

TECHNICAL REPORT

**ISA-TR106.00.01-2013**

**Procedure Automation for  
Continuous Process Operations –  
Models and Terminology**

**Approved 1 August 2013**

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ISA–TR106.00.01

Procedure Automation for Continuous Process Operations – Models and Terminology

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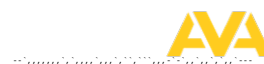
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## PROCEDURE AUTOMATION FOR CONTINUOUS PROCESS OPERATIONS – MODELS AND TERMINOLOGY

### INTRODUCTION

This technical report addresses the subject of procedure automation for continuous process operations. The intent is to provide a collection of good practices regarding procedure automation in process operations and strategies for incorporating automated procedures into industrial automation and basic process control systems (BPCS).

This technical report presents the first work of the ISA106 standards committee and complements the concepts described in several ISA standards that deal with the use of procedures in specific applications, among them batch processing and safety systems. Many of the fundamental concepts discussed in those standards are common to all procedures without regard to the context in which they are implemented, but there are needs specific to continuous processes. These needs are addressed in this technical report in the procedure requirements model, procedure implementation model, and physical model as well as in the subclause concerning mapping of procedures to BPCS components.

The good practices documented in this technical report were developed to address many of the human performance limitations that can occur during procedural operations pertaining to continuous operations. The technical report also describes the elements necessary to implement procedure automation. Such procedures are less prone to significant deviations in practice and may also improve response to disturbances.

Procedures represent the knowledge necessary to operate a system and are a critical component of continuous operations. Historically, procedures have been executed by humans reading from a manual, checklist document, or static display. This technical report describes the concepts in which procedures are integrated into the BPCS.

The intended audience for this document includes technical and operations managers and engineering personnel who are responsible for the operation or automation of continuous process operations; members of engineering departments of owner/operators; and engineering personnel of engineering and procurement companies, automation vendors and system integrators and other process engineering practitioners.

As a technical report, this is an informative document with a scope limited to automated procedures that monitor and control continuous processes.

Clause 2, References, provides a list of standards, publications, reference materials and other associated documents that have influenced the content of the technical report. The reference list provides an easy place to find related materials should the reader want to investigate further.

Clause 3, Definitions of Terms and Abbreviations, lists key terminology used throughout and provides clear definitions of terms used within the technical report. Frequently the same or very similar terms may be used in other standards, references, or within certain industry segments and may have different meanings than used within this technical report. It is requested that readers read this section before going in depth to the remainder of the report. This section should also be used as references for clarification should the reader have doubt about the meaning of a specific term when reading the report.

Clause 4, Historical Perspective, provides a brief summary of the use of procedures and automation in the continuous process industries up to the time of completion of this technical report.

Clause 5, Value Proposition, describes why automated procedures should be used extensively within the continuous process industries. There is a range of benefits available from the application of procedural control for nearly any type of continuous manufacturing business. This section of the technical report should be important to both technical and nontechnical readers.

Clause 6, Models, provides an informative set of models that can be used to understand how automated procedures fit into existing models used in process control and manufacturing operations management. Similar to other recent ISA work, the ISA106 committee realizes that models play an important role in understanding how information is communicated and applications are implemented.

## 1 Scope

This technical report provides an overview of the benefits, best practices, and language, including terms and definitions, for applying procedure automation across the continuous process industries. In agreement with the scope of the ISA106 Committee, this technical report focuses on automated procedures that primarily reside on systems within the supervisory control, monitoring, and automated process control section (as defined by ISA-95 functional levels 1 and 2 – see clause 2, References) of a production process (as defined by ISA-95 functional level 0). It was not the intent of the committee to have this technical report focus on procedure execution at the operations management functional level (as defined by ISA-95 level 3). The interaction with manual procedures is within the scope, but manual procedures are outside the scope of this technical report.

Additionally, the focus of this technical report is on continuous processes. However, the contents of the technical report may be used in other types of process control such as batch or discrete.

The technical report is intended to be applicable to process control activities within the basic process control system (BPCS) and its interactions with safety instrumented systems (SIS). Required safety instrumented functions (SIFs) should be analyzed and implemented in accordance with ISA-84 (see clause 2). Since automated procedures often interact with SIS, the creation of automated procedures should be performed in close cooperation with SIS implementation teams.

