ARC WHITE PAPER

By ARC Advisory Group

JANUARY 2017

Augmented Manual Procedures Can Help Improve Process Operations

Executive Overview

A combination of solutions has been deployed to mitigate unplanned process events since the introduction of OSHA PSM. Unfortunately, the rate of improvement has been flat since 2012. What will it take to reach the next paradigm of performance?

Twenty years ago, the US Occupational Safety and Health Administration (OSHA) issued its Process Safety Management (PSM) of Highly Hazardous Chemicals standard. The objective was to spell out the requirements for preventing or minimizing the consequences of catastrophic releases of toxic, reactive, flammable, or explosive chemicals that could result in toxic, fire, or explosion hazards.

Recent analysis of abnormal events in the process industry by both the AIChE – Center for Chemical Safety and the US Chemical Safety Board indicates that, though major progress has been made, the improvement trajectory seems to have plateaued.

Most companies affected by the regulation have deployed a combination of solutions involving human behavior management, equipment safety systems, and more extensive operating procedures as depicted in Figure 1.

Not only have improvements in avoiding abnormal events tapered off, a deeper investigation reveals that the severity of these less-frequent incidents is climbing at a disturbing and surprising rate from the perspective of injury, illness, environmental exposure, and property damage (Figure 2).

This raises the questions: "What is different?" and "Have the failure mechanisms that initiate abnormal events changed?"

The most recent investments in technology, training, and enforcement have not succeeded in eliminating the root causes of these complex events.

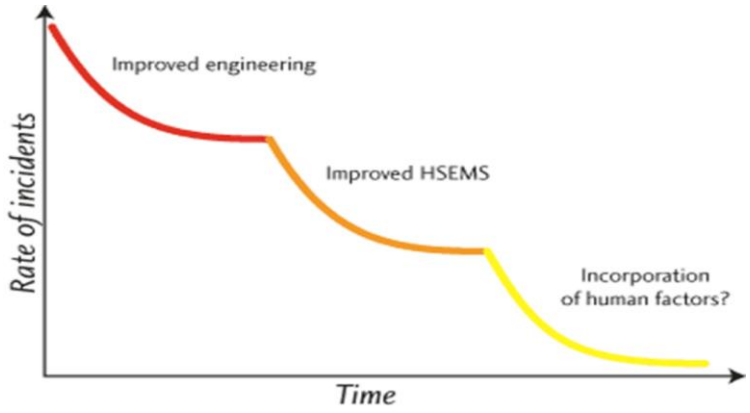

Fig. 1: Progress in Management of Abnormal Events (Source: Oil & Gas Institute)

Figure 2: Abnormal Event Severity Index (Source: AIChE Process Safety Database)

The Case for Change

This phenomenon has not gone unnoticed. The Abnormal Situation Management (ASM) Consortium, regulatory agencies, and other organizations have researched the root causes. A hypothesis has emerged suggesting that the increased span of operational control has made decision making more complex, especially when combining manual tasks with automated actions under stressful conditions.

The answer for dealing with today's complex operating environment goes beyond isolated solutions related to basic process automation, behavioral management policies, and operator training, respectively. Avoiding or mitigating the impact of abnormal situations involves interactions between man, methods, and machines (Figure 3). Closing the gaps between these three domains should mitigate systematic failure points that would otherwise be left unchecked in today's largely non-integrated solutions.

