

Training Requirements to Improve Operator Reliability and Process Safety in Managing Abnormal Situations



Paper presented on behalf of the Abnormal
Situation Management® R&D Consortium

Dr. Peter Bullemer

Dr. Charles Bloom

Dr. Dal Vernon Reising

Human Centered Solutions

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Message

- ❖ There are some promising opportunities to **improve training** for
 - **Abnormal Situation Management** and
 - **Process Safety Management** through the **broader use of existing effective practices and the adoption of methodologies found in other related industries**

Abnormal Situation Management

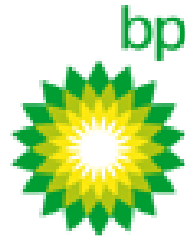
Joint Research and Development Consortium



Founded in 1994

Creating a new paradigm for the operation of complex industrial plants, with solution concepts that improve Operations' ability to prevent and respond to abnormal situations.

www.asmconsortium.org



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reaching new frontiers



Shell



TOTAL

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UCLA



What is an Abnormal Situation?

- ❖ 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.



- Loss of Life
- Personal Injury
- Equipment Damage
- Environmental Release
- Public Relation
- Product Throughput
- Product Quality
- Job satisfaction



An Abnormal Situation Impacts Process Safety



ASM Relation to PSM

Safety Pyramid Illustration

Process Safety Incidents

Abnormal Situation Incidents

Effective Operations Practices

Major Incidents

Incident above threshold for Process Safety Incident

Minor Incidents

Incident below impact threshold for PS Incident

Near Miss

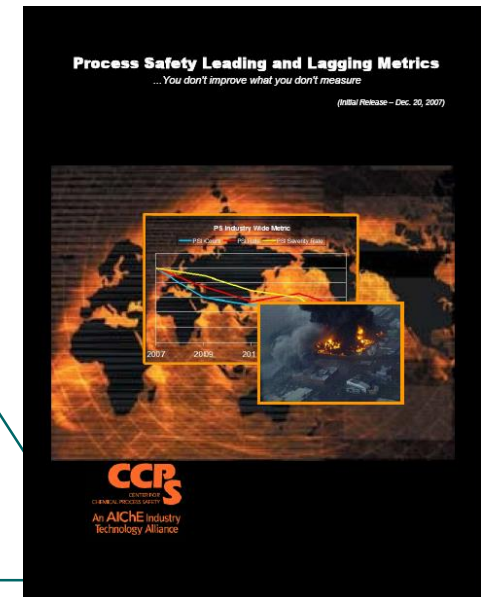
System Failures that could lead to an incident

Unsafe Behaviors

Insufficient Operating Discipline

Illustration from:

CCPS *Process Safety Leading and Lagging Metrics*.



<http://www.aiche.org/ccps/metrics/index.aspx>



- ❖ Our 2014 ERTC presentation reported on an ASM research project investigating challenges associated with heater operations
 - Found **ineffective individual & team situation awareness** was a major challenge
- ❖ To address this challenge, the ASM Consortium identified the need for **effective training for individual and team abnormal situation management.**

Addressing the Process Safety Challenges associated with Heater Operations in the Process Industry



Paper presented on behalf of the Abnormal Situation Management® R&D Consortium

Dr. Peter Bullemer

Dr. Dal Vernon Reising

Human Centered Solutions

November 20, 2014

ERTC 19th Annual Meeting
Lisbon, 18-20 November 2014

Project Overview

Approach



- ❖ Review literature to identify effective training in the process industries as well as other domains
 - Main source is crew resource management literature
- ❖ Conduct interviews with User member training specialist to understand how they are addressing ASM training needs
- ❖ Make recommendations based on research findings on how to improve effective training practices



Phases

Needs

Methods

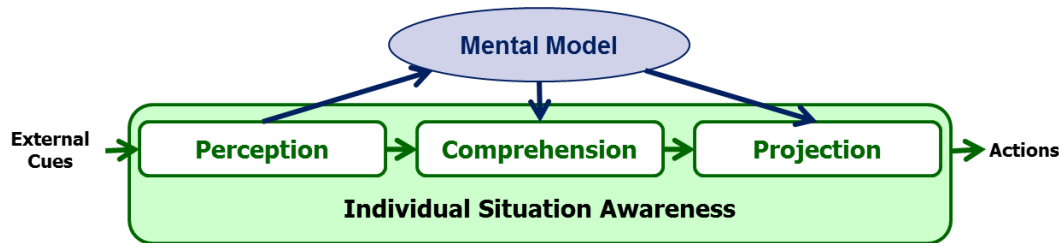
Evaluation

Results

- ❖ Conducted search of literature to identify effective training practices within process industries as well as related industries such as aviation & military
- ❖ Emphasis on crew resource management, i.e., training to establish effective teamwork thru development of communications and coordination competencies
- ❖ Reviewed over 100 documents
- ❖ Report has a total of 65 citations



