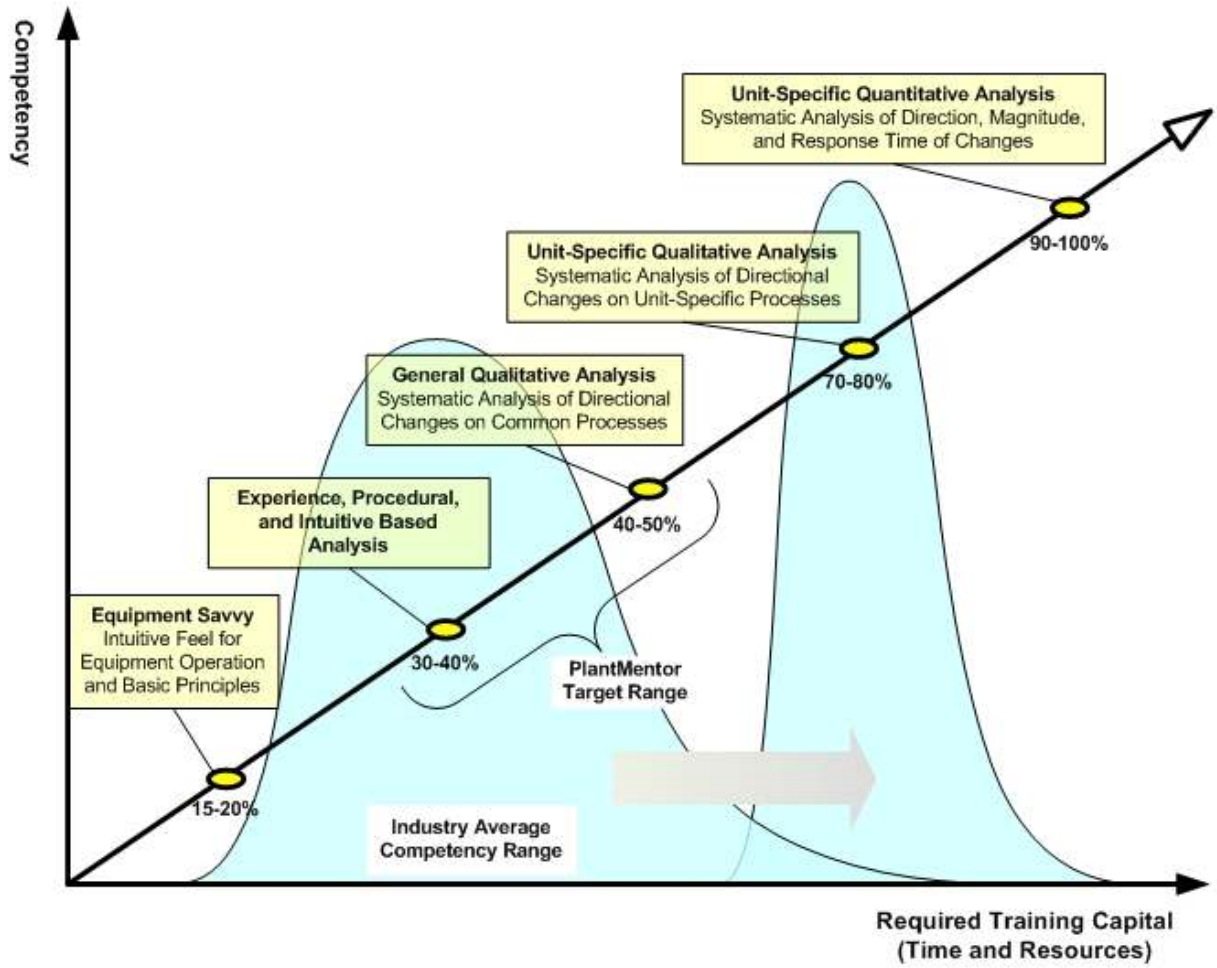

Figure 0-1: Operational Performance Competence

The model depicted in Figure 0-1 illustrates a five-level continuum of operational performance competence. At the left end of the continuum, operations personnel typically have only a basic understanding of unit operations that focuses on equipment operation.

