Background

- Major “industry defining” accidents such as Three Mile Island, Texas City, and Deepwater Horizon highlight the need for an effective safety culture in the operation of complex, high risk facilities

- Significant gains have been made in the performance and safety of nuclear power plants since Three Mile Island, and the lessons learned are applicable to the process and offshore industries

- A systematic risk framework can help integrate technical and organizational risk factors, and ensure that safety culture programs lead to tangible improvements in performance and safety

- DNV is collaborating with a Canadian nuclear utility to develop an approach for risk informed safety culture assessment

- The approach could be applied to safety management of refineries and offshore installations
Combining two complementary dimensions for safety management

- **Loss prevention** – intervening in events to prevent occurrence of accidents or mitigate the consequences
  - Common in the oil and gas and process industries
  - Focus on development and maintenance of barriers

- **Safety and performance objectives** – utilizing available resources to achieve safety and performance objectives
  - Safety and performance are interdependent
  - Focus on development and maintenance of critical functions
The loss prevention paradigm
Adding the complementary paradigm of safety and performance objectives

Maintain critical functions

Performance and safety objectives

Hazards

Accident

Intervene in accidents
Tool for assessment of barriers for loss prevention: bow tie diagrams

- Widely used in the oil and gas and other process industries
- Focuses on barriers (both prevention and mitigation) for intervening in event progression
- Can be used to cover both technical and organizational risk factors
A typical Bow Tie diagram
Simplified Bow Tie diagram for Three Mile Island
Tool for assessment and achievement of critical safety functions: defense in depth objective trees

- Based on the critical safety function concept developed following the Three Mile Island accident in 1979

- Objective trees were developed in the Severe Accident Management program for the US Nuclear Regulatory Commission in the mid-1980’s

- Objective trees were applied to defense in depth by the International Atomic Energy Agency, and extended to cover both technical and organizational risk factors
Example of an IAEA Defense in Depth Objective Tree

Safety functions

Maintain RCS Cooling

Challenges

Excessive heat production due to recriticality
Inadequate removal of heat from degraded core
Inadequate safety culture
Inadequate conduct of operations

Mechanisms

Core heat-up and relocation
Hydrogen generation
Environment not conducive to safety

Risk Management Strategies

Secondary side bleed and feed
RCS depressurization
Water injection into the core by any means

Technical risk factors

Desired behaviors reinforced by managers
Avoidance of inappropriate work patterns
Attention to good housekeeping

Organizational risk factors
Combining objective trees and bow tie diagrams to form the two complementary dimensions of performance and safety management.

**Organizational Objectives**
- Achieve safety and performance objectives
- Maintain reactor coolant system heat removal
- Maintain primary system integrity
- Maintain containment integrity

**Critical Functions**
- Maintain reactor coolant system heat removal
- Maintain primary system integrity
- Maintain containment integrity

**Challenges**
- Loss of coolant accident

**Mechanisms**
- Improper maintenance
- Mechanical failure

**Strategies**
- Prevention
- Mitigation
- Maintenance
- Surveillance
- Emergency procedures

**Relief valve sticks open**
- Reactor shutdown
- Core damage

Bow tie diagrams are developed for mechanisms.
Attributes of a healthy risk informed safety culture

- **Awareness** of plant processes, barriers, and critical functions and the effects of individual actions on them
- **Commitment** to maintain the barriers and critical functions
- **Effective tools** to enable effective risk informed decisions
- **Accountability** to involve a second set of eyes to validate assumptions and test conclusions

**Based on personal ownership!**

“...When doing a job – any job – one must feel that he owns it, and act as though he will remain in the job forever. He must look after his work just as conscientiously, as though it were his own business and his own money.”

- Adm. Hyman G. Rickover
The ladder of accountability relationships

Not this:

Fear
Blame

But this:

Partnership
Oversight

Requires mutual respect!

Accountability must be established and exercised at all levels
The importance of healthy regulatory engagement

- Effective partnership between regulator and industry can help both organizations achieve their responsibilities towards shareholders and citizens

- Analogy – “If someone forces you to go one mile, go with him two miles.”
  - Going the first mile under duress is the hallmark of standards based compliance
  - Excellence is achieved by “going the second mile”

- The key to going the second mile is to agree on the destination

- “Industry defining events” highlight the importance of effective regulatory-industry engagement
  - Three Mile Island – Industry oversight, critical safety functions
  - Piper Alpha – Safety cases, bow tie analysis
  - Challenger and Columbia – Continuous Risk Management, extensive PSA
  - Texas City – OSHA PSM, inspections
  - Deepwater Horizon - ???
Overall objective - evaluate effectiveness of the Bow Tie approach to:
- Communicate safety and risk issues across organizational and discipline boundaries
- Actively involve all personnel in managing barriers for preventing and mitigating accidents

Workshops to develop bow tie diagrams for the “Top 10” events of 2009
- Involved 60 personnel from across the organization and from all levels
- Focused on “what could have happened” as well as “what did happen”

Cross-functional safety management themes were identified, e.g.
- Need for extensive process understanding, e.g. awareness of system interrelationships and consequences of procedural steps
- Need for task-specific experience and competence for complex tasks
- Need for effective cross-functional communication when planning tasks
- Need to identify and apply context-relevant operating experience (OPEX)

Detailed results give insights on how to correct these issues
Safety culture insights were identified by discussing the World Association of Nuclear Operators (WANO) Principles of a Strong Nuclear Safety Culture in the context of the specific events, e.g.
- Importance of adhering to nuclear safety standards and requirements
- Importance of a systematic approach to incorporate safety in operational decisions

Feedback from participants on the value of the bow tie approach
- Increases appreciation of the consequences of events and individual actions
- Supports thought processes to analyze events and identify solutions
- Helps identify multiple barriers, giving a broader picture than root cause analysis
- Gets the right people into the room to discuss important cross-functional issues
- Provides a neutral framework to discuss sensitive issues
- A significant mutual learning experience results from inter-disciplinary discussion
Conclusions

- Industry defining events such as Three Mile Island, Texas City, and Deepwater Horizon show the critical need for an effective safety culture for the operation of complex industrial facilities

- Effective safety management requires the integration of technical and organizational risk factors

- A risk informed approach helps focus safety management and safety culture programs on the most critical needs

- DNV is partnering with a Canadian nuclear utility to develop an approach for risk informed safety culture assessment

- We are exploring possible application of the approach to the offshore industry and the post-Deepwater Horizon safety regime
Safeguarding life, property and the environment

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