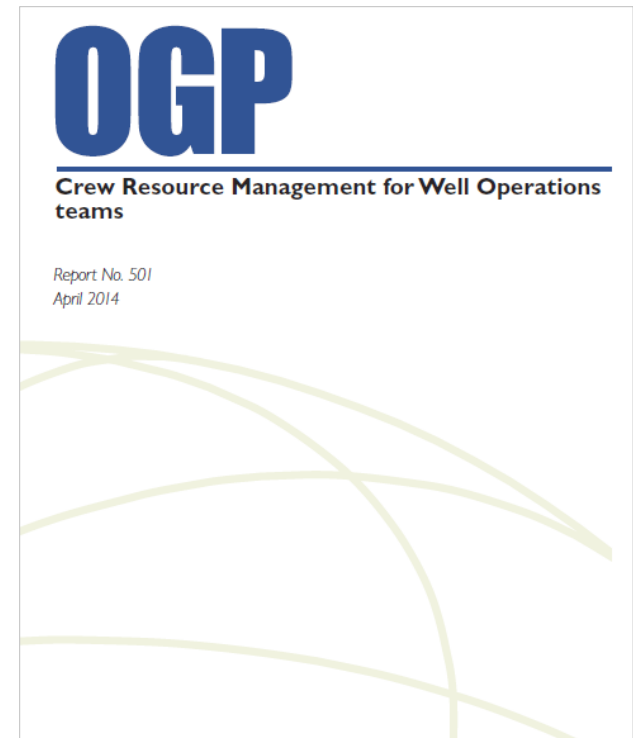
1. **Needs Analysis**—Define competencies, specify training goals and organizational constraints
2. **Design**—establish training objectives, define training methods based on instructional design principles, specify metrics for measuring training effectiveness
3. **Development**—Create training materials, develop full-scale prototype, validate and modify design/materials
4. **Implementation**—Prepare organization for training (i.e., change management), conduct training instruction
5. **Evaluation**—Determine effectiveness with measures at multiple levels, Revise training design based on results
6. **Support Transfer**—Reinforce trained behavior in work environment; provide recurrent training
7. **Assess Outcomes**—Monitor organizational impacts
See Salas, Wilson, Burke, Wightman, Howse (2006)



- ❖ Development of technical knowledge & skills necessary for effective situation awareness:
 - Level 1 Perception
 - Level 2 Comprehension
 - Level 3 Projection
- ❖ Operators need to develop the shared, effective mental models that support situation awareness at all levels
 - Each individual needs to know about the potential abnormal conditions for their area of responsibility, how to detect their presence using available instrumentation and tools and understand potential impacts
- ❖ Technical Knowledge & Skills were not covered in literature



- ❖ Emphasis on the cognitive, social and personal resource skills that complement technical skills and contribute to safe and efficient task performance (Flin et al., 2008)
 - **Positive changes to knowledge and attitudes are prerequisites for changes to safety relevant behavior**
- ❖ Recommended non-technical skills categories (OGP, 2014) based on assessment of the offshore platform work environment and recommendations in Crew Resource Mgmt (CRM) in related fields:
 1. Situation Awareness
 2. Decision Making
 3. Communication
 4. Teamwork
 5. Leadership
 6. Stress & Fatigue