Over time, they gain experience on the unit and progress to a stage where they become comfortable using a combination of physical tools (procedures, P&IDs, PFDs, etc.), their experience, and intuition to control unit operations. Many operations personnel stagnate at this level of competence.

Some highly motivated, skilled personnel continue to the third stage of the competency continuum. In this stage, they begin to develop an understanding of parameter relationships and qualitative analysis for common processes, such as distillation. It is at this stage that the personnel can answer questions such as "If the bottoms temperature increases, then the impact throughout the column will be ___."

Only the most advanced personnel continue to the fourth and fifth stages of the continuum. In the fourth stage, personnel develop the ability to systematically "stitch together" multiple processes and qualitatively analyze an entire process unit. Finally, in the final stage, personnel add the ability to systematically analyze the unit with both magnitude and rate of change for their specific unit and its unique operating envelope.

The studies conducted by RWD[1] indicate that the average competency level of the process operator population is around 30 percent of the maximum attainable (Stage 2 in the model) and that it generally takes over 10 years before operator competency reaches 70 percent (Stage 4 of the model), if at all. Further, process engineers take over 1.5 years to become sufficiently competent that their true value is realized. This, combined with high attrition rated for highly experienced operations personnel, makes it difficult for petroleum and chemical companies to achieve operational goals. It is apparent that a faster and more innovative approach to developing operational competency is needed to improve the rate of competency attainment from years to months.

A Better Way to Learn

To address the shortcomings in process unit operational competency, RWD combined its domain experience in the process industries with its deep understanding of the factors impacting human performance in high-technology settings and state-of-the-art instructional interventions to create the PlantMentor® suite of courseware.

From an instructional perspective, RWD looked outside process industries to a completely unrelated field – the medical profession. In examining how new doctors developed their competency, RWD uncovered a "simple to complex" learning model of instruction that relied on four key factors:

- Individuals undergoing training to become doctors must complete a rigorous curriculum in medical school during which they learn all about the human body and all of its components. They learn about various organs and systems, including muscular-skeletal, circulatory, respiratory, etc.

- They also to think systematically about various illnesses in injuries, to observe carefully, and to not overlook even the seemingly most trivial symptom. This rigorous focus on identifying symptoms and the process of diagnosis is critical.

[1] RWD tested over 450 incumbent Console Operators and Console Operator Candidates across more than 10 refineries for competency in troubleshooting and advanced unit analysis. Test results clearly indicated a strong clustering of competency around experience, procedural, and intuitive-based analysis with few "star performers" demonstrating competency at the General Qualitative Analysis level.

- In conjunction with medical school, doctor candidates undergo an extensive period of training as interns. During this phase of their training, doctors in training apply their new knowledge of the human body to the real world. The common model is for a number of interns to be assigned to a highly-qualified doctor where they accompany the doctor in treating patients. There are two very important concepts in this phase of training:

  - The interns are afforded the opportunity to see many patients from all parts of the demographic spectrum and to see how various diseases and injuries manifest themselves in individuals from a wide variety of racial, socioeconomic, age, and other demographic backgrounds.

  - The interns are instructed using a Socratic, or question-dialog, learning model. In this model, the instructor doctor might ask a question of the interns like "So Mr. Jones has kidney stones. Drawing on your medical school studies, how would you expect his kidney stone issue to be manifested – what symptoms would you expect to see?" They would be expected to apply their knowledge of the human body and its organs and systems and determine what symptoms *should* be present. As a group, they receive input and feedback from each other, the question-dialog process reinforces correct responses and ensures proper analysis, and they develop a deeper understanding of each symptom and how and why it is present. Basically, the interns are exercising their new ability to diagnose various illnesses by answering the instructor doctor's question in a systematic way: "Well, with kidney stones, Mr. Jones should have an elevated temperature, severe abdominal pain, etc." They then look to see whether or not all of the symptoms are present.

