Managing Human Reliability: 25 Years of Abnormal Situation Management Consortium Study



CCPS Webinar August 14, 2019 Peter Bullemer, Human Centered Solutions Tom Williams, Honeywell http://www.asmconsortium.net

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Speakers

• Tom Williams

- Director of ASM since 2013
- Global Operator Effectiveness Leader, Honeywell since 2008
- Process Design, Development, and Optimization (AlliedSignal, now Honeywell) 1986-2008
- Research & Development with Mobil (now ExxonMobil) 1976-1984
- Three patents, two dozen published papers, presentations, and podcasts
- BS ChE Princeton, MS ChE Rutgers

Dr. Peter Bullemer

- Senior partner, Human Centered Solutions, North American human factors consulting group
- Specializes in human performance in process industry operations for over 25 years
- Involved in the 1994 formation of the ASM Consortium
- Has participated as Principal Investigator, Director and Technical Contributor
- Over 100 published papers & conference presentations
- Ph.D., Experimental Psychology, U of MN









- What is an Abnormal Situation?
- Why We Need to Improve
- ASM Brief History
- ASM Consortium Study Rigor
- Where are We Now?
- What Can You Do?
- Find Out More About the Consortium



What is an Abnormal Situation?

Definition

- An industrial process is being disturbed, and the automated control system can not cope
- Consequently, the operations team must intervene to supplement the control system.



Piper Alpha Disaster July 6, 1988

Loss of Life
Personal Injury
Public Relations Issues
Environmental Impact
Equipment Damage
Reduced Production
Product Quality
Inh Dissatisfaction

Results

Business Impact

Major Accidents are Rare, But Even Small Mistakes May Have Some Consequence



ASM Relation to PSM



ASM Seeks to Develop Proactive Methods Based on Human Factors Research



In 2009, 118 reported incidents led to 78 deaths and 213 serious Injuries



LOSS OF LIFE

INJURY

Serious Incident Reported Every 3 Days: Recent Data are Not Better



Managing Human Reliability Causes of Abnormal Situations

• Based on available 1992-3 site incident reports, sources of abnormal situations were characterized as three basic types:



The sources had the following ranges:

- People & Work Context: 35-58%
- Equipment: 30-45%
- Process: 3-35%

 Based on a series of ASM Consortium studies from 2008-2012 of major process safety incidents:





So What is Industry Doing? ASM History



- Honeywell assembled a task force of 25 customers in 1989 to address Alarm Management
- Phillips' Petrochemical Explosion 10/23/1989 added
 urgency
- Discussion with US NIST led to formation of the Abnormal Situation Management Joint Research Consortium (ASM)
- US NIST Advanced Technology Development Program matched \$8.5M member funds with \$8.1M for a three year Research Program 1994-1996
- Since 1997 all funding has been from members. A total of approximately \$45M spent.
- 85% Research. 15% on Communicating Results



Abnormal Situation Management Joint Research and Development Consortium

29 Past & Present Members

Founded in 1994 - managed and lead by Honeywell

- 16 User Members
 - Amoco
 - BP
 - Celanese
 - ConocoPhillips
 - Equilon
 - Exxon
 - ExxonMobil
 - Mobil
 - NOVA Chemicals
 - Petronas
 - Phillips 66
 - Sasol
 - Shell
 - Texaco
 - Total
 - Union Carbide

- 6 Associate Members
 - ATR
 - Brad Adams Walker Architecture
 - Gensym
 - Human Centered Solutions
 - KBC
 - UCDS

- 7 University Members
 - Mary K O'Conner
 Process Safety Center
 - Nanyang Tech. U
 - Ohio State U
 - Penn State U
 - Purdue U
 - U of Alberta
 - UCLA



Key Learning Persistent Paradoxes

- Paradox of Automation
 - Better automation leads to more sophisticated processes.
 - More sophisticated processes leads to more opportunities for error.
 - We tend to "fix" the increasing errors with still more automation.
- Paradox of Reliability
 - Better equipment reliability leads to fewer operator interventions
 - Fewer operator intervention leads to fewer opportunities to learn from experience
 - Less experiential knowledge and skill leads to more human errors
 - We attempt to "fix" the increasing human error with equipment reliability improvements
- Consequently, when things go wrong, people have difficulty intervening to correct the problem.
- Need to better understand how to break the cycles and support human intervention activities