## 2 References

The following referenced documents are useful for understanding this technical report. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies. These references are broken into three categories, cited references, relevant references and reference of interest. These levels reflect the relative importance, relevance or applicability of the individual documents.

All documents designated as ISA or ANSI/ISA may be obtained at [www.isa.org/findstandards](http://www.isa.org/findstandards).

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### 3 Definitions of Terms and Abbreviations

#### 3.1 Definitions of Terms

##### 3.1.1 alarm

Audible, visible, or both means of indicating to the operator a process equipment malfunction, process deviation, or abnormal condition requiring a response.

Note: Based upon the definition in ANSI/ISA-18.2-2009

##### 3.1.2 alert

Audible, visible, or both means of indicating to the operator a process equipment malfunction or a process condition that requires awareness, that is indicated separately from alarm indications, and that does not meet the criteria for an alarm.

Note: Based upon the definition in ANSI/ISA-18.2-2009

##### 3.1.3 automation style

A consistent approach to developing and deploying implementation modules.

##### 3.1.4 basic control

The control dedicated to establishing and maintaining a specific behavior of the process.

Note: Basic control may include regulatory control, interlocking, and monitoring.

Note: As defined in ANSI/ISA-88.00.01-2010.

##### 3.1.5 basic process control system (BPCS)

System which responds to input signals from the process, its associated process equipment, other programmable systems, an operator or any combination thereof, and generates output signals causing the process and its associated process equipment to operate in the desired manner but which does not perform any safety instrumented functions with a claimed SIL  $\geq 1$ .

##### 3.1.6 command

The trigger that initiates an implementation module.

##### 3.1.7 control implementation module

An implementation module based upon control requirements for devices in the physical model.

##### 3.1.8 control requirement

The lowest level in the procedure requirements model, mapping to the device level in the physical model.

##### 3.1.9 device

The lowest level in the physical model that is an input or output to the BPCS and measures or manipulates the process.

##### 3.1.10 enterprise

A physical model level comprised of one or more sites that share a definite mission, goals and objectives to offer an output.

##### 3.1.11 enterprise procedure requirement

A procedure requirement that applies to the enterprise level of the physical model and cannot be fully implemented using the resources of a single site.

Note: Enterprise procedure requirements specify automation at ISA-95 level 2; they specifically exclude business and manufacturing operations management (MOM) system functions.

### **3.1.12 equipment**

A physical model level comprised of equipment, devices or both, and may include process hardware, that performs a finite number of specific processing activities.

### **3.1.13 equipment implementation module**

An implementation module based upon procedure requirements for equipment in the physical model.

### **3.1.14 equipment procedure requirement**

A procedure requirement for the equipment level in the physical model.

### **3.1.15 exception handling**

Those functions that deal with plant or process contingencies and other events which occur outside the normal or desired behavior.

Note: Based on the term as defined in ANSI/ISA-88.00.01-2010.

### **3.1.16 human error**

A mistake, human action or inaction that produces an unintended result.

Note: This is the definition found in ISO/IEC 2382-14-02-03, and differs from that given in IEC 191-05-25 by the addition of "or inaction". [ISO/IEC 2382-14-02-03]

### **3.1.17 human machine interface (HMI, HMI system, operator interface)**

The collection of hardware and software used by an operator to monitor and interact with the control system and with the process via the control system.

Note: As defined in draft ISA-101 WD R3 April 2012, Human Machine Interfaces for Process Automation Systems

### **3.1.18 implementation method**

A tool used to create a task.

Example Programming languages, BPCS configuration tools and a word processor are implementation methods.

### **3.1.19 implementation module**

The developed and deployed result of implementing procedure and control requirements in a BPCS.

### **3.1.20 mode of operation**

An aggregate view of selected lower level process states to facilitate communication among implementation modules and for presentation to the operator.

### **3.1.21 notification**

Messages or information sent to a person.

Note: Alarms, alerts, prompts and status notifications are types of notifications

### **3.1.22 operator**

The person who monitors and makes changes to the process.