- The final phase of training takes the third phase and flips it around. As residents, doctors apply their knowledge and systems thinking by looking for symptoms in patients and diagnosing the underlying illnesses or injuries. In this process, residents examine and interview patients to determine their symptoms, and they order various tests to uncover symptoms that may not be apparent at first glance. When they develop a full picture of the symptoms, the residents then work through a process of mental simulation. They quickly discard diseases and injuries that obviously do not apply and then begin working through a decision tree analysis process: "I see the following symptoms: XXX, YYY, and ZZZ. Hmm, it's possible that Mr. Jones has a kidney stone issue. If it were a gallbladder issue, I would expect to see the following set of symptoms…." The resident then confirms that the symptoms are present and, if necessary, orders additional tests to confirm the hypothesis. If some of the symptoms are not present, then the resident defaults back to the hypothesis stage, formulating a new hypothesis as to the root cause and determining whether or not the expected symptoms are present. This emphasis on rigorous and methodical diagnosis ensures that all symptoms are examined and "accounted for" and dramatically improves the quality of the diagnosis.

RWD's examination of the method by which new doctors are trained fit the process industries exactly as well. Application of a similar process could significantly improve the ability of process operators to troubleshoot their units, to improve production, and to enhance operational performance. Based on this research and thinking, RWD developed an instructional model for operations personnel that emphasized:

- Teaching personnel systematically about their units and the means by which the units are controlled.
- Applying a streamlined, yet rigorous and repeatable troubleshooting methodology.
- Developing competency through a questioning-dialog process – emphasizing "what-if" thinking to deepen individual and collective understanding of all aspects of the operation.
- Applying the newly gained competency by exercising it through complex problem solving and feedback.

PLANTMENTOR® DESIGN BASIS

PlantMentor® is the registered brand name for a suite of hosted, Web-based eLearning courses that support advanced training and certification of operations personnel and engineers at petroleum refineries, petrochemical plants, and chemical facilities. Interactive learning and exercises employed in the PlantMentor® approach make the courses powerful "hands on" training tools that enable skill building, accelerated competency, and mastery of complex technical knowledge and decision-making capabilities.

The instructional approach described in the previous section is intended to guide students along a competency path that significantly improves their knowledge of a process unit. At the same time, students learn the troubleshooting / analysis approach to which they will apply their new knowledge. This approach, depicted in Figure 0-2, is conceptually similar to the process that doctors employ to diagnose their patients.

