Automating Procedures in Continuous Process Applications using ISA 106

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MESA KNOWS
SUSTAINABILITY & ECO-EFFICIENCY - LEAN - METRICS & PERFORMANCE MANAGEMENT - INFORMATION INTEGRATION - SAFETY - ASSET PERFORMANCE MANAGEMENT - B2MML - QUALITY & COMPLIANCE - PRODUCT LIFECYCLE MANAGEMENT - AUTOMATION

Do you know MESA?
Today’s Goals

• Provide an overview of current standardization activities regarding automated procedures

• Explain how you can get started
Agenda

• Automated Procedures Introduction – Dave Emerson
  – Historical Perspective
  – ISA106 Standards Committee
  – Benefit Proposition
  – Examples

• Modular Procedural Automation (MPA) – Leila Myers
  – What is MPA?
  – Consulting Methodology
  – How to select the right tool for the job
  – Exapilot examples
  – CENTUM VP examples
Over the course of the continuous process industry’s life there has been steady movement to automate procedures.

In the early days:
- All operations done in the field
- Lots of people required
- Few valves per person
- Procedures used, may not have been written
- 1st automation was probably bringing measurements to the operator
- Less field work required
- Quicker feedback to operators on actions they performed

The power of knowing what MESA knows
Remote actuators on valves introduced
- Operators could manage larger parts of the process
- Fewer field operators

PID controllers removed operators from the loop
- Operators now supervised loops, no longer performed control
- Operators could manage larger parts of the process
• Computer based control systems...Distributed Control Systems...Centralized control rooms...Advanced Process Control
  – more pieces of process equipment are merged into larger and more complex control strategies
  – Additional layers of abstraction takes place

• But, in most continuous process plants operators still perform most procedures manually
  – Complex procedures
    • Starting a distillation column
  – Repetitive procedures the operator adds little value to
    • Starting pump sets by controlling individual values and pump controls
Why Not Just Use ISA-88?

• In the 17 years since ISA-88 has been a standard it has been widely adopted in the batch industry, but only used on an individual basis in the continuous process industries
  – When used for continuous processes “tweaks” had to be made, so not a perfect fit
• Continuous processes have different characteristics from batch
  – Ingredients not treated the same
  – Many different procedures used, not always tied in a nice “recipe bundle”
  – Equipment independence not a significant factor
→ No significant adoption, Time for something different
  – ISA106 is an attempt to get the continuous process industries to discuss and standardize procedure automation holistically
  – Goal: Make procedure automation an expected part of any capital project
ISA-106

- ISA standards committee
- Creating a standard
  - Procedure Automation for Continuous Process Operations
- Membership
  - Owner/Operators, Suppliers, Consultants
  - Open to any interested person or company
Membership (partial)

- ABB
- Aramco Services Co
- AREVA
- Bayer MaterialScience
- BP Lubricants
- Braskem
- CDM Smith
- CH2M HILL
- Chevron
- Conocophillips
- DSM Corporate Operations
- DuPont
- Emerson Process Management
- ExxonMobil
- Herman Storey Consulting
- Honeywell
- Innovatia
- Invensys
- Mustang Automation and Control
- NovaTech Process Solutions
- PAS
- Prosys
- Rockwell Automation
- RSI Simcon
- Saudi Aramco
- Savannah River Nuclear Solutions
- Shell
- The Dow Chemical Company
- Valero Energy Corp
- Yokogawa
Committee Work Items

• Recently completed the first of three Technical Reports
  – TR #1 - Procedure Automation for Continuous Process Operations - Models and Terminology
  – TR #2 – Examples
  – TR #3 – Automated Procedure Life-cycle

• Standard will be produced based upon the Technical Reports and industry feedback
Benefit Proposition

• Automating procedures
  – Improves business results
  – Reduces risk – fewer operational errors
  – Ensures compliance

• Studies have shown that procedure errors are a primary cause of many incidents
Procedural Operations

• ALL process operations in ALL industries have procedural operations
  – Normal, safe operation
  – Change of state e.g. Start up, Shut down, Transition

• Procedures may be:
  – Operator Knowledge (Tribal lore)
  – Manual via Written SOP’s
  – Semi-Automated
  – Automated


Refinery Incidents - FAT/CATs

• Kern Oil Refinery in Bakersfield, California on January 19, 2005
  – Incident killed one employee and caused multiple injuries to other employees
  – Crude unit start-up
  – Workers over pressurized a pump casing which catastrophically ruptured, releasing and igniting hot oil that immediately exploded

• Giant Industries Ciniza Refinery, Gallup, New Mexico, April 8, 2004
  – 6 employees were injured, 4 requiring hospitalization with serious burn injuries
  – During hydrofluoric acid (HF) alkylation unit maintenance a shut-off valve was not closed as required, caused release of flammable liquids and vapors which caused subsequent explosions
Typical Targets for Automated Procedure

