HYDROCARBON ENGINEERING

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Elbert van der Bijl, Yokogawa Europe, and Dr. Maurice J. Wilkins, Yokogawa North America, discuss the future of modular procedural automation in the process industries.

Automated KNOWLEDGE

The world of process operations is governed by procedures, which can be lumped into three primary categories: manual, prompted and automated. In manual procedures, the operator performs the necessary actions required manually, either through their own years of experience or by following standard operating procedure (SOP) manuals. As one might expect, the consistency with which manual procedures are performed can vary greatly depending on the level of experience of those carrying out the procedures. Manual procedures also call for manual records to be kept, which can vary equally in their effectiveness and quality.

Electronic records are preferable, but their quality can also vary depending upon how well they were entered into the system, only reflecting the procedures that were purportedly carried out. There is no way to verify that the manual procedures followed were in fact consistent with printed SOPs.

Prompted operating procedures go one step further, where the procedures are implemented in the process automation system and the operator is prompted to start each procedure and to acknowledge that each step has been successfully completed in order to continue. Prompted procedures make it easier to keep electronic records and verify that procedures were followed correctly, and can even reduce transition times and variability.

Like prompted operating procedures, automated procedures are implemented in the process automation system. The difference is that automated procedures will go through the entire operational sequence before stopping, unless there is intervention from the operator or the system on an exception basis. Automated procedures can provide even more reductions in variability and transition time.

Many industries have been using prompted or automated procedures for some time. The batch industries, such as life sciences, and food and beverage production have been using the ISA88

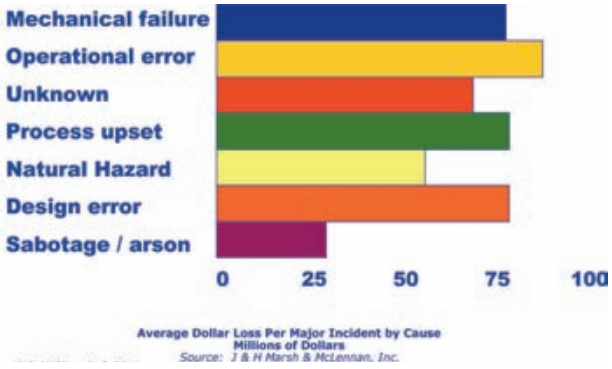

Figure 1. Operator error accounts for the highest financial losses per incident in the process industries.

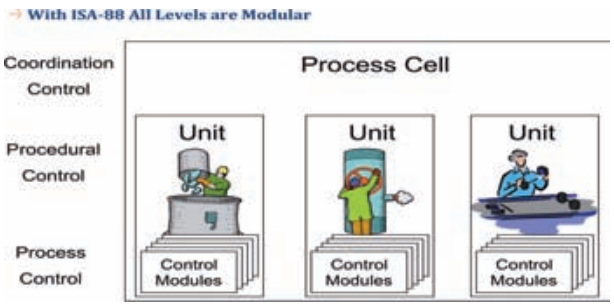

Figure 2. The modular approach adopted in the ISA88 standard for batch automation.

standard for years. ISA88 defines a modular approach to batch automation and batch procedures. In the continuous process industries, however, prompted and automated procedures are not the established way of operating. There is no equivalent to the ISA88 standard in continuous process manufacturing, and operations such as starting up and shutting down a refinery unit for instance, are considered by many end users to be a craft or an art form that relies heavily on experience and knowledge of the particular plant and its quirks.

This is not to say that automated procedures are unknown in the continuous process industries. Many companies have implemented sequence logic that allows procedures to be automated. However, these have been done largely in an ad hoc framework using custom programming methodologies that can become cumbersome when the time comes to upgrade the automation infrastructure. This ad hoc approach also carries a high cost of ownership, since the custom logic has to be maintained by the end user. Changes made to the code over time can create a tangled mass of 'spaghetti code' that can be impossible to translate and maintain.

