Comment on
"Humans: The Last Interlock"

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Introduction

"Safety is our first priority" – most companies will not only agree with this statement, but will recognize it as a core value of their corporate culture. The ARC insight "Humans: The Last Interlock" by Dick Hill (2009) describes this positive trend and asks, first, what has been done and, second, what more can be done to reduce the risk of incidents. Specifically, the article makes the observation that a lot of effort has gone into equipment safety, but that, perhaps, insufficient attention has been given to the human in the loop – the last interlock.

Indeed, the attention to the human in the loop has not been sufficient industry-wide, but it has started to grow. For example, most companies will have implemented or heard of alarm management with both EEMUA 191 and the draft standard ISA-18.02 explicitly addressing human limitations. Nevertheless, there seem to be two main problems causing the lack of attention. First, there is limited awareness of the depth of research and best practices available – mostly because it is housed in different disciplines, i.e., in human factors engineering – sometimes called cognitive ergonomics – rather than control engineering. Second, and more important, there is a lack of awareness of the breadth of the problem – it is not only about training, procedures or alarm management, but about the entire design, operate & maintain lifecycle.

This pervasive industry failing with respect to the "human side" is and remains important and has been the focus of the Abnormal Situation Management® (ASM®) Consortium for the past 15 years. The mission of this consortium is to empower operating teams to proactively manage their plants to maximize safety and minimize environmental impact while allowing the processes to be pushed to their optimal limits. In addition to the ASM Consortium, there are several organizations and research groups that study the human in the loop in continuous process control systems, such as the U.S. Nuclear Regulatory Commission; the human factors group at the Brookhaven National Lab; the OECD Halden Reactor Project; and EEMUA, PRISM and NAMUR in Europe.

Therefore, the goal of this letter is to increase the awareness of the breadth and depth of the challenge in dealing with the human in the loop and to promote cross-disciplinary and cross-company research and best practice sharing. The breadth will be shown by sharing the framework that the ASM Consortium uses to investigate the human factor in abnormal situations. Of course, only an indication of the depth can be given in this letter: a selection of short examples of research and development performed by the ASM Consortium is intended to indicate the depth.

First, we should take a closer look at the stated challenge "So, what can we do to reduce the occurrence of hazardous incidents to zero?"

The Challenge

With modern safety systems and layers of protection analysis, incidents are mostly limited to situations when several failures occur simultaneously: a valve is in the wrong position; key information is spread across multiple operator displays; an alarm is missed; a trip is bypassed; and mechanical containment is found to be inadequate.

Therefore, no single solution will be adequate. Rather, we need to look at all failure pathways and their interaction: a confusing procedure that hasn't been followed; operator displays that are difficult to learn, do not support the procedures and do not show all relevant information; a non-rationalized alarm system with many nuisance alarms; communication failure around the operational state of equipment – perhaps because of unstructured shift handover; insufficient management support for safety related activities.

These are all human errors. But, it should be clear that the errors do not fall solely on the operator and that no single discipline can solve this problem. The solution requires the collaboration from a variety of academic fields: control engineering, chemical engineering, human factors engineering and management science – to name just a few. Also, it requires a structured approach – which will be discussed in the next section.

The Solution Framework

The ARC Insight by Dick Hill (2009) suggests that most companies address human errors with training and procedures. Arguably, training and procedures focus on operator action when the facility is running and may not correct for underlying errors made earlier in the lifecycle. Regardless, training and procedures, while important, are just two out of the seven practice areas that the ASM Consortium has identified as a solution framework. The seven practice areas will be briefly described here; more detail can be found via the list of sources.

Understanding Abnormal Situations has the broad scope of investigating the causes and impacts of abnormal situations. The goal is to prioritize future research, and to efficiently and accurately inform continuous improvement programs that mitigate and reduce abnormal situations. One of the research projects in this area focused on the common causes for abnormal situations and has made specific recommendations on, amongst others, Root Cause Analysis (RCA) investigations, common language and systemic error elimination.

Organizational roles, responsibilities and processes focuses on determining the management systems, work practices, organizational structures, and continuous improvement culture that support the prevention and mitigation of abnormal situations. An interesting example of potential research is on effective first line leadership during abnormal situations: what are the skills required; what support is required; what tools could provide assistance?