• Refining
  – Transition Management - Crude Switchover
  – Regeneration

• Petrochemical
  – Startup / Shutdown
  – Transition Management – Grade Changes
  – Line Switchover
  – Cleaning

• Polymers
  – Grade change
  – Switchover

• Furnaces
  – Decoking
Refinery – Transition Automation

- Opportunity to automate a feed switch
- Benefits:
  - Operator workload reduced by 60%
  - A 42% reduction in product yield loss
  - Increased feed throughput during transition by 18%
  - Reduced feed switch transition time by 36%

Console Operator Moves per Hour Comparison from paper “Improving Refinery Unit Transitions Using Process Automation Technology in a base Oil Hydroprocessing Facility. AIChE Spring 2011 Robert M. Tsai, Chevron, Richmond, CA
Acrylic Acid Production

- Start-up time to steady state was reduced by 30%.
- Less variability in start-up time.
- Reactors able to come on stream 70% faster.
- Process safety margins, of explosive conditions during startup, were significantly increased.

Benefits Derived from Automating Procedures

- **Improved safety performance**
- **Improved reliability**
  - More consistent operation
- **Reduced losses**
  - Fewer operator errors
  - Improved responses to disturbances
- **Increased Production**
  - Faster & more consistent startups and shutdowns
  - More efficient transitions
- **Improved Operator Effectiveness**
  - Automated procedures are tools for the operator
- **Knowledge capture**
  - Improved training
- **Improved insight into the process**
  - Design process can improve procedures

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• 1st Technical Report
  – States committee’s current thinking on how to organize and approach procedure automation

• Models
  – Concepts to give the industry a common mental model for automated procedures

• Terminology
  – Definitions to give the industry a common language for automated procedures
Physical Model

- Organizes physical equipment into a hierarchy
- Provides a common set of terms and equipment levels for companies & industries to map their terms to
  - Common terms enable products and people to work more efficiently with different owner/operators.
- Physical model is the foundation of the ISA-106 work
  - Each item in the model can have procedures
## Physical Model - Today

### Results of committee owner/operator terminology

<table>
<thead>
<tr>
<th>ISA-106</th>
<th>Chemical Company</th>
<th>Oil Refinery</th>
<th>Offshore Oil Platform Example 1</th>
<th>Offshore Oil Platform Example 2</th>
<th>Paper Industry</th>
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</thead>
<tbody>
<tr>
<td>Enterprise</td>
<td>Enterprise</td>
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<td>Field</td>
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<td>Platform</td>
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<td>Plant</td>
<td>Plant</td>
<td>Complex</td>
<td>Package</td>
<td>Mill</td>
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<td>Plant Area</td>
<td>Area</td>
<td>Plant</td>
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<td>Unit</td>
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<td>Equipment</td>
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<td>Device</td>
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</table>
### Physical Model - Examples

#### Results of committee owner/operator terminology

<table>
<thead>
<tr>
<th>Enterprise</th>
<th>Corporate</th>
<th>Division</th>
<th>Business Unit</th>
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</thead>
<tbody>
<tr>
<td>Site</td>
<td>Complex</td>
<td>Train</td>
<td>Facility</td>
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<tr>
<td>Plant</td>
<td>Platform</td>
<td>Train</td>
<td>Verbund</td>
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<td>Plant Area</td>
<td>Separation</td>
<td>Train</td>
<td>Sub-sea</td>
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<td>Injection</td>
<td>Utilities</td>
<td>Water</td>
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<td>Treating</td>
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<td>Plant</td>
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<td>Gas</td>
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<td>Compression</td>
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<td>Production</td>
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<td>Manifold</td>
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<td>Unit</td>
<td>Separator</td>
<td>Dry/Wet Oil</td>
<td>Pipeline</td>
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<td>Tanks</td>
<td>Pumps</td>
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<td>Hydrocyclone</td>
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<td>Equipment</td>
<td>Pump Set</td>
<td>Feed System</td>
<td>Reboiler</td>
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<td>Sampling</td>
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<td>System</td>
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<tr>
<td>Device</td>
<td>Control Valve</td>
<td>Transmitter</td>
<td>Pump</td>
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<td>Analyzer</td>
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</tbody>
</table>

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Ethylene Furnace Example
Procedure Requirements Model

- Procedures are associated with objects in the physical model
  - Most common for units, equipment and devices

- Definition of the procedure
  - What must be done to accomplish it’s objective
  - Functional requirement for the automated procedure
The actual automated procedure

- Program, function block, sequential function chart, flowchart,…

The design of implementation modules is an engineering process

- Procedure requirements are the specification
- Not always a 1:1 mapping with procedure requirements
Implementation Modules

- Consist of a set of ordered tasks
  - Tasks may contain tasks
- Tasks perform step by step actions
Implementation Modules

- Implementation methods are any type of tool used to create a task.
  - Programming
  - Continuous Control
  - Human Actions.