Not By Technology Alone



ASM Solution Framework Not By Technology Alone

- A general conclusion from the initial 1993 study was that the effective humanmachine system solution involved more than developing the right technologies
 - Cochran & Bullemer, 1996
- Improving human reliability required addressing the
 - Work culture
 - Organization structure
 - Work processes
 - User acceptance and adoption
 - Appropriately designed technology



 Understand the user problems and design solutions that address the problem and fit the work context



- The ASM Consortium has conducted dozens of studies each year for past 25 years
- ASM Consortium research methodology is grounded in the field of human factors and experimental psychology
- The research has been led by human factors professionals working with personnel from member company operating facilities
- Data has been collected through on-site observations and interviews as well as simulator-based studies with plant operators
- Experimental studies are conducted both at Universities and Member plant sites



The ASM Uses Sophisticated Tools



- Research carried out to determine how operators do their work by tracking their eyes to see what information they need, when, and how long they must observe to obtain the information they need.
- Next few slides provide examples of research projects conducted by the ASM
 Consortium in the seven operations practices areas



- Shared understanding of abnormal situation causes and impacts, widely communicated across the site, in order to efficiently and accurately inform continuous improvement programs that mitigate and reduce abnormal situations.
- Example project: Root Cause Analysis of Industry Incident Reports
 - Develop understanding of operations practice failures in 42 industry incident reports

	Public	Site	Total	
USA	21	8	29	
Non USA	6	7	13	
Total	27	15	42	



ASM Incident Analysis Study Common Operations Failures

Rank	ASMC Operations Practice Category	%
1	Organizational Roles, Responsibilities, and Work Processes	46%
2	Communications	16%
3	Process Monitoring, Control, and Support Applications	9%
4	Procedures	8%
5	Knowledge and Skill Development	7%
6	Understanding Abnormal Situations	3%
7	Work Environment	1%
	Others	9%
	Total	100%

- 42 incidents were analyzed using TapRoot incident investigation methodology
- Organization/Management System Category most significant impact

Bullemer, P.T. and Laberge, J.C. (2010). Common operations failure modes in the process industries. *Journal of Loss Prevention in the Process Industries*, 23(6), 928-935.



ASM Incident Analysis Study Common Operations Failures

Top Operations Practice Failure Areas	%
Hazard analysis/ communication	15%
First-line leadership	12%
Continuous improvement	11%
Safety culture	7%
Task communications	6%
Initial and refresher training	5%
Comprehensive MOC	5%
Cross functional communication	4%
Compliance with procedures	3%
Design guidelines and standards	3%
All other failure modes	29%

- Top 10 covered ~70% of identified operations practice failures
- 6 of 10 practice failures associated with the organizational roles, responsibilities and work process category



ASM® Consortium Guidelines Effective Operations Practices

Last Revision Date: 10 January 2014 Version: Version 7.00

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Organization Roles, Responsibilities & Work Processes

- Management systems, work practices, organizational structures, and a continuous improvement culture that supports prevention and mitigation of abnormal situations.
- *Example project:* Improve first-line leadership role
 - Create plant manager's audit checklist based on root cause analysis failure modes

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Organization Roles, Responsibilities & Work Processes

- Management systems, work practices, organizational structures, and a continuous improvement culture that supports prevention and mitigation of abnormal situations.
- Example project: Improve first-line leadership role
 - Create plant manager's audit checklist based on root cause analysis failure modes
- The supervisor maintains a presence in the control room and field areas with face-toface contact periodically throughout a shift to ensure good situation awareness of operations and maintenance activities.
- □ The supervisor assigns a stand-in responsibility when leaving the job site.
- □ The supervisor enforces clear guidelines on when and how to conduct pre-job briefings.

Bullemer, P. T. and Laberge, J.C. (2011). *Improving process safety culture: An audit checklist for effective first-line supervision based on common operations failure modes.* Paper presented in the 13th Process Safety Symposium at the 7th Global Congress on Process Safety, Chicago, IL.



Knowledge & Skill Development

- Knowledge and skill development establishes and maintains the competencies needed for effective abnormal situation response.
- Knowledge and skill development is a continuous process that is supported by a performance evaluation framework
- *Example project:* Training ASM competencies
 - Literature review of crew resource training in other domains
 - Site Interviews of current effective practices in technical and non-technical training in abnormal situation management



Bullemer, P.T., Bloom, C.P. and Reising, D.C. (2016). Training requirements to improve operator reliability and process safety in managing abnormal situations. Paper presented at the 19th Annual Meeting of the European Refining Technology Conference. Lisbon, PT.