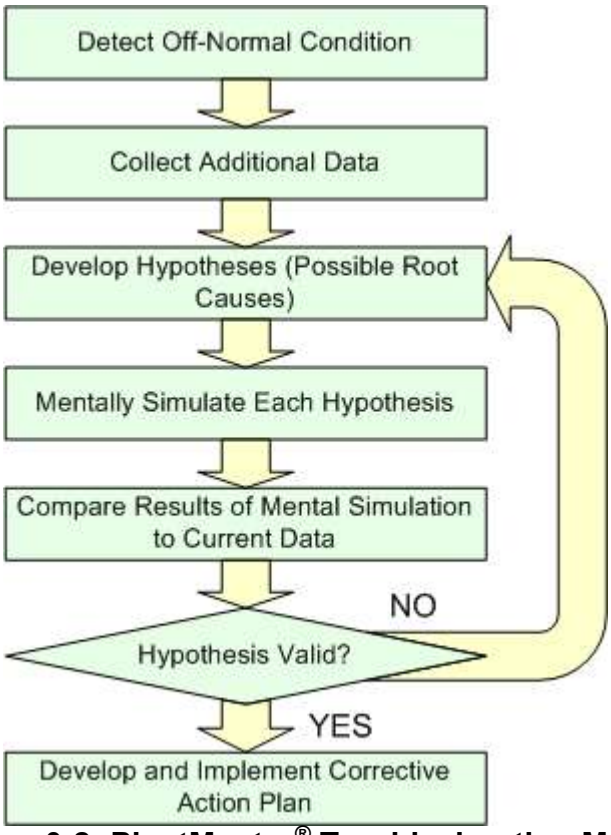

Figure 0-2: PlantMentor® Troubleshooting Model

The PlantMentor® offering utilizes a building-block approach that guides operations personnel and engineers through a progression of learning events designed to develop within them a level of unit competency that has never before been consistently achieved. The offering, which also supports continuous lifelong learning, builds on the instructional model described previously to develop within operations personnel a standardized approach to troubleshooting / unit optimization based on a common, shared understanding of the unit and how it operates — a simple concept that rarely exists prior to a PlantMentor® implementation. PlantMentor® represents a quantum improvement in process unit operational training because it leverages technology to deliver superior training at lower cost.

As Figure 0-3 illustrates, each five-module course guides students through progressively more difficult concepts, with the final module focusing on troubleshooting and optimization problems. To complete each module, students must pass an assessment before proceeding to the next module. Module 4 and Module 5 of each course contain complex exercises designed to exercise and reinforce the previously-learned knowledge and systems thinking.

