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New Paradigms in Mitigating Unplanned Events Caused by Human Error

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Abstract

Statistics from several industry and government sources indicate that the OSHA PSM process safety incident frequency has dropped dramatically. However, the improvement trend seems to have plateaued.

It has also been noted that operator error was identified as either the primary or secondary root cause in over 80% of these events.

Much has been accomplished by employing computer systems, behavioral policies, and compliance actions in various stages of implementation. However, the desired results are not being achieved. The asymptote in performance could be due to uncoordinated technology implementation and policy enforcement which are not synergistic in achieving the overall goal. It is hypothesized that the next paradigm in process safety and human productivity will require an integrated approach to man-machine-method solutions.

Failure to follow established standard operating procedures continues to be the single most repeated cause for human failure. Academic research points the finger at the cognitive decision-making disconnect between executing the written procedure manually and the level of automation applied to the process.

It is proposed that computer augmentation of written procedures, mobile-enabled with real-time links to a process control system, is a missing capability which could error-proof manually executed tasks. Pilot attempts using this technique have been deployed but have been limited to proprietary, custom solutions.

This paper will explore advances in platform-neutral computer technology, including breakthroughs such as augmented reality, which could provide cost-effective alternatives to the traditional hardwired approach of deterministic automation solutions to reduce human factor errors.

The Case for Change

According to Townsend, the relationship curve between increasing safety regulations and decreasing fatalities is plateauing [1]. 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 inter-actions between man, machine, and method (Figure 1). 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.

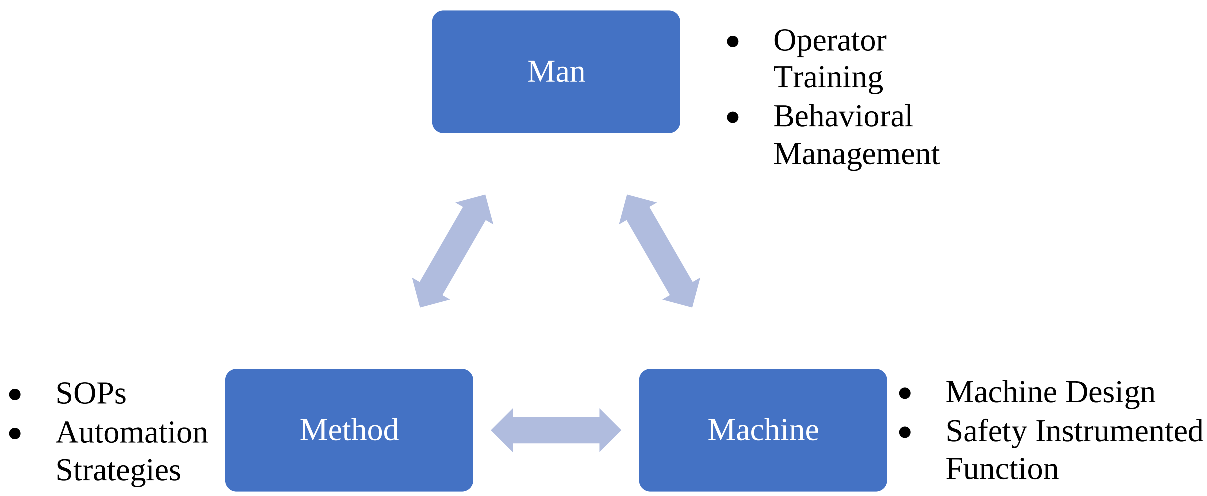

Figure 1. Mitigating the impact of abnormal events involves interactions between man, machine, and method.

The Problem

Incidents rarely have a single cause. In most, if not all, cases, a combination of factors comes together resulting 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 2 shows the categories and percentage of abnormal incidents based on primary root cause assigned by the incident investigating body. An ARC Advisory Group [2] study has operational or human error as the primary cause in 42 percent of the cases. In addition, research by the UK's Health & Safety Executive [3] has shown that up to 80% of accidents may be attributed to human factors.

It would not be accurate to ascribe "operator error" as the main contributor to process events. However, given the significant contribution human factors have 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-method might be a means to quantify the risk and reward of addressing the problem.

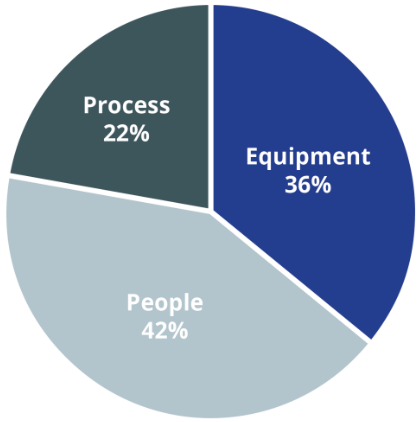

Figure 2. Primary categories of causes for abnormal process events.

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 which 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 method.

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.

The challenges in industry today are twofold:

1. Fewer than 50 percent of the field devices are instrumented for full 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 enable a breakthrough in operational performance, an integrated, computer-assisted 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.

This solution can be launched on a control room HMI, and laptop or tablet to enable field mobility. Field proximity devices such as RFID or barcoding can also be integrated into the overall solution using scanners to identify location and devices that are not connected to the automation system. In the future, augmented reality solutions will provide hands-free capability.

Manual procedures can be linked to the control platform through OPC, which enables completed field tasks to be communicated. 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 operator, confirming that field actions were completed in the appropriate time and sequence. The effect of the two-level review ensures accuracy and conformance to the approved procedure, thus reducing human factors errors and improving execution consistency.

Use Cases

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 deal 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 which 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 decisive actions which need to be made expediently.

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 - Isolation and interlocking of a pump to be repaired
- High Integrity Material Flow - Hand adds to a reactor
- Material Loading or Off-loading - Tank truck / rail car to storage
- CIP (clean-in-place) - Decontamination of 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

Conclusion

Manual procedures in the process industries will surely persist into the future due to economic factors and/or cultural norms. There must be a technical and human compromise to achieve a breakthrough in operational performance and abnormal event prevention. The capabilities and associated reliability of man, machine, and method must be assembled in a comprehensive and integrated manner.

References

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