- Examples of programming types
  - Computer programs
  - Configurable function blocks
  - Continuous control functions
  - Executable flowcharts.
  - Procedure Function Charts (PFC)
  - Sequential Function Charts (SFC)
Procedure Execution

- Each Procedure, Implementation Module & Task has 3 execution work items
  - Command – Trigger
  - Perform – Actions
  - Verify – Success/Failure
- Computer/Human Mix
  - C-P-V work items can be done by a computer or human

Command >>>>>> Perform >>>>>> Verify
Implementation Module Execution

• Three work items are typically used for implementation module execution:
  – Command – The trigger to initiate the implementation module. When received this causes the implementation module to perform its tasks.
  – Perform – The execution of an implementation module’s tasks.
  – Verify - Verification that the implementation module’s tasks were performed successfully or failed.
Automation Styles

- Organization of the structure of the implementation module such as using procedure sections or process states
- Use of computer or operator action for command, perform, verify
- Amount of precision used for verification
- Human machine interface philosophy
- Degree of automation from minimal automation to complex automation

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Automation Style Examples

• Manual
  – The Operator is responsible for the command, perform and verify work items, minimal automation is used

• Computer Assisted
  – Operator and computer share responsibility for the command, perform and verify work items. The amount of automation used may vary.

• Fully Automated
  – Computer is responsible for the bulk of the command, perform and verify work items.
# Operator Notifications

<table>
<thead>
<tr>
<th>Operator Notification Types</th>
<th>Operator is expected to take an action</th>
<th>Operator might need to be aware but is not required to take action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arises from an abnormal process or equipment situation (ISA-18.2)</td>
<td>Alarm</td>
<td>Alert</td>
</tr>
<tr>
<td>Arises from a normal situation (ISA-106)</td>
<td>Prompt</td>
<td>Status Notification</td>
</tr>
</tbody>
</table>

ISA-106 has worked with ISA-18.2 which has published an alarm management standard.
State-based Control

• A plant automation control design technique that assigns process states and defined transition procedures
  – Most effective at the unit level
  – Provides a high degree of automation
  • Startup, Shutdown, Transitions, Abnormal Situation Responses

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State-based Control Example

Preparing Mode of Operation

Ready (Idle) Mode of Operation

Startup Mode of Operation

Running Mode of Operation

Abnormal (Off Spec) Mode of Operation

Shutting Down Mode of Operation

Prepare Procedure

Startup Procedure

Production Rate of Change Procedure

Abnormal Condition Handling Procedure

Controlled Shutdown Procedure

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Control System Architecture

Manual Procedures

Operator

Basic Process Control System

Advisory Computer

Procedure Implementation Modules

Human Machine Interface

Controller

Procedure Implementation Modules

Safety Instrumented System

Auxiliary control system
(PLC, compressor control, skid, robot, vision,...)

Inputs

Outputs

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ISA-106 Key Models

**Physical Model**
- Enterprise
  - Site
  - Plant
    - Plant Area
    - Unit
    - Equipment
      - Device

**Procedure Requirements Model**
- Enterprise Procedure Requirements
  - Site Procedure Requirements
    - Plant Procedure Requirements
      - Plant Area Procedure Requirements
        - Unit Procedure Requirements
          - Equipment Procedure Requirements
            - Device Procedure Requirements

**Procedure Implementation Model**
- Site Implementation Modules
  - Plant Implementation Modules
    - Plant Area Implementation Modules
      - Unit Implementation Modules
        - Equipment Implementation Modules
          - Control Implementation Modules

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Part 1 Summary

• Automated procedures in continuous process operations can help make a plant safer & more competitive

• Automated procedures are not widely used today
  – Great opportunity for improvement

• ISA-106 is open to all interested parties
  – ISA membership is not required

• TR #1 is the first step
  – We need more industry input
Thank you

20 YEARS & KNOWING
OUR MEMBERS ARE THE MOST AGILE COMPANIES IN THE WORLD. THEY KNOW THEY HAVE A RESPONSIBILITY TO INDUSTRY AND TO ONE ANOTHER. THEY KNOW THE CONSEQUENCES OF AVOIDING A SINGLE IMPROVEMENT CAN MEAN MILLIONS OF DOLLARS AND A POSSIBLE GLOBAL IMPACT. THEY KNOW THE POWER OF KNOWING WHAT MESA KNOWS.

“We saved $2.4 million because our operations team was able to make a case for improvement with resources from MESA.”

Global Education Program
MESA has trained over 500 professionals and provides 800+ pieces of content valued at over $13 million dollars.

“At the Global Education Programs, I learn from mistakes and successes of other manufacturers, I network with the best, AND the cost is credited to my membership fees. Becoming a member was a no-brainer.”

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