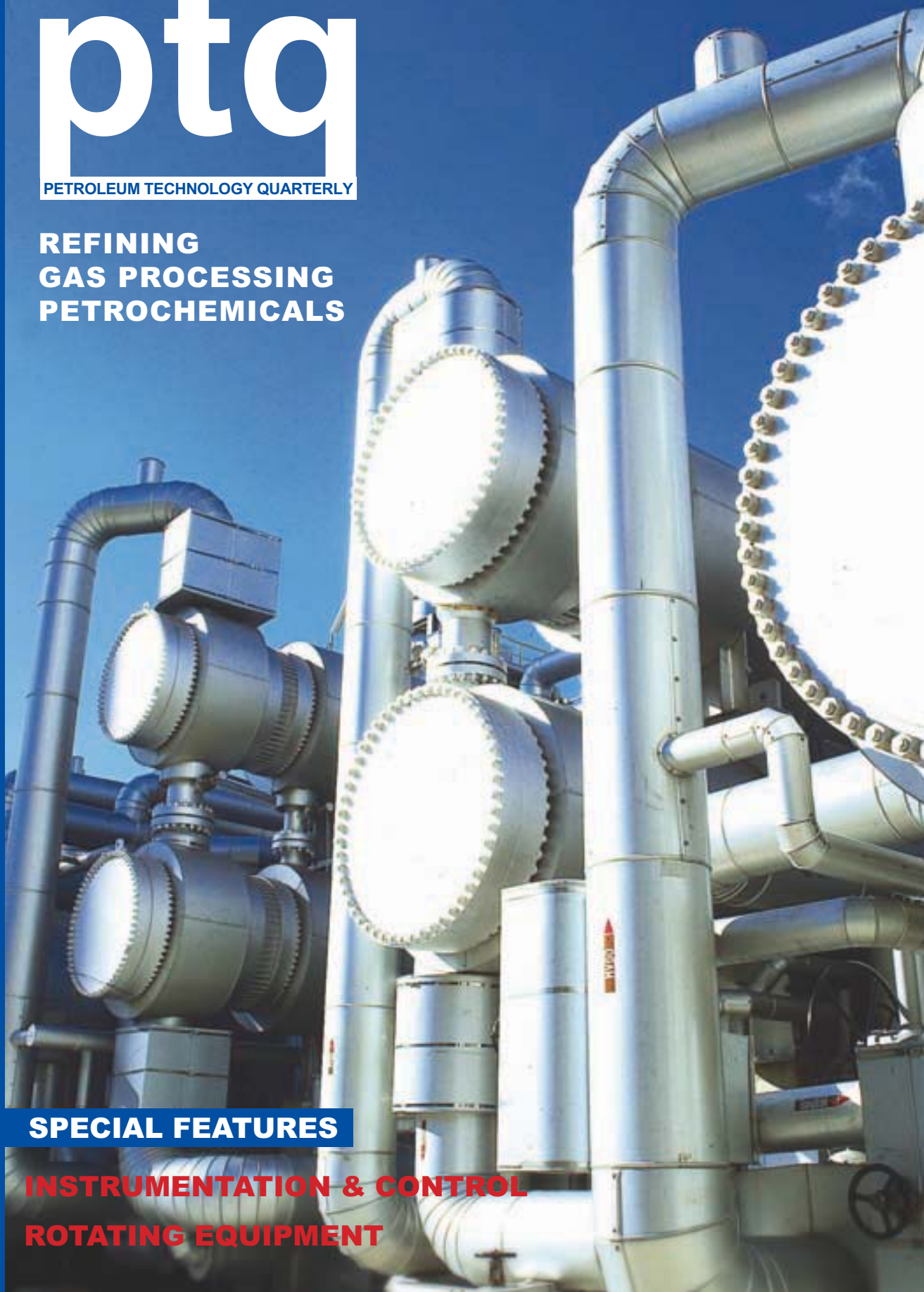Q3 2011

ptq

PETROLEUM TECHNOLOGY QUARTERLY

REFINING
GAS PROCESSING
PETROCHEMICALS

SPECIAL FEATURES

INSTRUMENTATION & CONTROL

ROTATING EQUIPMENT

87 000 b/d vacuum gas oil plant supplied by Uhde at ConocoPhillips' Wilhelmshaven refinery, Germany.

Photo: ThyssenKrupp Group

Automating procedural operations for continuous processes

Progress towards a standard for automating operational procedures in refinery operations

MAURICE WILKINS and MARCUS TENNANT
Yokogawa Electric Corporation

Process plants are run according to operational procedures. These procedures consist of a set of tasks that are executed in a consistent manner to achieve a specific objective, such as starting up, shutting down or transitioning a unit as part of making a product. The level of detail, purpose and frequency of use of these procedures varies by process, company and site, but they are the basis for how to operate plants.