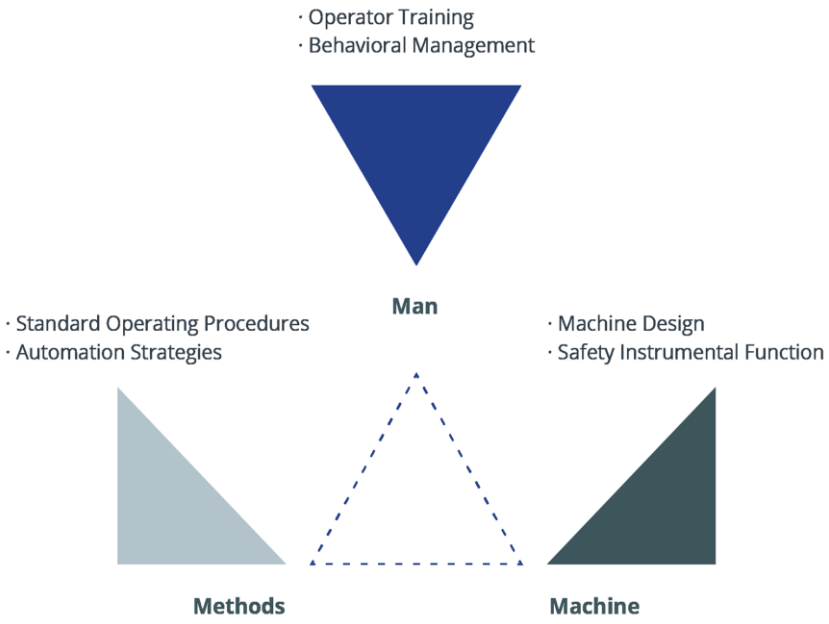

Figure 3: Integrating Routine and Non-Routine Manual Tasks with Automated Procedures and Fail-Safe Designs

The Root Causes

Incidents rarely have a single cause. In most, if not all cases, a combination of factors results in an unplanned event. Addressing these multiple factors in an integrated manner requires first evaluating the sources or root causes at the points of failure. Figure 4 shows the categories and percentage of abnormal incidents based on primary root cause assigned by the incident investigating body. The process event database identifies inappropriate human action as the primary cause in 42 percent of the cases and human actions were also noted as a secondary contributing cause in over 80 percent of the cases.

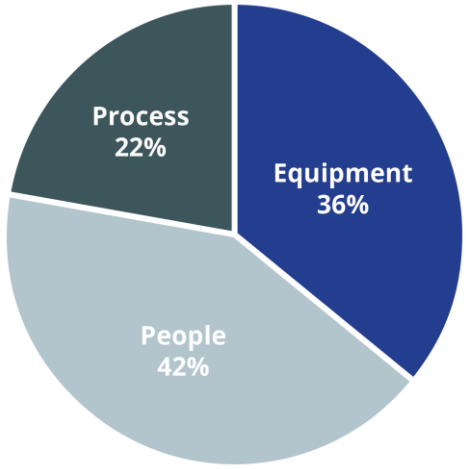

Figure 4: Primary Categories of Causes for Abnormal Process Events (Data Sources: Oil & Gas Producers Report and AIChE Process Incident Database)

It would not be accurate to ascribe "operator error" as the main contributor to process events. However, given the significance of human factors in preventing these events, a more comprehensive or integrated IT solution approach must be developed if the

industry is to achieve a breakthrough in improving safety. A holistic, system-level reliability analysis of man-machine-methods might be useful to quantify the risk and reward of addressing the problem. Figure 5 depicts a physical model for Man + Computer + Method.

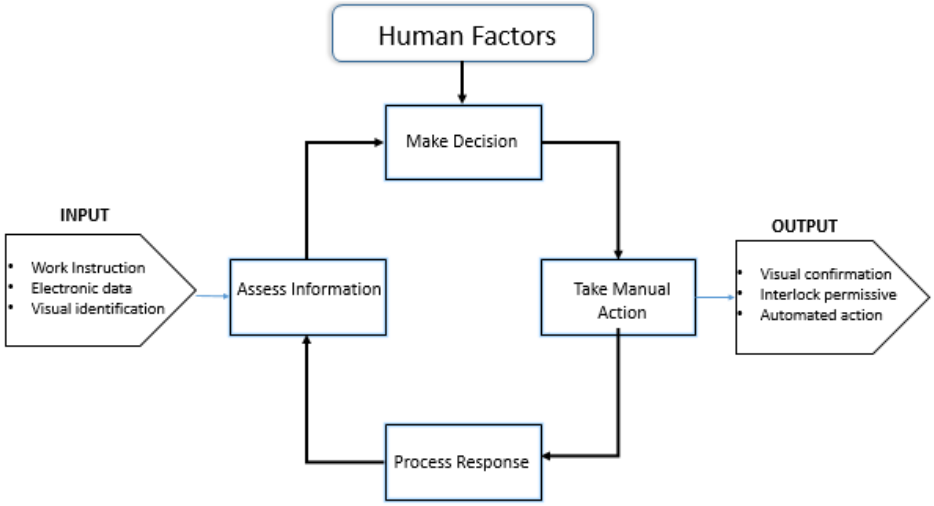

Figure 5: Process Diagram – Human Factors in Decision Making

Probability of failure on demand (PFD) is a recognized metric for performing risk-based analysis. Using the manual task physical model, one can perform risk analysis of all component failures to address the problem represented by the holistic system.