Many end user companies in the process industries today are also the result of mergers and acquisitions. Along with that comes the many system platforms and unstructured code implementations that have accumulated over the years. Clearly, this is not a sustainable way to operate. As a result, more and more end users are standardising their approaches.

The need for modular procedural automation

An open and modular approach to automated procedures is required to overcome the issues associated with approaches based on proprietary code. Modular applications enable functions to be more manageable and standardised across plants, sites and the entire business enterprise. A standardised approach means that engineering costs, labour costs and the total cost of ownership are reduced.

It is unreasonable to think that all procedures can be automated. The right balance must be struck between manual, prompted and automated procedures. The approach to procedure management comes from a consultative methodology with an eye toward improving operations and reliability in the plant based on the needs of the user. Specifically, the benefits include increased safety, energy savings, increased throughput, improved quality, faster transitions and the ability to capture knowledge from a rapidly ageing workforce. Modular procedural automation will be the way of the next generation of plant operations.

Procedure automation enables human reliability

The following issues are facing process industries:

- Keeping safety, health and environment (SHE) at the forefront.
- An ageing workforce being replaced with lower skilled workers.
- Improving equipment availability.
- Maintaining quality.
- Increasing operator workload. Distracted operators make mistakes. Operational error is the single biggest reason for unscheduled shutdowns.

In demand limited industries like refining, the overarching objective is to improve utilisation, which cannot be achieved without reducing unplanned downtime. Research has shown that the largest reason for unscheduled downtime is operational or human error, which accounts for approximately 42% of the unscheduled shutdowns in the process industries. Of that 42%, 16% is directly related to procedural error. When researching the role of operators in the refinery of the future, several major operating companies concluded that this can be addressed first by empowering a higher level of perspective, one which enables flawless intervention by exception and relieves operators of manual tasks, freeing time for more value added activities.

Procedure automation was one of the key process automation system functions identified to provide the environment of flawless intervention, along with alarm management and the operational perspective. The knowhow and operating level of experienced operators can be incorporated into automatic sequences and used to standardise operating methods and improve the efficiency of all operators.

ARC has a vision for the collaborative process automation system (CPAS) of the 21st century. An important part of this vision is that, in developing an overall automation strategy, humans should be allowed to do what they do best and automation should be allowed to do what it does best. Humans are good at ad hoc intervention and non-linear reasoning. They do best when empowered with an overall production cycle perspective. Machines and automation are good at repetitive functions, steady state and transition management. Automation provides an environment for unbroken, precise execution and linear reasoning, and can consistently implement best practices through automated procedures.

Increased plant safety

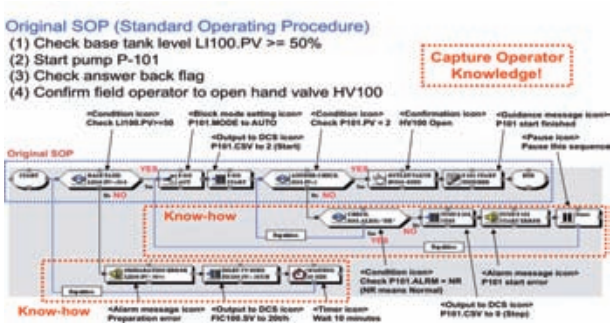

Figure 3. Capturing best practices using standard operating procedures.

Figure 4. Yokogawa's Centum VP process automation system is the basis for refinery control systems running the Exapilot automated procedure control solution.

A further benefit of modular procedural automation is enhanced process safety.

There is increased emphasis on health, safety and environment in today's process plants. Accidents continue to occur in many manufacturing facilities even after the installation of safety systems and other safety protections that were initially considered adequate. Many operators, when faced with an abnormal situation, are presented with a landslide of information and possibly a flood of alarms. It can be difficult to sort through all the noise to get to the right data and make a good decision in a crisis. Procedure based recovery from abnormal situations is faster and more reliable than recovery based on random operator knowledge, even from expert operators.