This article reviews progress and developments in the recently formed ISA106 standards and practices group: Procedural Automation for Continuous Process Operations. It outlines current models and best practices to follow in order to improve a plant's operational procedures. Several examples highlight different requirements and how various tools can be applied to implement operational procedures. These best practices will enable plant operations to execute procedures efficiently and consistently.

Challenges affecting process operations

As an example of the issues facing the process industries, let us focus on distillation, as it is the most widely used separation process. In the manufacturing sector, distillation uses 24% of the total energy demand. Oil refineries, in particular, rely heavily on distillation, which consumes approximately 40% of all the energy used in refineries.

Consider the distillation process from a steady-state perspective, with most attention focused on achieving an optimal steady state to ensure that the process remains within safe
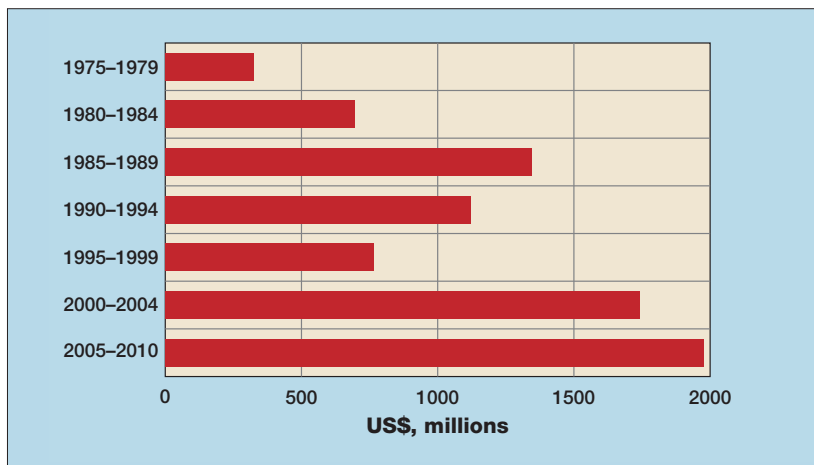

Figure 1 Five-year loss totals in the refining industry have continued an upward trend over the last few years. Piping failures or leaks (caused by corrosion or incorrect metallurgy) and startup and shutdown events continue to be significant causes

operating limits. Those who run and manage continuous process units understand that procedural activities are critical to safe and efficient operations. Often this procedural information is not well documented, not readily available or can reside in an operator's individual knowledge acquired through years of experience. Procedural activities in a distillation process are most prevalent and critical at certain times of the process operation

Startup

Safe and efficient startup of a distillation unit is critical to its overall operation. Startup frequency can vary, from once every day to once every five years. If startups occur often, they can occur on different shifts, and the time and skill of the operator on duty can determine the efficiency of the startup. If startups occur at longer intervals, companies run the risk of not having

experienced personnel available to run and oversee the startup. There have been cases where companies have had to bring operators out of retirement to restart a unit after a shutdown.

Shutdown

Orderly and safe shutdown of a distillation unit is just as critical as a startup. One key item in the shutdown procedures is recognising that a shutdown might not be scheduled. System problems or severe weather such as approaching hurricanes can require a shutdown of distillation operations at very short notice. As with startups, on-shift operating personnel might not have the most experience in shutting down a system.

Feedstock and product output transitions

Many chemical processing units regularly operate at more than one

optimum steady state. In refineries, for example, many refiners purchase crude oil of different types in tankers. As they run out of one type of oil, they must adjust operations to process correctly the next type of oil. Similarly, in chemical plants, a single plant will often make a variety of products in a campaign fashion by changing operations to meet the new product specification.

Transitions inherently increase the risk of disruptions that can lead to incidents. According to a report by Marsh Ltd, over the period 1975–2009, the five-year loss rate (adjusted for inflation) in the refinery industry continues to rise (see Figure 1). Incidents that occur during startup and shutdown continue to be a major factor.

An additional study by J & H Marsh & McLennan shows that the examination of major incidents by the average loss per incident indicates that operational error represents the largest average dollar loss (see Figure 2).

With distillation operations consuming a large amount of the energy requirements in a refining or petrochemical application, efficient production is a key to meeting product specifications and producing the best possible yields of valuable products. Performing procedural operations in an inefficient or time-consuming manner will have a significant economic impact on the complete operation.