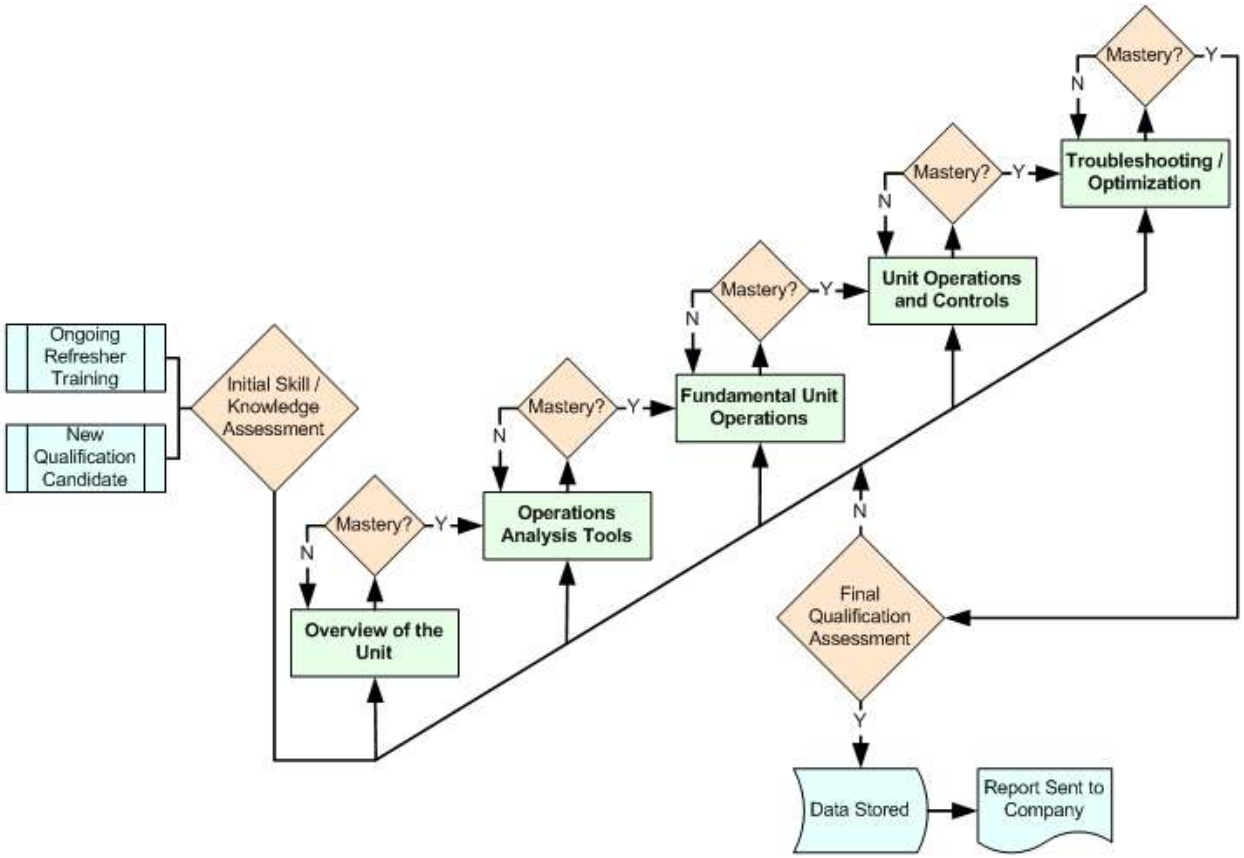

Figure 0-3: PlantMentor® Course Design

Let there be no doubt – PlantMentor® courses are extremely challenging. But students also find the courses to be very valuable because the courses address a deeper level of understanding and competency that has been lost over time. Courses often take 40 hours to complete and require students to think logically and to reason their way through problem scenarios instead of relying on experience-based knowledge.

In creating the PlantMentor® courseware, RWD also considered how the courses should be delivered. The modular nature of the courses, and the time required to complete them, suggested that a self-paced eLearning delivery strategy would be most applicable. With the delivery decision made, RWD then considered the broader eLearning industry and determined that the courses should conform to the eLearning requirements specified by the SCORM standard.[2]

[2] SCORM, or Shareable Content Object Reference Model refers to the Advanced Distributed Learning's (ADL's) standard for eLearning content and Learning Management Systems (LMS). Conformance to the standard ensures that the courses are "portable" and can be installed, launched, and tracked using any LMS that conforms to the SCORM standard.

PLANTMENTOR® COURSES

The petroleum-chemical curriculum includes the following PlantMentor® courses:

- RWD Amine Loops
- RWD Crude Unit Distillation
- RWD Delayed Coking
- RWD FCCU Main Column
- RWD FCCU Reactor-Regenerator
- RWD Gas Plant Absorbers and Strippers
- RWD Hydrogen Reforming
- RWD Hydrotreating
- RWD Isomerization
- RWD Light Ends Distillation
- RWD Semi-Regen Reforming
- RWD Sulfur Recovery Unit
- RWD Sulfuric Acid Alkylation
- RWD Tail Gas Unit

PLANTMENTOR® BENEFITS

TRAINING PERSPECTIVE

PlantMentor® was designed to accelerate time-to-competency and to raise the overall level of competency for plant operations personnel and engineers. When used as part of a broad-based operator certification program, PlantMentor® courses can also be used to bridge the gap between training and on-the-job performance – providing the final step in the training where everything comes together and individuals become fully proficient in their job roles. With these goals in mind, the following training benefits quickly become apparent:

- PlantMentor® reduces training time and cost – by augmenting and accelerating your existing approach to training.
- PlantMentor® reduces time-to-competency; i.e., shortens the time to achieve on-the-job effectiveness.
- PlantMentor® improves training productivity – by taking advantage of "free time," whenever that occurs at any time of the day or night, and by effectively supplementing and eliminating the constraints associated with "classroom session time."
- PlantMentor® affords students the convenience and practicality of being able to progress through the courses at their own pace and when they are available – 24 hours per day, 7 days per week.
- PlantMentor® creates better learning through structured interactive learning and exercises specifically targeted for operators and engineers.
- PlantMentor® relies on rigorous instructional design, with clear, measurable learning objectives and embedded knowledge checks to give the learner constant feedback.
- PlantMentor® contains extremely effective and highly technical training content – even the most competent incumbents will gain additional proficiency from exposure to this unique training experience.

BUSINESS PERSPECTIVE

Perhaps more important than its value in training, PlantMentor® represents a sound financial investment as well. While some of the business benefits have not been quantified, the results from an analysis by the Glomark Corporation suggest that the quantifiable business benefits are quite compelling.