Modular procedural automation could possibly also stop abnormal events from happening in the first place. Several major incidents in the past few years have been caused, at least in part, by plant personnel not following proper operating procedures while under pressure. In addition, operators and maintenance personnel do not always follow standard operating procedures when they are required to execute them manually. For every one such incident that occurs due to poor procedural operations, there are probably 10 near misses.

Modular procedural automation can also help in the development of the safety lifecycle. A study conducted by the UK Health and Safety Executive states that many failures are due largely to inadequate safety management. To ensure safe operations, current safety standards specify lifecycle activities that need to be followed over the entire life of a production system. This is known as safety lifecycle management. It is a method or procedure that provides the means to specify, design, implement and maintain safety systems in order to achieve overall safety in a documented and verified manner. Modular procedural automation can help implement the procedures required to developed safety lifecycle management in the same way that it can help execute transition changes and other functions in the plant.

Constrained worker resources

Finding experienced personnel is a challenge for the process industries. The retiring wave of 'baby boomers' in North America and the shortfall of qualified engineers in Asia and other parts of the world are creating a skilled labour shortage that will drive growth in demand for services and more sophisticated forms of automation.

Driving a modular procedural automation strategy in a company can also help facilitate the process of capturing the knowledge of skilled employees before they retire or are laid off. Recent research has shown that up to 42% of all corporate knowledge is actually stored in employee's brains.

Many firms continue to operate with lean technical staffs, yet the level of technological complexity is increasing. The timely flow of information, data and knowledge is more important than ever in the process industries.

This downward trend in staffing and the increased demand for accurate, real time information will translate into additional systems and higher, more sophisticated levels of automation being applied, including modular procedural automation. The smaller, less experienced workforce that will exist in the future must be empowered with new technologies and workflows that can transfer knowledge on demand.

Operators today can be under huge amounts of stress that will impact on their responses to abnormal situations. Under normal operating conditions, they can apply their training and basic knowledge successfully. Even at the first sign of a fault, the operator is capable of acknowledging the event and responding accordingly. As the situation begins to deteriorate, however, the ability of the operator to respond effectively deteriorates too.

Effective transition management

A 2008 survey by ARC indicated that continuous manufacturers are now seeing effective and repeatable transition management along with the use of sequence based operating procedures as a competitive advantage, but in the continuous process industries there is no standard they can use to base their procedures on.

Most plants do not always operate under steady state conditions and do not always rely upon applications such as advanced process control to manage transitions. Instead, as indicated earlier, they use varying degrees of manual and automated procedures to manage complex procedures during shutdown, startup, grade changes and other planned and unplanned unsteady state events.

State logic control

State transitions in the plant are a major subset of modular procedural automation. Since state transitions are the most hazardous parts of operations, and the primary time where off specification product and its resulting yield loss are generated, ARC's collaborative process automation system (CPAS) model requires that there be no difference in the way continuous and batch control systems are defined. Economics should then

determine if the state transition procedures are automated, prompted, or made advisory in a manual state transition procedure operation. In all cases, continuous processes must be treated as though they were batch processes, and the process logic must be defined for the state transitions of all processes.

All control systems should provide the basic languages for controlling sequential and concurrent operations, and in ARC's view that language is a sequential function chart (SFC). Even when the operation of the process under state change conditions is too complex for analysis based on 'first principles' modelling, it is always possible to codify operations to automate the best operator actions.