Knowledge and Skill Development looks at the development and maintenance of a competent work force through training and the creation of a continuous learning environment so that personnel can effectively respond and cope with abnormal situations. Research in this area has, amongst others, looked at the benefit of high-fidelity over low-fidelity simulation, and identified the need for training on effective usage strategies, e.g., how to use the alarm summary more effectively when faced with an alarm flood.

Communications investigates ways to ensure successful communication to enable situation awareness under normal, abnormal and emergency situations. Specifically, the practice area investigates how information media can be used effectively to ensure work continuity between operational and functional team members. Currently, research is undertaken to determine the benefits of electronic shift handover over paper based systems.

Procedures investigates the different aspects that enable effective procedure use such as procedure development, deployment, accessibility, accuracy, analysis, automation and lifecycle management. Also, it looks at ways of dealing with abnormal situations during a procedure and deviations from procedural intent. An example for this practice area is the development of improved operator display elements for procedural automation.

Environment focuses on work place design factors that enhance the situation awareness of personnel, such as controlled lighting, reduced noise and improved operator console lay-out. For example, a dark control room can significantly reduce the alertness of an operator over a 12-hour shift; an ineffective operator console lay-out will cause unnecessary foot traffic which increases the potential for distraction during abnormal situations.

Process Control and Monitoring looks at the effective design, deployment, and maintenance of a comprehensive and user-centered set of applications and tools that enable a single point of access to the information required by the operations team for situation awareness and abnormal situation response. A significant amount of best practices and research is available in this area. Currently, the ASM Consortium is in the process of making selected research available to the public and has released its guidelines on *Effective Alarm Management Practices* and on *Effective Operator Display Design*.

The ASM Consortium actively pursues research in all practice areas. The aim is not only to increase understanding, but also to identify best practices and develop solutions in the form of guidelines and tools to assist the operations team and the operator in particular. Furthermore, the research findings directly drive development activities by ASM Consortium members.

From a deployment perspective, the ASM Consortium has developed an operations practices benchmarking process that member companies can use to compare the operations activities of a facility against industry standards and best practices. The benchmark report provides specific suggestions for improvement for the assessed site and also indentifies new best practices that the site might have in place.

It is clear that the research in these seven practice areas goes significantly beyond the areas identified in the ARC Insight: appropriate operator training and well designed procedures. When applied in full, the available best practices and research will significantly reduce the likelihood of human error in the design, operate & maintain lifecycle.

Conclusion

"So, what can we do to reduce the occurrence of hazardous incidents to zero?"

It might not yet be entirely achievable, but the answer is not elusive. Significant improvements can be achieved with the proper application of guidelines already available. Also, many research questions are known that, when solved, will further reduce the incident rate. Admittedly, a state of zero incidents can never be achieved with a single intervention – it is going to require repeated intervention and changed practices not just in operations, but also in areas such as design, budgeting, project management, maintenance and, of course, leadership.

List of Sources

Please visit www.asmconsortium.net for more information and references.

Understanding Abnormal Situations

Bullemer, P.T. and Laberge, J. C. (2009). *Common operations failure modes in the process industries*. Presentation at Mary Kay O'Conner Process Safety Center International Symposium. College Station, TX.

Bullemer, P.T. (2009) *Better metrics for improving human reliability in process safety*. Paper presented in the 11th Process Safety Symposium at the 5th Global Congress on Process Safety, Tampa, FL.

Organizational roles, responsibilities and processes

Barreth, R., and Bullemer, P.T. (2004). *Assessing staffing levels for console and field: A rational approach to measuring job complexity*. Paper presented at Emerson Exchange User Group, Nashville, TN.

Bloom, C. P., Barreth, R. & McLain, R. (2007). A rational methodology for conducting operations staffing assessments. *Proceedings of the NPRA 2007 Annual Meeting*.

Bullemer, P.T., Jiron, S. and Nimmo, I. (2004). Shaping the future role of the operator. *Chemical Engineering Progress*. 100 (5), May 2004.