Communications

- Successful communication between operational and functional team members enables situation awareness under normal, abnormal and emergency situations.
- Team members coordinate with respect to goals and activities, through the use of effective information media to ensure continuity in work conditions.
- *Example project:* Use of checklist to improve shift handover communications
 - Assess impact of handover checklist with structured electronic logbook
 - Develop recommendations for structured communications



Plocher, T., Yin, S., Laberge, J., Thomson, B. and Telner, J. (2011). Effective shift handover. International *Conference on Engineering Psychology and Cognitive Ergonomics* (EPCE 2011), pp 332-341.

8/14/2019



Use of Procedures

- Procedure content (whether automated or manual) is up-to-date and provides the guidance and instruction needed to minimize, avoid and recover from deviations in operating intent
- A comprehensive usage policy and procedure development, deployment, analysis, and lifecycle management practices enable effective procedure use
- *Example project:* Procedure Execution Failure Modes during Abnormal Situations
 - Understand how and why failures occur
 - Identify solutions to mitigate failures

Common Manifestations	#
Inappropriate action	15
Fail to detect abnormal condition	12
Lack understanding of impact	8
Fail to detect abnormal situation	4
Unaware of hazard	1
Total	40

Bullemer, P.T., Kiff, L. and Tharanathan, A. (2011). Common procedural execution failure modes during abnormal situations. *Journal of Loss Prevention in the Process Industries*, 24 (6), pp. 715-916.

8/14/2019



Work Environment

- The work environment enhances operations team situation awareness within their scope of responsibility, operator alertness, efficient work practices, collaborative interactions (including with other disciplines) and abnormal situation prevention and response.
- *Example project:* Vigilance Decrement on Alertness
 - Understand time course of alertness loss with console operations activity



Li, J., & Rothrock, L. (Submitted). Physical Activity for Vigilance Decrement Avoidance in a Simulated Process Control Task. Human Factors and Ergonomics in Manufacturing & Service Industries.



Process Monitoring, Control, & Support

- A comprehensive and user-centered set of applications and tools that enables a single point of access to the information needed for operations team situation awareness and effective prevention and response to abnormal situations.
- *Example project:* Visual Thesaurus
 - Develop feasible and effective visualization techniques for consolewide overview displays



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Tharanathan, A., Bullemer, P., Laberge, J., Reising, D., and McLain, R. (2010). Functional versus schematic overview displays: Impact on operator situation awareness in process monitoring. *Proceedings of the Human Factors and Ergonomics Society 54th Annual Meeting*, San Francisco, CA.



Managing Human Reliability Effective Practice Gap Analysis

 Illustration of progress in operations practice solutions & remaining opportunity gaps include:



08/14/2019



What can you do to reduce the risk? **Improve the Integrity of your Operations Practices**

- 1. Understand the sources of abnormal situations in your facilities
- 2. Establish effective first-line leadership
- 3. Address the work culture of not using procedures
- 4. Improve communications
- 5. Improve operator competency for abnormal situation management
- 6. Provide a Control Room Environment conducive to alert and productive operations
- 7. Develop effective console operator HMI based on human factors principles



Conclusions

- Significant progress has been made since 1993 in improving operations practices to address the abnormal situation management challenges
- Raising the typical industry practices to known effective operating practices is the opportunity gap to
 - Improve human reliability and
 - Reduce the associated process safety risk





Published ASM Guidelines



A Summary in Guideline Form of ASM Findings, Summarizes <10% of Research

- Effective Operations Practices to be released later this year
- Available for purchase, See ASM Consortium web site



What's on the ASM Web Sites

- Public web site (<u>http://www.asmconsortium.net</u>):
 - Intro to ASM Concepts
 - Archive of Incidents
 - Published presentations, webinars, journal papers, etc

ASM Guidelines Documents

Effective Alarm Management Practices (ISB Visit https://www.createspace.com/3384799

Effective Procedural Practices (ISBN: 978-14

Visit: https://www.createspace.com/3456983

Effective Console Operator HMI Design Practices (ISBN: 978-1514203859) Visit https://www.createspace.com/5540086 to purchase.