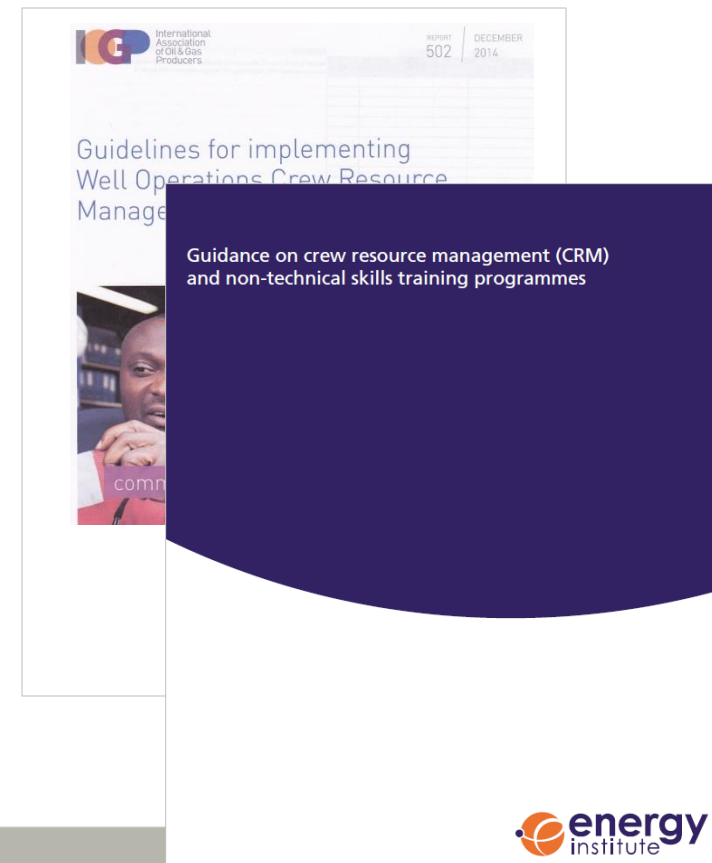
Literature Review

CRM Training Methods



Phases Needs **Methods** Evaluation Results

- ❖ CRM training first developed in early 70s in aviation
 - Mature practice has been used in several domains such as: Healthcare, Nuclear Power, Offshore Oil Drilling, Maritime, Fire Service, Railroad
- ❖ Effective training method has three distinct phases (includes elements of explicit and implicit learning)
 - **Awareness**—Theory & concepts in classroom setting (typically 2 days)
 - **Practice & Feedback**—Exercises in conjunction w/classroom in coached setting with feedback on individual/team performance
 - **Continual Reinforcement**—Refresher training in specific areas
- ❖ CRM training is group based with skilled facilitator/instructor
 - Aviation requires certification for trainers





Literature Review

Other Training Methods

Phases

Needs

Methods

Evaluation

Results

- ❖ Additional methods that offer **opportunity to integrate technical and non-technical knowledge & skill development**
 - **Guided Team Self Correction Training**
 - Event Based Training (EBAT)
 - Team Facilitator Training
 - Stress Exposure Training
 - Simulation-based Training
 - Cross Training

- ❖ **Guided Team Self Correction Training**
 - Used in context of Team Dimensional Training (TDT) (Smith-Jentsch et al.,1998)
 - » Uses 'guided team self-correction' to develop team members' **teamwork-related knowledge & skills**
 - A structured team briefing strategy that has three steps:
 - » **Prebrief, Perform/Observe, Debrief**

Literature Review

Training Evaluation



Phases

Needs

Methods

Evaluation

Results

- ❖ Four Levels of Training Evaluation (Kirkpatrick 1994)
 - **Reaction**—Did trainees like the training and find it useful?
 - **Learning**—Did the trainees increase knowledge or change work attitude?
 - **Behavior**—Did the trainees improve their work performance either on job or in simulation?
 - **Organizational Impact**—Did training improve work performance relative to goals such as safety and plant performance?

- ❖ Literature provides examples of metrics for all four levels

Literature Review

CRM Training Results



Phases

Needs

Methods

Evaluation

Results

- ❖ CRM training generally produces positive results from trainees
 - However the impact on learning and behavioral changes suggest mixed results across and between domains (Salas et al., 2006)
 - There were no studies that indicated CRM does not work

- ❖ **Myth #1:** High fidelity simulators are necessary for transfer of learning to the work environment
 - Psychological fidelity needs to be high, i.e., the simulation allows trainees to use the same cognitive processes as in their work environment

- ❖ **Myth #2:** Subject matter experts should drive the training design
 - SMEs can articulate the task environment; learning experts should drive the training design

Training Specialist Interviews

Overview



Objectives Needs Delivery Evaluation

- ❖ Conducted telephone interviews with six training specialists from User member companies
- ❖ Covered four main topics:
 - Training objectives
 - Training needs assessment & development
 - Training delivery
 - Training evaluation
- ❖ Each of the training specialists provided some **innovative examples of effective training solutions** developed in a work environment that has some significant constraints on how training may be conducted.

Training Specialist Interviews

Training Objectives



Objectives

Needs

Delivery

Evaluation

- ❖ Most of the programs addressed detection of abnormal situations to some degree
 - **only 2 of 6 had comprehensive unit-specific training objectives** specific to equipment such as furnaces

Training Program	A	B	C	D	E	F
Technical Objectives	P	✓	P	P	✗	✓
Nontechnical Objectives	P	P	✗	P	P	P

✓: Good coverage; P: Partial coverage; ✗: limited or no coverage.