Reijn, H. and Bullemer, P.T. (2007). *Achieving a paradigm shift in production effectiveness: Wintershall's migration to remote controlled operations*. Paper presented at the EMEA Honeywell User Group Meeting, Salzburg, AU.

Knowledge and Skill Development

Bullemer, P.T., and Nimmo, I. (1996). A Training Perspective on Abnormal Situation Management: Establishing an Enhanced Learning Environment. *Proceedings of the 1996 AICHE conference on Process Plant Safety*, Houston, TX.

Communications

Laberge, J. C., Bullemer, P.T. and Whitlow, S. D. (2008). Communication and coordination failures in the process industries. *Proceedings of the Human Factors and Ergonomics Society 52nd Annual Meeting,* New York, NY

Bullemer, P.T., Cochran, E., Harp, S & Miller, C. (1999). *Collaborative decision support for operations personnel*. Paper presented at the INTERKAMMA ISA Technical Conference, Dusseldorf, Germany.

Procedures

Bullemer, P.T. and Hajdukiewicz, J. (2004). A study of effective procedural practices in refining and chemical operations. Proceedings of the Human Factors and Ergonomics Society's 48th Annual Meeting. New Orleans, La, September 20-24, 2004.

Environment

Errington, J. and Bullemer, P.T. (1998). Designing for Abnormal Situation Management. *Proceedings of the 1998 AICHE conference on Process Plant Safety*, Houston, TX.

Bullemer, P.T., Cochran, E., & Millner, P. (1999). Effective control center design for a better operating environment. *Proceedings of NPRA Computer Conference*, Kansas City, MO.

Process Control and Monitoring

Soken, N., Bullemer, P.T., Ramanathan, P., and Reinhart, B. (1995). Human-computer interaction requirements for managing abnormal situations in chemical process industries. *Proceedings of the ASME Symposium on Computers in Engineering*, Houston, TX.

Bullemer, P.T., and Reising, D.C. (2008). Improve operator situation awareness with effective design of overview displays. *Proceedings of the 2008 NPRA Annual Meeting*, San Diego, CA.

Guerlain, S., Jamieson, G., and Bullemer, P.T. (2000). Visualizing model-based predictive controllers. *Proceedings of the Human Factors and Ergonomics Society 44th Annual Meeting*, San Diego, CA.

Reising, D.C. and Bullemer, P. T. (2008). *Operator-centered alarms sounds for multi-console control rooms*™. Paper presented at the Emerson Global Users Exchange 2008, Nashville, TN.

Hajdukiewicz, J., & Reising, D. C. (2004). Best practices in effectively deploying mobile computing devices for field operations: A survey of refining & petrochemicals. In *Proceedings of the Human Factors and Ergonomics Society 48th Annual Meeting* (pp. 1155-1159). Santa Monica, CA: Human Factors and Ergonomics Society.

Reising, D. C., Errington, J., Bullemer, P., DeMaere, T., & Harris, K. (2005). *Establishing operator performance improvements and economic benefit for an ASM® operator interface*. Paper presented at the NPRA Plant Automation & Decision Support conference, Grapevine, TX, October 18-21.

Errington, J., DeMaere, T., & Reising, D. (2004). *After the alarm rationalization: Managing the DCS alarm system*. Paper presented at the AIChE 2004 Spring Meeting, New Orleans, LA, April 25-29.

Bell, M., Errington, J., Reising, D. & Mylaraswamy, D. (2003). *Early event detection: A prototype implementation*. Paper presented at Honeywell Users Group 2003, June 9-13, Phoenix, AZ.

Elsass, M., Saravanarajan, Davis, J. F., Mylaraswamy, D., Reising, D., Josephson, J. (2003). An integrated decision support framework for managing and interpreting information in process diagnosis. Accepted to *Proceedings of the 8th International Symposium on Process Systems Engineering PSE2003*. June 22-27, Kumming, Yunna Provice, China.

Montgomery, T., Reising, D., Errington, J., & Nordh, P. (2004). *ASM Alarm Management Results*. Paper presented at Honeywell Users Group 2004, June 14-18, Phoenix, AZ.

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