Need for procedural best practices in continuous process operations

A 2008 survey by the ARC Advisory Group indicates that continuous process manufacturers are now seeing effective and repeatable transition management, along with the use of sequence-based operating procedures, as a competitive advantage. Additionally, the safety aspect of automating procedures should be assigned a high tangible value. The cause of some recent industrial accidents has been linked, in part, to a lack of good emergency shutdown procedures during an abnormal condition. This put too much pressure on operators in a crisis, leading to improper procedural operations that resulted in disastrous consequences.

Process industries have used semi-automated and automated procedures in the process industries for years, especially in batch processes. These procedures, when implemented in recipes, use a modular approach in accordance with the ISA-88 batch control standard.

Semi-automated and automated procedures are not widely adopted in continuous processes due to a lack of general industry expectations and standards. Increased operational excellence has put more focus on business drivers that require increased safety, improved throughput, reduced cost and knowledge capture to retain years of operational experience that would soon be lost due to retirement.

Automated procedures for continuous processes in the past have typically been implemented using ad hoc designs and programming techniques, usually resulting in difficult-to-maintain code. While this can provide short-term operational benefits, the total cost of ownership of these procedures is higher than necessary. This is a result of the increased implementation costs of changing and updating successive procedures over time due to a lack of reusable software modules.

Implementing a modular approach could also provide companies with the ability to standardise functions across plants, sites and enterprise, achieving corporate-wide repeatability and reproducibility. This would help to reduce engineering labour costs, provide consistent operation and lower the total cost of ownership (TCO). The ultimate aim is to obtain the best practices of the best operator on their best day, every day, to provide consistent, optimal and safe operations.

Modular procedural automation

Yokogawa introduced modular procedural automation (MPA) to address industry needs and to improve and apply a uniform approach to operating procedures. It is a consultative methodology, whose purpose is to document and automate procedural operations in continuous processes. A modular design approach facilitates standardised implementation within sites and across companies. This approach optimises user acceptance and reduces deployment costs.

Using a modular approach provides a number of benefits, such as:
● **Hierarchy of procedures** Breaks large and complex procedures into smaller modules and organises them into a hierarchy. This modularisation provides easier

verification of documentation and implementation of the discrete pieces of procedural logic and knowledge

● **Reuse of procedural logic** Whether implemented with manual, prompted or automated procedures, MPA can help reuse the same procedures and logic in different parts of the plant and with different products. When procedural logic (that is, portions or modules of procedures) is reused, business gains repeatability and reliability and it lowers the cost of developing duplicate procedures

● **Multi-site consistency** Companies with multiple production sites can experience an efficiency gain and product improvement by standardising procedural knowledge between plants. Without modular procedural automation techniques, this level of standardisation would be very cumbersome to maintain. Modular procedures, both prompted and automated, allow easy sharing of procedural knowledge between facilities.

A scalable approach to automation avoids the one size fits all approach. Different types of procedure implementations contain scalability for manual, prompted and automated control. The hierarchy of modular procedures is easily adjusted to fit the application requirements. Application requirements can vary the level of complexity (for instance, normal sequencing only or complex exception handling).

Manufacturing benefits

Skills retention

The loss of operational skills due to an ageing workforce has already begun to hit process manufacturers around the world. One plant reported problems with a turnaround because operators lacked sufficient experience on restarting the plant. Retired operators with experience were brought back to start up the plant safely and efficiently. MPA provides a systematic approach to capturing valuable skills before they are lost. The procedures developed can also be used to train new operators who do not have the benefit of the years of
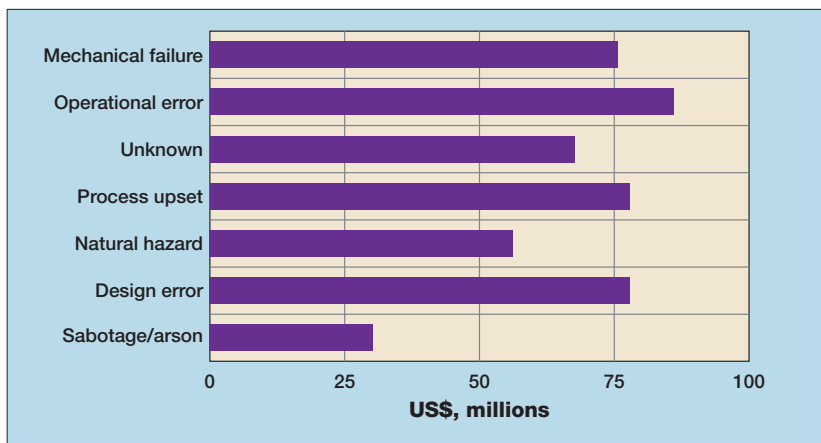

Figure 2 Average loss per major incident by cause   *Source: J & H Marsh & McLennan Inc*

knowledge developed by those retiring.