With failure modes identified, a rigorous assessment of the potential effect of each event scenario can then be performed to prioritize the need and type of mitigation best suited for the problem based on the frequency of occurrence, the severity of an incident, and the detectability of the failure mechanism mitigations.

Most abnormal events have a human procedural execution component. Therefore, it is likely that a semi-automated or *computer-assisted* solution that augments and error proofs the human execution of a manual task, in concert with an automated control strategy, may provide a cost-effective solution to meet the emerging performance challenge.

Typical Use Case

Operations personnel deal with routine tasks daily on an ad hoc basis. Process control systems deterministically deal with steady-state regulatory control on a second-by-second basis. Standalone behavioral management systems work well with disciplined execution and associated compliance issues in an ad hoc manner, as needed.

Unfortunately, in the real world, deviations from steady-state operating conditions do occur. This requires corrective action by either the automation system, the operator, or both, following the prescribed rule set that applies to that equipment and task. Each of these systems is designed to solve their respective problem, but not necessarily that of the operator in his/her complex work environment.

Most manufacturing businesses create a combination of the above solutions and deliver them to the doorstep of operations. Operators are then tasked to use these tools and systems to perform their daily duties. For the most part, these non-integrated solutions are acceptable, until the operator faces events requiring expedient decisive actions.

Computerized assistance could help mitigate abnormal events. This assistance could be provided to the operating team to augment human decisions and associated manually executed tasks, in concert with integrated control system actions.

Common activities requiring procedural integration include:

- ***Maintenance Prep*** - Isolating and interlocking a pump to be repaired
- ***High Integrity Material Flow*** – Making manual additions to a reactor
- ***Material Loading or Off-loading*** - Tank truck/rail car to storage
- ***CIP (clean-in-place)*** - Decontaminating a vessel prior to a new campaign
- ***Tank Lineups*** - Valve alignment for movement between a network of storage options
- ***Decoking*** - Cyclic removal of debris to improve heat transfer in fired equipment

Proposed Solution

Several emerging technologies (such as process state engines) and standards (such as ISA88 and ISA106) could potentially address the problem through increased levels of automation. The consensus of several end users and practitioners in the process industries suggests there are two competing approaches:

1. One incorporates a high degree of human control over a process, complete with fully manual procedural execution with detailed written procedures, formalized auditing, and rigid enforcement.

2. The other is a fully automated solution that eliminates the human factors altogether.

For the 20 percent of those problems that are process safety-critical, maximum automation would make the most sense. For routine, non-critical tasks, manual procedures could certainly be implemented.

In most situations, the decision is not clear cut, requiring a balanced compromise. This choice is typically made based on cultural norms and/or economic constraints. The consequences of these choices result in potential failure points due to integration gaps between man, machine, and methods.

Finding the Compromise

In most cases the starting point is the documented operating discipline provided to the technician. This could be issued as a primary work instruction or a supplement or reference. Most tasks in the process industries are covered by a standard operating procedure (SOP) written by process-knowledgeable engineers for the operators to execute. SOPs have been mandated for use in highly hazardous processes and are considered good manufacturing practices for non-hazardous operations.

A balance needs to be found between fully instrumented, automated procedures and those manually executed by operators.

The challenges in industry today are twofold:

1. Fewer than 50 percent of the field devices are instrumented for fully closed-loop control. In many cases the economics do not justify capital investment in higher levels of automation.

2. Strong resistance by the operations community remains when it comes to taking control out of the hands of operators. This resistance is largely based on cultural norms and labor contracts.

To achieve a breakthrough in operational performance and preventing unplanned events, a balance needs to be found between fully instrumented and automated procedures and those manually executed by operators. The integration of man, methods, and machine must thus be considered as a holistic and viable solution.

The NovaTech Solution – Augmented Manual Procedures

To enable a breakthrough in operational performance and find the balance between manual and automated actions, an integrated, computer assisted procedural automation solution is required. This solution must strive for:

- Standardized, open technical architecture that can supplement the existing automation platform to provide incremental improvement without extensive capital investment
- A user experience that adapts to both the needs of the engineer and operator
- A solution that is extensible to environments in the field as well as the control center
- Secure transmission of interlocking permissives between the manual and automated domains

NovaTech's *Paperless Procedures™ (PLP)* is being enhanced to become a platform-neutral solution that bridges operator manual procedures and engineered control strategies (Figure 6). PLP helps ensure safe and consistent decision-making, provides a fast way to disseminate new procedures, and facilitates documentation and compliance requirements. The PLP application is displayed in run-time as an operator-friendly checklist.

