Using Procedural Automation to Improve Safety and Operational Efficiency

Marcus Tennant  
Yokogawa Corp. of America  
Carrollton, TX 75006 U.S.A.

Dr. Tom Fiske  
Yokogawa Corp. of America  
Carrollton, TX 75006 U.S.A.

ABSTRACT

Over the past few years, the power industry has changed dramatically. Clean, renewable energy is playing a bigger role in meeting the ever increasing demand for energy. Meanwhile, emission regulations are getting stricter. In this environment, energy producers must be more flexible and efficient than ever before. Operational procedures are an important component to the safe and efficient operation of power stations. These procedures consist of a set of tasks that need to be executed in a consistent manner time after time to achieve a specific objective such as starting up, shutting down or transitioning a unit through a load change or a maintenance activity. This presentation will review examples of how a power station facility can improve operational efficiency and ensure safety margins by automating both routine and infrequently used procedures. It will highlight the challenges faced by companies in other industries and their successes in automating complex procedural operations traditionally performed by operators. Additionally, other activities of the recently formed ISA-106 standards and practices group – Procedural Automation for Continuous Process Operations – will be discussed.
Introduction

In all process industries, procedures executed by control room and field operators are a fact of life. Throughout oil & gas, power, chemical, paper and many other process overall can be considered continuous process and generally maintain steady states but all still need to be started up, shut down or transitioned from one set of operating conditions to another.

Despite the strong focus on safety in the all process industries, there continues to be incidents and many are caused by operational errors. For instance, in power, a study by the National Board of Inspectors (NBIC) showed that 40% of accidents are caused by human error and the biggest risk is the startup and shutdown of equipment. Additionally, incorrect operation has been a contributing cause in many of the incidents involving equipment or material failure due to repeated incorrect operations over time causing stress on the system.

In the development of process control systems over the past 30 years, both Programmable Logic Controllers (PLC) and Distributed Control Systems (DCS) initially focused on discrete and continuous control. Procedural control functions were added later and the logic was more complex. Batch processes are procedural in nature, but typically involve sets of procedures running in parallel on varying process units and almost always need to have inbuilt flexibility. The ISA-88 standard released in 1995 addressed batch automation very well and was widely adapted in food, pharmaceutical and specialty chemical industries. But the execution of procedures in continuous process applications remained a very manual and intensive task for control room and field operators who can be prone to human error and cause safety incidents or inefficient process operations.

Benefits of Procedural Automation

Reduced Variability – When procedures are performed manually, there is often a large variability in how they are executed by different operators. Automating procedures enforces consistent execution of procedures and operation of the process, resulting in reduced process variation and higher throughput. Operators are able to operate with fewer errors and less stress, enabling them to concentrate on the overview of all the processes they are responsible for in the control room or a higher situational awareness. This results in more efficient and safer operations.

Capturing Operator Knowledge – In many plants, the existing paper-based Standard Operating Procedure (SOP) manuals contain the “static” knowledge documented when the production platform was being built and brought on-line. Over time, the actual procedural knowledge and skill resides more and more in the heads of the most experienced operators. In many cases, this knowledge and the accompanying skill sets are leaving the workplace due to retirement, and the availability of experienced operators to run these procedures manually is diminishing. How to preserve the knowledge of the best operators is an important need in many process plants and
pipelines. Additionally, many plants and pipelines continue to operate with lean technical staffs and 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 increased demand for accurate, real-time information will translate into additional systems and higher, more sophisticated levels of 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.

Figure 1 below depicts the methodology of capturing procedural best practices. The goal of this approach is to “distill” best operating practices of operators and find the right balance between manual and automated procedures, documenting and implementing the procedures and then performing continuous improvement cycles on them. Automating every procedure does not always provide the best solution. What does provide the best solution is to consciously examine events, then examine the procedural operations associated with those events, document them and determine what type of implementation will provide the best operational result while improving safety, health and the environmental metrics for the facility.

**Figure 1: Capturing Procedural Best Practices**

**Improving Process Flexibility and Reliability** – By automating procedures, the goal is to improve overall performance through faster and smoother transitions from one set of process conditions to another. This contributes to extended equipment life and optimized production, throughput or product yield. There are three broad operational procedures involving transitions: startup, shutdown and unit state change. The unit state change includes transitions like fuel source changes, load following changes, process equipment switches, etc. Managing state transitions through procedural automation can be applied to a complete process unit and to a selected piece of equipment in a process unit, like a shutdown valve, or a test separator or a heat exchanger.

Additionally, procedural automation can address issues like a process trip resulting in a unit shut down or a larger event causing a plant-wide shut down. In some abnormal conditions, most of the time there is an opportunity for a process operator to reset equipment and operating
conditions to reestablish normal conditions before a safety system shutdown. The goal is to minimize generation disruption. But the time window is narrow and is very challenging and stressful to execute during an abnormal event and most often the affected process is brought to a much longer shutdown state with the result of a longer shutdown.

Challenges in Automating Procedures

For the last 20 years, many owner/operators in the process industries have made an attempt at automating procedures. Often, a dedicated engineer would go in and write code in a control system or a bespoke sequential control software application and meet with initial success in implementing automated procedures. Commonly, the engineer would transition to a different job and a new engineer would take responsibility. However, the procedural code would not be structured or documented well which would make the new engineer reluctant to make updates, changes and improvements. This typically would cause the automated procedures to fall into disuse and the plant operators eventually return the traditional ways of using manual procedures. Batch manufacturers had a similar problem and developed an industry wide standard, ISA-88, in 1995 where end-users, automation vendors, and system integrators were able to apply the same common definitions and structural models to solve procedural control and automation. Many attempts were made to adapt the ISA-88 standard to continuous process applications in many industries including power generation but it was never widely adapted because it did not address many requirements in continuous process applications.