- Substantial body of knowledge: Over 1000 reports: Status, Gate Reviews, about 250 Final Reports, substantial User Member In-kind report archive
- Search Engine

<u>, , , , , , , , , , , , , , , , , , , </u>			The challenges facing the industry in handling abnormal situations. There are described in $1 < 2 < 3 + 3 + 5 + 6 = 4$ a causification incident.
	Contact Us Need assistance? Have questions? Please Contact Us! ASM Consortium Upcoming Event	Honeywell hosts the first quarterly review meeting of the ASM Consortium at their Houston Facility The first QRM of 2010 was successfully concluded at Honeywell's Houston office. The QRM attendese, who are the operating company members and honeywell outsmost. Sidoussed the year's new research proposals and reviewed the progress of the ongoing research. The Quarterly Review Meetings are a platform for the ASM Consortium members to share the benefits gained from the ASM practices and products, and to discuss new challenges faced in platfor persisten.	Quick Links Penn State University Members Area Information on Joining Contact Us Guidelines Guidelines Smart Manufacturing Units Library
ars, journal papers, etc.	Members Only Cuartery Review Meeting	The ASM Consortium Records More Than 1000 Incidents Globally In 2015 To create awareness about the serious nature of process safety incidents, the ASM Consortium continues to brack and record incidents and accidents happening globally in 2015, we recorded more than 1000 Incidents on ur website. The incidents laits and all inclusive but provides a comprehensive list of global incidents affecting process industries as reported in the media. The ASM Consortium has been archiving such incidents since 2008.	 Incidents Hazardous chemical leak at Pace plant contained Jun 22- A hazardous leak at a Pace chemical plant has been contained, the plants owner said
ASM Guidelines Documents	Barbour County citizens react to second explosion at gas plant	→ Subscribe to the Incidents List Feed	Thursday. Normal operations resume at Evonik's C4
The Consortium has compiled guidelines in several areas that represent best practices as demonstrated through research and application by member companies. These documents have been through several revision cycles and through numerous peer reviews over the past decade. They reflect many years of experience in the successful application of human-centered design in	Jun 21- The McDonald Volunteer Fire Department has posted news of the passing of Chaft Stock at Albertin on their website. This is the second explosion to happen at the Midland Resource Recovery chemical plant in a month.	The Canadian Standards Association group refers the ASM Consortium guidelines in their latest publication. The Canadian Standards Association (CSA) group has come up with a Human Factors Quideline CSA groups guideline document refers the ASM Consortium 14MI guidelines document "Effective Console Operator Hull Design". It also recommends refering the ASM Consortium's guidelines Effective Asims management and CEdeolus procedual FaceOcta for Jamma and Updelines Center Asims management and CEdeolus procedual FaceOcta for Jamma and	plant in Antwerp Jun 22- According to a statement issued by chemical company Evonik Industries this week, its C4 integrated production facility in Antwerp site was successfully restarted earlier this month.
ane management and automation of plant operations. Available for purchase:	Pakistan's Byco to restart refinery 2 years after fire	◆ Pipeline Human Factors Express Document	Propane tanks cause explosion at Kent County recycling center
Effective Console Operator HMI Design Practices (ISBN: 978-1514203859)			

HOME ASM DEFINED RESEARCH AREAS RESOURCES DEPLOYMENT NEWS ABOUT US TWENTY YEARS OF THE ASM CONSORTIUI

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io?	Procedures	This area focuses on all appents of procedure use such as an essability, accuracy, starty, and policy compliance so that personnel can accomplian important trains of an industrial site, particularly startup and shuldown.				
and the second	Deviconment	This area focuses on work place design factors that impact performance of personnel during abnormel alturations.	🗄 Topic : E	Effe	ective Alarm Management Practices (1)	
for'	Monitoring	This area focuses on effective design deployment, and maintenance of hardware and software platforms that support process monitories, control and support for effective operations.				



- The Consortium is pivoting from Research Alone to Helping Members Apply Best Practices:
 - Seek to disseminate the Research, Guidelines, and Best Practices to a broader group.
 \$45Million worth of research documented on Share Point Site
 - Assist members and former members to practice what's been learned:
 - » New "members-only" Share Point Site
 - » Access to webinars
 - » Fast track access on website to Guidelines, Best Practices
 - » Write new guidelines where appropriate
 - » Better quality webinars on a broader series of topics
 - Cultivate relationships with other Safety Organizations, like AIChE's CCPS.
 - Expose next generation engineers to human factors and best practices to improve human performance.



Thank You for Attending

- For more information:
 - See the Public Website: <u>www.asmconsortium.net</u>
- If interested in ASM Consortium membership, contact Tom Williams, thomas.n.williams@honeywell.com