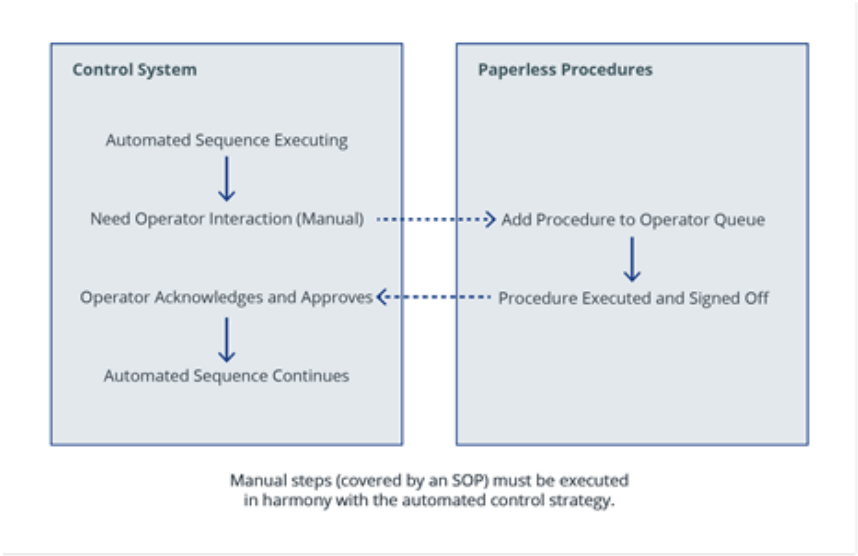

Figure 6: Integrating Manual and Automated Actions

The application can be launched on a control room HMI, tablet, or smartphone to enable field mobility. Field proximity devices such as bar-coding or markers can also be integrated into the overall solution using scanning capability to identify location and position of devices that are not connected to the automation system. In the future, NovaTech envisions that the PLP platform can be deployed with augmented reality solutions to provide hands-free capability.

In the field, the manual procedure is linked via mobile device to the process control platform through OPC, which enables bidirectional communication of associated equipment status and field task completion. The automated control schema consumes the task completions as digital permissives to conditionally interlock automated actions. Permission for the automatic mode to proceed is then enabled by the board operator, confirming that field actions were completed in the appropriate time and sequence. The two-level review helps ensure accuracy and conformance to the approved procedure, thus reducing manual errors and improving execution consistency.

A Unique Value Proposition

To improve its products, NovaTech conducts ongoing surveys among its customer base to enhance the functional capability and utility to end users. Third-party research, coupled with customer interviews, indicates that accuracy of procedure, presentation format, accessibility in the field, and platform-neutral compatibility are required for effective implementation.

NovaTech designed its PLP solution (Figure 7) with some key differentiators versus competitors' solutions:

- Ensuring Procedural Accuracy - NovaTech PLP utilizes the industry-recognized ISA88 methodology for manual procedure decomposition and validation using a Microsoft Visio environment for the engineer to configure and confirm the logical correctness of execution.

- Presentation Format - Operator user experience has been aligned to cultural norms in the form of a MS Word or PDF checklists. These checklists are written in the language of choice to ensure operator understanding.

- Automated Documenting - Completed tasks are self-auditing and time-stamped for future reference and compliance reporting.

- Open System - OPC-compliant integration provides platform-neutral compatibility across disparate control systems. This reduces the costs required to upgrade the level of automation, since the existing infrastructure can be retained.