ISA-106: An Emerging Standard to Address Automation Procedures in Continuous Process Applications

In 2010, the ISA (International Society of Automation) approved the formation of a new committee and it adopted the title “Procedural Automation for Continuous Process Operations.” At the first meeting in June 2010, the committee agreed that its purpose was to develop standards, recommend best practices and publish technical reports on the lifecycle of automated procedures for continuous process industries.

Over the last 5 years, the committee has grown in size substantially. It has received input and support from 39 manufacturers and suppliers including many energy companies that run refining, petrochemical, nuclear processing and offshore oil production operations. The committee met their goal to publish a technical report based on good practices that are used today. The technical report was approved in August 2013 and published by the ISA. Currently, the committee is working on refining the material to publish a standard.

Some of the contents that would be relevant to the standard are as follows:

Common Definitions and Terminology – The technical report has defined a common set of 52 terms with uniform definitions to describe the requirements for improvements and changes in
automating procedures. This improves communication between EPCs, system integrators, automation suppliers, and internal company functional departments.

The primary models that are used in the technical report to organize equipment and procedures are as follows:

**Physical Model** – Organizes physical equipment into a hierarchy that is the foundation for the Foundation of the ISA-106 work. Each item in the model can have procedures associated with it. The model’s common set of terms and equipment levels allow for companies in different industries to map their terms to such. A mill in the paper industry would be associated with the common term plant.

**Procedural Requirements Model** – Procedure requirements are the definition of what actions are required to accomplish an objective. They are used as functional requirements when automated procedures are implemented. Procedure requirements may exist at any physical model level.

**Procedure Implementation Model** – This model shows the hierarchy of implementation modules that result from implementing procedure requirements. Implementation modules are created based upon procedure requirements. They represent the configured or programmed result of implementing procedure requirements in the control system used for the process.

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**Figure 2 ISA - 106 Key Models**
Examples of Applying the Models

As an example of applying the **physical model**, we show how an ethylene furnace plant is broken down into the model components to form a hierarchy. For this example (Figure 3) we will start at the plant area with five furnaces representing the units within the plant area. Next, by focusing on Furnace 3, we see how the equipment is broken to functional equipment grouping such the heater as an equipment module. The heater is further broken down to the device level that is the individual heating blocks.

![Figure 3 Physical Model applied to an Ethylene Furnace](image)

To show how the **procedural model** may be applied, we will look at the startup procedure for a plant with a reformer as a unit in the process. As you can see in Figure 4, the procedure is broken down into hierarchal segments of unit, equipment and device procedures components. With this hierarchal design, it makes it much easier for an individual to review and make modifications to the procedure.
An **Implementation Modules** example in Figure 5 shows the components and inputs/outputs of an implementation module. The components consist of a set of ordered tasks. Tasks may contain other tasks. Each task provides plant operations with step-by-step instructions for accomplishing the actions that are to be performed automatically or manually.
Implementation Examples

**Example 1:** A chemical company operates an acrylic acid production facility in Germany that has integrated into the process two reactors, four distillation columns, and a crystallizer for the manufacturing process. A regular system shutdown of the production of acrylic acid is required for cleaning and maintenance. The startup procedure for acrylic acid manufacturing requires the skills of experienced operators to bring the process up to steady state. Any additional time to bring the process to full production results in unnecessary rework and waste of production utilities.

The plant engineers developed their requirements for automating procedures and implemented the automation. The results were:
1) Process operators were able to start up their distillation columns 30% faster
2) Reactors were able to come on stream 70% faster
3) Process safety margins of explosive conditions during startup were increased significantly

![Figure 6 Column start-up results](image)

**Example 2:** A refinery operations team recognized there was a large optimization opportunity to automate a feed switch. This involved adjusting reactor conditions and feed rates, and then adjusting distillation operations to optimize product output. A console operator had to make approximately 300 adjustments to the control system over an 8-hour period to complete the transition. The operator was also responsible for monitoring additional processes in the plant and during the period of the feed switch, there was potentially less monitoring of the other processes under his/her responsibility.

The team initiated a project that automated the feed switch transition using a graphical procedural execution application that automated sequential tasks of system adjustments that were previously performed by the console operator. As a result of the transition, the operator work
load was reduced by 60%, which enabled the operators to focus on monitoring all process application under their responsibility.

Figure 7 Feed switch board moves

Additional benefits in automating the feed switch procedure were:

1) A 42% reduction in product yield loss
2) Increased feed throughput during transition by 18%
3) Reduced feed switch transition time by 36%

Summary

The value of procedural automation is well-proven in many process applications and in many different industries. Properly designed and programmed, it will improve repeatability, utilization, and safety in your plant. Still today, many procedural operations in continuous applications are run manually and often inefficiently and sometimes unsafely. With an aging workforce and business pressure to reduce cost, improve quality and reduce safety and environmental incidents, automating procedures offers the ability to preserve and manage a plant’s and company’s operational and procedural knowledge and improve safety performance. Modularizing the design and implementation also provides cost savings while allowing the flexibility to make changes without impacting production. The general need for procedural automation, the ISA106 Technical Report, and upcoming standards committee can provide guidance in implementing procedural automation.
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