New Paradigms in Mitigating Unplanned Events Caused by Human Error

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The Problem

602 day timeframe:
- 355 chemical accidents
- 79 deaths
- 1500 hospitalizations
• "More than 100 people treated after chemical leak in Atchinson, Kansas"
  • Sodium hypochlorite and sulfuric acid were inadvertently mixed

• "Third body found after chemical plant explosion"
  • Workers had been carrying out scheduled maintenance on an empty pipeline connecting storage tanks to an area where liquids are unloaded from ships

• "Explosion at industrial estate kills 12 workers"
  • Explosion and fire occurred while workers were cleaning the polymer production line to change between batches and using toluene as a cleaning solvent

• "Geismar, Louisiana chemical plant explosion leaves 2 dead, 77 injured"
  • CSB found a number of PSM weaknesses... deficiencies in implementing Management of Change (MOC), Pre-Startup Safety Review (PSSR), Process Hazard Analysis (PHA) programs, and procedure programs causal to the incident
People Make Costly Mistakes

• Human error is the primary cause in 42% of abnormal events; 80% when included as a secondary cause

• Human error has led to losses in excess of $75 million per incident

Source: ASM Consortium

Source: Marsh & McLennan
Industry Plateau

• Statistics from industry and government sources indicate that the process safety incident frequency has dropped dramatically.

• However, the improvement trend seems to have plateaued.

Source: Performance Consultants International

Fatal injuries among workers in the oil and gas extraction industry in United States

Industry Breakthroughs

- Industry has made breakthroughs due to guidelines around human factors
  - ISA 88: Batch
  - ISA 18.2: Alarm Management
  - ISA 101: HMI
  - ISA 106: Automated Procedures
Improvements in Automation

• Computer-based automation
• Automated sequence control
• Batch management
• Integrated control/advanced process control
• HMI improvements – high performance HMIs and alarm management
Typical Manual Tasks

- Material loading and unloading
- Startups and shutdowns
- Tank to tank line-ups
- Grade changes
- Clean-in-place
- Decoking
Why Not Automate?

• Economics rarely justify capital investment in higher levels of automation
  • Fewer than 50% of field devices are instrumented for full, closed-loop control

• Coordination between different islands of automation
Progress with Manual Procedures

- Books written on how to write better procedures
- Software
  - Algorithms to check for consistency
  - Repositories
  - Procedure and user management
  - Checklists
Top 5 Reasons Why SOPs Are Not Used

1. People **lack** personal **skills and experience**
2. People **assume they know** what is in the procedure
3. **Not enough time** if they followed the procedure "to the letter"
4. People are **not aware** that a procedure **exists**
5. **Too difficult to locate** the right procedure

Source: Human Reliability Associates
Current Method – Uncoordinated Efforts

- Operator Training
- Behavioral Mgmt

- Standard Operating Procedures
- Automation Strategies

- Machine Design
- Safety Instrumented Function

MAN

METHOD

MACHINE
Integration of routine (and non-routine) manual tasks with automated procedures and fail safe designs can provide the next paradigm in operational performance.
Integrated Solution Requirements

- Standardized, open technical architecture that can supplement the existing automation platform without extensive capex
- A user experience that adapts to both the needs of the engineer and operator
- Secure transmission of interlocking permissives between the manual and automated domains
- Usable within a range of plant environments
Higher Levels of Automation for Manual Procedures

• Deterministic behavior is valued in process control
• How can we apply the same to manual procedures?
  • Accessibility
  • Consistency (human factors)
    • Writing and executing a procedure
  • Connectivity
  • Culture
Integrating Automated and Manual Actions

Automated (Control System)

- Automated Sequence Executing
- Manual Operator Action Required
- Operator Acknowledges and Approves
- Automated Sequence Continues

Manual Actions (Procedures)

- Add Procedure to Operator Queue
- Procedure Executed and Signed Off
Integrating Automated and Manual Actions

Manual Actions  
(Procedures)

- Manual Procedure Executing
- Automated Action Required
- Procedure Waits for Control System
- Manual Procedure Continues

Automated  
(Control System)

- Receive Instruction from Procedure
- Execute Instruction
Enabling Technologies

• OPC
• Wireless networks
• Location tracking (e.g. GPS, indoor)
• Fiducial markers
  • Electronic: NFC/RFID
  • Physical: Barcode/QR
• Cameras and image recognition
• Augmented Reality
Example

- Material Unloading
Sample Procedure

5.2.4 IS the Mix Tank sample GOOD?

Yes

NOTE:
These steps will prepare and UNLOAD the Mix Tank to a truck.

- 5.2.4.1 INSPECT all truck hoses for leaks and wet spots.
- 5.2.4.2 SECURE the tank vehicle with wheel chocks and interlocks.
- 5.2.4.3 VERIFY the vehicle’s parking brakes are set.
- 5.2.4.4 ESTABLISH adequate bonding/grounding prior to connecting to the fuel transfer point.
- 5.2.4.5 ENSURE cell phones are turned OFF.

CAUTION:
Driver must stay with the vehicle at all times during loading/unloading activities.

5.2.4.6 ENSURE agitator MIXM100U1 is STOPPED.

OK

- 5.2.4.7 ENSURE MIXXV106U1 is OPEN.
- 5.2.4.8 ENSURE MIXXV107U1 is CLOSED.
Summary

• Failure to follow established SOPs continues to be the single most repeated cause for process incidents.

• Computer-assisted integration of routine (and non-routine) manual tasks with automated procedures and fail safe designs can provide the next paradigm in operational performance.

• Cost-effective technology exists today to ensure a safer (and more profitable) tomorrow.