Glomark Corporation Business Analysis Results

Table 0-1 presents an expected value analysis for implementing PlantMentor® for two FCCU's at a refinery site in the Midwest region of the United States. The analysis was prepared by Glomark Corporation and is based on data obtained from experts at this site.[3]

As is evident from the results, the value proposition for investment in PlantMentor® is compelling, and PlantMentor® users should recover the investment cost quite rapidly.

Table 0-1: PlantMentor® Expected Value Analysis (6-Year Cumulative)

	Best Case	Likely Case	Worst Case
Simple ROI	3,147%	1,145%	127%
Payback	4 months	4 months	7 months
Added Value	$22,664,630	$6,184,467	$515,107
Risk of Not Making Investment	$6,044,400	$1,813,000	$113,333

The analysis provided in Table 0-1 was generated from value obtained from each category defined in Table 0-2. All of the results presented in Table 0-2 are based on a 6-year investment in PlantMentor®.

Table 0-2: PlantMentor® Business Benefits Summary (6-Year Cumulative)

Value Category	Best Case	Likely Case	Worst Case
Improved Process Efficiencies	$15,111,000	$6,044,400	$755,550
Improved Recovery Time	$13,248,000	$1,242,000	$41,400
Improved Training Productivity	$345,000	$129,375	$17,250
Reduced Environmental Incidents	$1,380,000	$690,000	$115,000
Reduced Process Downtime	$6,044,400	$1,813,000	$113,333
Reduce Process Engineering Cost	$1,769,000	$524,153	$65,519
Total	**$37,897,400**	**$10,447,928**	**$1,108,052**

[3] Glomark Corporation assists technology and service providers in implementing an economic value selling approach and also assists technology and service buyers in forecasting, comparing, and tracking the economic value of investments / projects.

Other Business Benefits

In addition to the compelling results uncovered by Glomark, there are many other business benefits as well. These include:

- PlantMentor® improves ROI by giving operations personnel and engineers better knowledge, skills, and decision-making tools to avoid problems and keep the unit at optimal performance.
- PlantMentor® requires only a minimal investment for training of this quality – customers need only purchase a "seat license" to enroll in desired courses.
- PlantMentor® improves and reinforces skills for executing operational and recovery procedures.
- PlantMentor® improves Operations' ability to avoid accidents and environmental incidents.
- PlantMentor® improves troubleshooting skills, helping personnel determine the best upset recovery strategy more quickly – resulting in less disruption of production goals.
- PlantMentor® improves optimization skills, maximizing the time that the unit runs at optimum levels within the acceptable process parameter ranges.
- PlantMentor® helps bring all operations and engineering personnel to the same competency level of the most accomplished performers.
- PlantMentor® helps to turn accomplished performers into exceptional performers.

SUMMARY

PlantMentor® was designed from the ground up to address the compelling safety and operational performance needs of the process industries. Operations personnel and engineers who complete the courses develop a new level of competency that greatly enhances both their individual capabilities and their value to the organization.

While the benefits of achieving higher levels of performance are self-evident, the results Glomark's external analysis also supports the business case for PlantMentor® implementation. These compelling results suggest that the benefits of an implementation can improve performance both in normal operating conditions and in responding to unit upsets and incidents.

The petroleum-chemical industry is capital intensive, highly-regulated, and incredibly intolerant of operational errors. A single operational excursion can result in millions of dollars in equipment damage, fines, civil penalties, adverse publicity, or other sanctions. Anything organizations can do to significantly reduce or eliminate human performance errors on the part of those personnel operating and controlling the process units will doubtless reduce the frequency and impact of a potential error.

The essence of risk mitigation is that it attempts to balance frequency and consequence. In the petroleum-chemical industry, accidents and incidents tend to occur infrequently, but their consequence is invariably severe. PlantMentor® helps organizations reduce both the frequency and the consequence.

The PlantMentor® courseware suite really is a product whose time has come.