Knowledge management

Capturing operational knowledge is important. MPA provides a methodology for the captured knowledge to be documented, distilled into best practices, and implemented in reusable and repeatable procedures. Without this ability, captured knowledge is not well managed and simply becomes information on a shelf that is not utilised.

Improved safety

Prompted and automated procedures can reduce the risk of health, safety and environmental incidents. Available and repeatable procedures can lower the chance of accidents due to human error. As indicated above, operating procedures provide the biggest source of risk for process safety management. MPA can ensure that a process is shut down safely, automatically or at the push of a button. This can be invaluable during an incident, when the operator may have many things going on to distract them and could potentially make mistakes.

Reduced variability

When procedural knowledge is implemented as prompted standard operating procedures (SOPs) and automated procedures they are available to all operational teams and all operator skill levels. Their use can drive down variability in operation, resulting in more consistently on-spec product. The lower product and operational variability

enables further process improvement and refinement of the procedures.

Increased productivity

The combination of consistent and repeatable procedures and reduced variability can increase productivity by eliminating lost time due to poor operational decisions and actions.

The combination of these benefits can result in improved metrics used to measure operational excellence.

Improving plant operations

MPA is an approach to improving plant operations; it is not a single product or software package. It begins with a multi-step consultative process supported by a design methodology, control systems and applications.

The goal of this approach is to distil best operating practices and find the right balance between manual, prompted and automated procedures, documenting and implementing the procedures and then executing continuous improvement cycles on them. Automating every procedure does not always provide the best solution; neither does manually executing every procedure. What does provide the best solution is to consciously examine all procedural operations within a plant, document them and determine what type of implementation will provide the best economic return while improving safety, health and the environmental metrics for the facility.

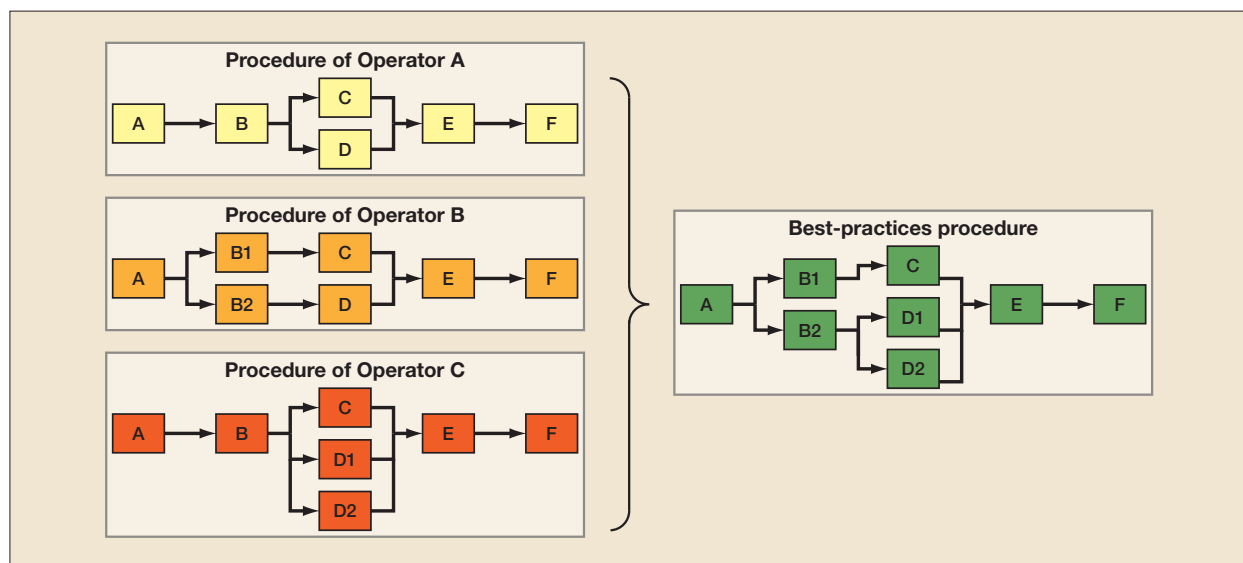The criteria for how to implement a procedure can vary between

Figure 3 Consolidating operating procedures into best practices

industries and companies. Characteristics of procedures that it may be wise to automate are those that are repeatable, demand fast reactions, are well understood and can reduce variability. While procedures that cannot be defined in algorithms or sequences, do not require fast responses or low variability, are well known and not time consuming may be better candidates to be implemented as manual or prompted procedures.