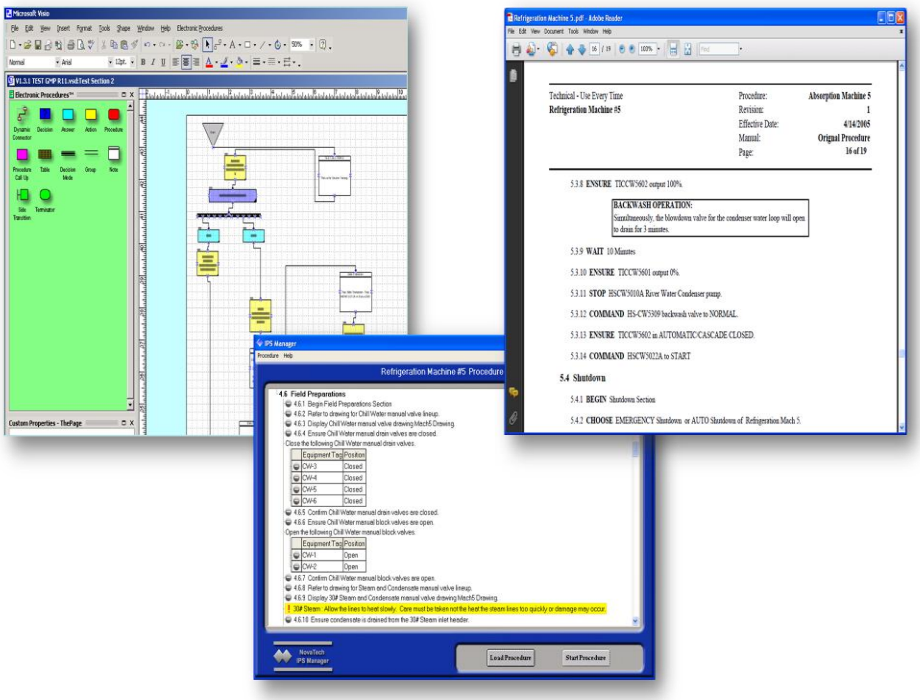

Figure 7: Functional Features of NovaTech PLP Solution
Views Supported: S88 Engineering; AIChE Operator Checklist; Compliance Auditing

Summary and Recommendations

Manual procedures in the process industries will surely persist into the future due to economic factors and/or cultural norms. To optimize operational performance, operating companies must strike a balance between the two different styles of procedural execution.

Computer-augmented manual procedures represent such a compromise by combining SOPs with automated process control strategies. NovaTech's PLP accomplishes this in a platform-independent, mobile-enabled manner.

Paperless Procedures improves plant performance and safety by increasing the integration between field manual and automated procedures, enabling more consistent, reliable execution of procedures.

Recommendations

- Users should perform failure modes analyses on the most critical tasks to determine where integrated man-machine-methods solutions could be best applied.
- Users interested in improving operational performance should consider investigating augmented procedural management solutions to find cost effective alternatives for implementing higher levels of automation.
- Users should consider open solutions, such as NovaTech's PLP, to improve levels of procedural automation and reduce the frequency of abnormal events and/or mitigate their impact.

Analysts: Mike Williams and Peter Reynolds
Editors: Paul Miller and Sharada Prahladrao

Acronym Reference: For a complete list of industry acronyms, please refer to www.arcweb.com/research/pages/industry-terms-and-abbreviations.aspx

API	Application Program Interface
ASM	Abnormal Situation Management Consortium
B2B	Business-to-Business
BPM	Business Process Management
CAGR	Compound Annual Growth Rate
CAS	Collaborative Automation System
CMM	Collaborative Management Model
CPG	Consumer Packaged Goods
CPM	Collaborative Production Management
CRM	Customer Relationship Management
DCS	Distributed Control System
EAM	Enterprise Asset Management
ERP	Enterprise Resource Planning
HMI	Human Machine Interface
IOp	Interoperability
IT	Information Technology
MIS	Management Information System
OpX	Operational Excellence
PAS	Process Automation System
PFD	Probability of Failure on Demand
PLC	Programmable Logic Controller
PLM	Product Lifecycle Management
RFID	Radio Frequency Identification
ROA	Return on Assets
RPM	Real-time Performance Management
SCM	Supply Chain Management
SOP	Standard Operating Procedures
WMS	Warehouse Management System

Founded in 1986, ARC Advisory Group is the leading research and advisory firm for industry. Our coverage of technology from business systems to product and asset lifecycle management, supply chain management, operations management, and automation systems makes us the go-to firm for business and IT executives around the world. For the complex business issues facing organizations today, our analysts have the industry knowledge and first-hand experience to help our clients find the best answers.

 This research has been sponsored in part by NovaTech. However, the opinions expressed by ARC in this paper are based on ARC's independent analysis.

You can take advantage of ARC's extensive ongoing research plus experience of our staff members through our Advisory Services. ARC's Advisory Services are specifically designed for executives responsible for developing strategies and directions for their organizations. For membership information, please call or write to:

ARC Advisory Group, Three Allied Drive, Dedham, MA 02026 USA
Tel: 781-471-1000
Visit our web pages at www.arcweb.com

3 ALLIED DRIVE DEDHAM, MA 02026 USA 781-471-1000