Procedural automation standard for continuous processes

Given the lack of a standard for modular procedural automation, it seemed only logical to propose one. A new ISA standard (ISA106, Procedure Automation for Continuous Process Operations) was proposed in November 2009 and ratified in April 2010, providing industry with benchmarking data and design considerations for procedure automation in continuous processes. The proposed standard will address topics ranging from models and terminology to modularisation of procedural steps with an eye toward reusability and lower cost of ownership. Other potential areas to be addressed include:

- Exception handling for handling abnormal situations.
- State models for procedural logic.
- Process unit orientation with operational perspective.
- Compliance requirements.
- Recommended best practices.
- Implementation of startup, shutdown, abnormal situations, hold states and transition logic.
- Recommended target platform (i.e. control system or safety system) for different types of procedures.
- Lifecycle management best practices.
- Training and certification best practices.
- recommended display hierarchies.

In theory, the final standard will incorporate elements of training, a certification process and best practices, as well as specific HMI structures. At the time of writing, the standard committee has released its first technical report (Models and Terminology) for ballot.

Toolsets to support MPA

As a major supporter of modular procedural automation and the procedural automation standard, Yokogawa already has a toolset that can support modular procedural automation (MPA), from applications as small as scheduling sequences consisting of many sequential function chart (SFC) steps to more complex and integrated multiproduct solutions incorporating the Centum VP process automation system. SFC is the desirable means of defining the state relationships, concurrency and transition conditions, otherwise known as the state model of the process, in the control system. With the application of additional procedural programming, the state model itself becomes the root of the control system.

The primary tool that Yokogawa has to implement MPA in the continuous process industries, however, is Exapilot, an automated procedure control solution now installed in over 1000 plants around the world. Exapilot is used to describe steady state and non-steady state operations carried out by operators as a graphical flow diagram of the sequence of actions. The operations can be fully or semi automated. By capturing procedures for a process unit across several groups of operators it is possible to find the best practice procedure, thereby preserving the procedural knowledge for that unit. In addition to Exapilot, the Exaplog event analysis package helps to refine the controllability of a plant and identify parts of the plant operation that could be improved, by analysing alarms and operator actions side by side. Combining Yokogawa's consulting skills with products such as Exapilot allows users to integrate operator actions and the control system into a single unified environment for best practice plant operation. Some operators have a lot of knowledge, but are not familiar with computers or Exapilot, so someone has to put this knowledge into Exapilot.

Yokogawa's knowledge engineers specialise in capturing this knowledge from experienced workers and entering it into the system.

Strategies and challenges moving forward

Developing a successful standard for ISA, IEC or any other standards body is a challenging task. Fortunately, there is much source material that the ISA106 committee can draw on, particularly ISA88 (ISA's batch control standard) and its application to continuous processes. ARC believes there is value in creating a procedure standard for end users, and that MPA has the ability to address many of the challenges that the process industries will face and are facing today, from the shortage of qualified and experienced personnel to the increased focus on health, safety and environment. Getting the standard completed is one of the primary challenges for Yokogawa. ARC believes that the future standard must be defined in a way that makes it easy for end users to deploy, relies on open technology to implement and conforms to other existing standards.

But what is the real value of creating a standard for procedure automation? Many suppliers have tools that can provide a path to procedure automation. The benefits of an MPA standard would be similar to those provided by the ISA 88 standard for batch automation. Design time and time to startup are both greatly reduced. ISA88 could be called the 'universal batch translator'. Every supplier, large or small, currently offers an ISA88 'aware' batch control system, and everyone in the batch industry knows what control modules and equipment modules are. They know what the system commands are and what impact they should have, when to go into hold or abort, when to go back to run and how, and so on.

In business terms, this approach has saved many companies a lot of money, in terms of system development, changes to system design, engineering and the flexibility to respond to changing market conditions without having to reprogram the control system completely. ISA88 is the most successful set of standards ever produced by ISA. A standard for MPA in the process industries would have similar benefits, and would experience a similar level of success.

Acknowledgment

This article is based on a White Paper entitled 'Yokogawa's Modular Procedural Automation is a knowledge preservation tool for the process industries' and published by the ARC Advisory Group: the leading Global Market Research Firm for Automation, Asset Management and Supply Chain Solutions in January 2010.