Note: As defined in ANSI/ISA-18.2-2009.

### **3.1.23 perform**

To execute an implementation module's tasks.

### **3.1.24 physical model**

The depiction of the hierarchy of tangible process equipment in an enterprise.

**3.1.25 plant**

A physical model level comprised of plant areas, units, equipment, devices or any combination thereof used for producing a set of products.

**3.1.26 plant area**

A physical model level comprised of units, equipment, devices or any combination thereof required for coordinating the operation of units.

**3.1.27 plant area implementation module**

An implementation module based upon procedure requirements for plant areas in the physical model.

**3.1.28 plant area procedure requirement**

A procedure requirement for the plant area in the physical model.

**3.1.29 plant implementation module**

An implementation module based upon procedure requirements for plants in the physical model.

**3.1.30 plant procedure requirement**

A procedure requirement for a plant in the physical model.

**3.1.31 procedure automation**

Implementation of a procedure on a programmable mechanical, electric, or electronic system.

Example Procedures programmed in a BPCS.

**3.1.32 procedure**

A specification of a sequence of actions or activities with a defined beginning and end that is intended to accomplish a specific objective.

Example A clean-in-place procedure.

Note A procedure such as a clean-in-place procedure may define a process that does not result in the production of product.

**3.1.33 procedure implementation model**

The depiction of the hierarchy of implementation modules in a site.

**3.1.34 procedure requirement**

The definition of what is required to accomplish an objective using a procedure.

**3.1.35 procedure requirements model**

The depiction of the hierarchy of procedure requirements in an enterprise.

**3.1.36 process**

1) a sequence of chemical, physical, or biological activities for the conversion, transport, or storage of material or energy.

2) a sequence of chemical, physical, or biological activities that change the condition of equipment. An example would be a clean-in-place process.

Note As defined in ANSI/ISA-88.00.01-2010.

**3.1.37 process control**

The control activity that includes the functions needed to provide sequential, regulatory, and discrete control and to gather and display data.

Note As defined in ANSI/ISA-88.00.01-2010

### **3.1.38 process state**

A definable operating condition of process equipment as it progresses from shutdown to operating and back to shutdown. Each process state represents a unique operating regime that supports the process equipment's objectives of processing an input into a desired output.

**Example** A unit's maintenance wait (down for maintenance), a dual pump set's process wait (getting ready for startup or maintenance) and a plant area's start-up are examples of process states.

### **3.1.39 product**

The desired output or by-product of the processes of a defined portion of the physical model.

**Note 1:** A product may be an intermediate product or end product from a business perspective

**Note 2:** Also defined in ISO 10303 Part 1 as: a substance produced by a natural or artificial process

### **3.1.40 prompt**

A notification that requires the operator to take an action that is part of normal operation.

### **3.1.41 safe state**

Condition of the process when it meets predefined safety requirements.

**Note 1:** In going from a potentially hazardous condition to the final safe state the process may have to go through a number of intermediate safe states. For some situations a safe state exists only so long as the process is continuously controlled. Such continuous control may be for a short or an indefinite period of time.

**Note 2:** This term deviates from the definition in IEC 61508-4 ed2.0 to reflect differences in process sector terminology.

### **3.1.42 site**

A physical model level comprised of plants that is identified by physical, geographical, or logical segmentation.

### **3.1.43 site implementation module**

An implementation module based upon procedure requirements for sites in the physical model.

### **3.1.44 site procedure requirement**

A procedure requirement for the site level in the physical model.

### **3.1.45 state-based control**

A plant automation control design based upon the principle that all process facilities operate in recognized, definable process states that represent a variety of normal and abnormal conditions of the process.

### **3.1.46 status notification**

A notification generated by the BPCS that helps provide the operator situational awareness, is part of normal operation and does not require operator action.

### **3.1.47 task**

Specific action or activity to accomplish a procedure requirement.

### **3.1.48 unit**

A physical model level comprised of equipment, devices or both, and may include process hardware, that carries out one or more major processing activities.

### **3.1.49 unit-based control**

State-based control implemented at the unit level.

### **3.1.50 unit implementation module**

An implementation module based upon procedure requirements for units in the physical model.