MPA can be implemented as either a top-down or bottom-up process. With a top-down approach, the focus is initially put on product knowledge to decide how the equipment capabilities should be used to most efficiently and consistently produce the product. In a bottom-up process, identification of equipment capabilities available to production and a definition of limits that define the safe and desirable operating envelope for any product would be a starting point to build product-related procedures.

Modular procedural automation supports any level of procedural hierarchies. In some cases, it may be appropriate to automate only equipment modules, such as pump sets, dryers and manifolds, and not product-specific procedures. In other cases, multi-level product-oriented procedural hierarchies may be required to automatically produce products, as is often done in batch control applications.

Examples of applications are:
● SOPs defining the sequence of activities to start, stop or transition a process unit
● Groups of SOPs that define how to bring a production line or plant up or down
● SOPs that define normal operating conditions for a continuous plant
● Consolidation of operating procedures into best practices (see Figure 3)
● Starting and stopping pump sets (the collection of a pump and associated valves and instrumentation)
● Transition from one operating state to another due to higher or lower production rates, grade changes or crude switching (see below)
● Recovery from process upsets
● Specific unit operations such as decoking.

Case study: oil refinery crude switch
An oil refinery in Japan in normal operations underwent crude oil feedstock switches two or three times a week. The efficiency of the operation depended on the experience and skill of the board operator running the distillation unit. With a skilled operator, the time to reach normal steady-state operations was typically five hours. A junior, less experienced operator could take more than eight hours to reach the same normal steady-state operations. These long transition times

had an impact on product quality and production efficiency. It also caused the inefficient use of utilities such as fuel gas, power and cooling. Additionally, with junior or less experienced operators, there was a higher incident of operational errors, resulting in abnormal conditions and off-spec product.

Yokogawa's engineers worked with the operational staff at the refinery. They interviewed the board operators from different shifts and were able to uncover and document their best practices. For instance, when ramping up feed temperatures, junior operators would typically ramp feed temperatures at a linear rate throughout the temperature zones. The veteran operators had the operational experience to change the temperature ramp at different rates, depending on the temperature zone of the column. It was also discovered that operators typically had to make more than 100 adjustments to the process through the DCS system during the switchover. This was in addition to responding to false alarms that were set for normal operating conditions.

Implementing MPA methodology and automation enabled the refiner to make significant improvements in the operations switchover time to a predictable four-and-a-half hours regardless of which operator was on shift. Crude switchover reduced the operators' workload significantly, with over 100 control system

adjustments reduced to 10 and more than 2000 process alarms reduced by configuring the system to be operationally aware of process conditions. Additionally, there was increased process knowledge sharing, a significant reduction in operator errors and reduced operator training.

ISA106: a procedural standard for continuous process operation

In view of the need for an industry standard, the International Society of Automation approved the formation of a new standards committee in April 2010, and the committee adopted the title Procedural Automation for Continuous Process Operations. The purpose of the committee at its first meeting in June 2010 was to develop a standard, recommended practices and technical reports for the lifecycle of automated procedures for process operations in industries.

Topics being considered for the standard are:
- Models and terminology
- Modularisation of procedural steps to foster reuse and lower total cost of ownership
- State models for procedural logic
- Process unit orientation with operational perspective
- Exception handling of abnormal process conditions
- Implementation of startup, shutdown, abnormal conditions, hold states and transition logic
- Recommended target platform (ie, control system versus safety system) for different types of procedures
- Training and certification best practices.

So far, these topics have input and support from 39 manufacturers and suppliers, including many companies that run distillation operations.

The committee has met face to face three times and held monthly teleconferences since June 2010 and now consists of five working groups preparing material for the initial technical report. The groups are:
- Knowledge management
- Definitions and terminology and models
- References (other standards and industry publications)
- Examples and use cases
- Work process.

The initial goal is to publish a technical report based on the good practices used today, with a target release of June 2011. Following that, the committee plans to refine the material and publish a standard.

Maurice Wilkins is Vice President of Yokogawa's Global Strategic Technology Marketing Center (USMK) in Dallas, Texas. He was head of the team that proposed the ISA106 standard to the ISA Standards and Practices Board.
Email: maurice.wilkins@us.yokogawa.com

Marcus Tennant is a Principal Systems Architect with Yokogawa Corporation's Global Strategic Technology Marketing Group in Carrollton, Texas. He holds a BS in chemical engineering from Michigan State University and an MS in operations and technology management from Illinois Institute of Technology.
Email: marcus.tennant@us.yokogawa.com