❖ Nontechnical training objectives

- 4 of 6 had some for **both supervisors & console operators**
- 1 of 6 had for only **supervisors**
- 0 of 6 had for **field operators**
- 5 of 6 reported
 - » **Communications**
 - » **Leadership**

Nontechnical	Supervisors	Console Operators	Field Operators
Situation Awareness		A	
Decision Making			
Troubleshooting		A	
Communications	A,C	A, B, C*, D, F	C*, F
Teamwork	A, D	A, B	
Leadership	B, C, D, E	B, D, F	F
Stress & Fatigue Mgmt	A, B	A, F	F
Mentorship	D, E	D, F	F

* Radio protocol only

- ❖ General recognition that they **could be doing more** in the area of nontechnical competency development

Training Specialist Interviews

Needs Assessment



Objectives Needs Delivery Evaluation

- ❖ Most interviewees reported having a list of basic competencies required for operators in different units
 - Although, the competencies tended to be oriented towards technical knowledge and skills
- ❖ Some variability in the use of formal methods to define the competencies that ranged from
 - Corporate initiatives to define competencies for different refinery process units to
 - Supervisors monitoring day-to-day performance of operators & recommending refresher training needs
- ❖ Some training specialists reported monitoring performance of individuals during procedure-based activities or emergency/upset responses
 - to identify potential training needs & inform training program development

Training Specialist Interviews

Training Delivery



Objectives Needs **Delivery** Evaluation

❖ All indicated the use of a mix of

- Dedicated trainers
- Designated trainers
- 3rd party providers

to deliver the training to supervisors and operators

Training Role	Dedicated	Designated
Unit-specific Induction	C*, E*, F*	B, C, D*
Job-specific Induction	C*, F*	A, B*, C, D*, E
Job-specific Advanced	A*, C*, D, F*	B*, C, D*, E
Special Technical Topics		E

*Receive some formal instruction on how to be an effective trainer

- ❖ All dedicated trainers had some form of instruction on how to be effective trainers with some background in adult learning and instructional design
- ❖ 2 of 6 reported that the designated trainers received some ‘train-the-trainer’ instruction
 - One report of a corporate initiative to improve the quality of the OJT across the company through the development of a core of designated trainers

Training Specialist Interviews

Training Delivery



Objectives Needs **Delivery** Evaluation

- ❖ Common use of training simulators for both basic & advanced console operator training that covered
 - Responding to unit-specific fault conditions
 - Practicing procedure-based activities

Delivery Methods	Technical	Nontechnical
On-the-Job Pairing	A, B, C, D, E, F	C
Instruction Manuals	B, C, F	
Classroom/PowerPoint	D, F	A, B, D, E, F
Group Exercises/Drills	A, B, C, D	A, B
Toolbox/Safety Meetings	B	B
Video	A, F	A, F
Computer-based Modules	B	B
Simulation-based Exercises	A, B, C, D, E, F	A, B*, C^

*Only in limited cases, needs to be more prominent practice

^Mainly focus on shift handover and radio communications skills

- ❖ 3 of 6 reported efforts to develop **technical & nontechnical competencies together** in the simulation training program
- ❖ Three innovative approaches were reported that **used simulation-based exercises in the group setting** to develop both
 - technical & nontechnical competencies related to ASM

Training Specialist Interviews

Innovative Approaches



Objectives Needs **Delivery** Evaluation

- ❖ 1: for Supervisors and Console operators
 - A two-day offsite emergency/upset response course with a combination of classroom and simulator-based exercises.
 - » Classroom covers the background knowledge supporting nontechnical learning objectives
 - » Simulator-based training supports both technical & nontechnical skills training
- ❖ 2: for Console and Field operators
 - A pilot program to improve heater operations with technical & nontechnical training
 - » Classroom-based instruction providing an overview of heater operations
 - » Scenario-based learning on handling abnormal heater situations
- ❖ 3: for Console and Field operators
 - Group training exercises that combined the concept of red tag drills
 - » Each shift team required to run procedure-based drills once a month with different team members leading the session
 - » The team conducts a pre-brief & debrief after each session to evaluate how they performed as a team & to identify any issues with the procedure content itself

Training Specialist Interviews

Training Evaluation



Objectives Needs Delivery Evaluation

❖ Most of the training specialist indicated use of formal methodologies to obtain data on

- The first two evaluation levels pertaining to trainee reaction to the program and
- Whether trainees acquire additional knowledge or skills

Training Program	A	B	C	D	E	F
L1 Reaction	✓	✓	✓	✓	✓	✓
L2 Learning	✓	✓	✓	✓	✗	✓
L3 Behavior	✓	A	A	A	✗	✗
L4 Organization Impact	A	A	A	✗	✗	✗

✓: Formal methods; A: Anecdotal methods; ✗: limited or no evaluation.

❖ One training specialist reporting the use of an anonymous evaluation protocol that is effective in obtaining feedback both on

- The trainer and
- The training program

❖ With respect to Level 3 and 4 evaluation data regarding impact of simulation-based training on job performance or organizational performance

- Most evaluation methods were limited to using anecdotal accounts either
 - » Through their own observations & through the observation of supervisors



- ❖ The ASM study findings reveal some promising paths forward to
 - **Improve the effectiveness of the ASM-related training** in the process industries through
 - The **broader use of**
 - » **Existing effective practices and the**
 - » **Adoption of methodologies**
 - Found in other related industries**



❖ **Please ask questions or offer comments**

***Thank You for
Attending***