### **3.1.51 unit procedure requirement**

A procedure requirement for the unit level in the physical model.

### **3.1.52 verify**

Confirmation that an implementation module's tasks were performed successfully or failed.

## **3.2 Abbreviations**

|        |      |                                                   |
|--------|------|---------------------------------------------------|
| 3.2.1  | ANSI | American National Standards Institute             |
| 3.2.2  | ASM  | Abnormal Situation Management Consortium          |
| 3.2.3  | ASME | American Society of Mechanical Engineers          |
| 3.2.4  | ASTM | American Society for Testing and Materials        |
| 3.2.5  | BPCS | Basic Process Control System                      |
| 3.2.6  | DOE  | United States Department of Energy                |
| 3.2.7  | HMI  | Human Machine Interface                           |
| 3.2.8  | IEC  | International Electrotechnical Commission         |
| 3.2.9  | IEEE | Institute of Electrical and Electronics Engineers |
| 3.2.10 | IEV  | International Electrotechnical Vocabulary         |
| 3.2.11 | ISA  | International Society of Automation               |
| 3.2.12 | ISBN | International Standard Book Number                |
| 3.2.13 | ISO  | International Organization for Standardization    |
| 3.2.14 | MOM  | Manufacturing Operations Management               |
| 3.2.15 | NPRA | National Petrochemical & Refiners Association     |
| 3.2.16 | NQA  | Nuclear Quality Assurance                         |
| 3.2.17 | PFC  | Procedure Function Chart                          |
| 3.2.18 | PID  | Proportional Integral and Derivative              |
| 3.2.19 | SFC  | Sequential Function Chart                         |
| 3.2.20 | SIF  | Safety Instrumented Functions                     |
| 3.2.21 | SIL  | Safety Integrity Level                            |
| 3.2.22 | SIS  | Safety Instrumented System                        |
| 3.2.23 | SPE  | Society of Petroleum Engineers                    |

## 4 Historical Perspective

Over the history of the continuous process industries there has been steady movement to automate procedures.

In the early days, plant operation and control were primarily manual activities. Many people were required to run a chemical plant since each person could only manage one or two, or maybe a handful of valves at most. For example, a distillation tower may have had one person manage the reboiler and a second person the reflux drum. Each was an operator and used a set of procedures for each operation. These procedures would instruct them as to which valve to open or close and when/how this was to be performed.

Probably the first use of automation occurred when measurements were brought to the operator. This made procedures simpler to execute as less communication among operators was required. This automation also allowed the scope of work for an operator to be extended and provided the operator with direct feedback of his actions.

The next level of automation was the use of remote actuators on valves. This allowed the operator to manage an even larger part of the process, enabling the use of fewer operators, which in turn made the procedure even simpler as less communication and interaction was needed among operators.

The advent of the PID controller enabled operators to manage many more devices. This automation changed the procedures. With PID controllers, the procedure no longer had to describe if the valve needed to be opened or closed; rather, it only had to instruct when and what setpoints needed to be set. The technology of PID controllers moved many of the original procedures into basic control.

PID controller technology advanced from pneumatic to electronic, and then from electronic to software. Procedures in turn changed to accommodate the newer technology. Procedures became more focused on the process and objectives and less on the mechanical management of the process equipment. This was the generation of loop based control and paper procedures.

Today there are more powerful BPCS and the next generation of automation is occurring. As more pieces of process equipment are merged into larger and more complex control implementation modules and equipment implementation modules, additional layers of abstraction are added.

If no integration is applied to a pump with its block valves, each device needs to be addressed as a separate entity, and the pump start procedure needs to address which valves need to open first and when to start the pump. If the pump and its valves are automated as an equipment implementation module and all the automation is embedded in it, the procedure does not need to know the type of pump, the valve setup for a specific pump, or even the procedure to open valves and start the pump. The procedure only needs to request that the pump be started and all the necessary basic control be executed in the equipment implementation module. As a result, the valves will open in the correct order and the procedure will be much simpler.

Manual procedures may be made smaller and simpler by automating parts of the procedure through creating equipment implementation modules and control implementation modules.

This technical report describes how companies are performing this latest generation in the ongoing evolution of procedure automation.