DRIVING PSM PERFORMANCE BEYOND KPI METRICS

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Purdue University, West Lafayette, Indiana
Remembering the world’s Process Safety Guru

M. Sam Mannan
1954 - 2018
Discussion Outline

- Review of Process Safety Management (PSM) metrics & past performance

- The relationship between the non-fatal incident rate and fatal and serious incidents rates

- Barrier health management as a key to reducing the number of operating plant incidents

- A different approach to safety to reduce fatal accident rates
Process Safety Indicators Pyramid
(IOGP, Report 456, November 2018; API 754, April 2016)

- **Tier 1**: LOPC events of greater consequence
- **Tier 2**: LOPC events of lesser consequence
- **Tier 3**: Challenges to safety systems
- **Tier 4**: Operating discipline & management system performance indicators
Example of PSM KPI Metrics

- **Tier 1 PSE**: an unplanned or uncontrolled release of any specified material from a process that results in one or more of the seven specified consequences.
- **Tier 2 PSE**: an unplanned or uncontrolled release of any specified material from a process that results in one or more of the five specified consequences not a Tier 1 release.
- **Tier 3 PSE**:
  - Safe Operating envelop excursion
  - Pressure relief device or Emergency blowdown system activation
  - Fixed gas detection system activation
  - Safety system or device failure to function on demand or test
  - Disabled / non-functional safety systems and devices
- **Tier 4 PSE**:
  - Process Hazard Analysis (PHA) Completion
  - Process Safety Action Item Closure
  - Procedure review
  - Work order compliance
  - Emergency Response drills
  - MOC / PSSR
  - Alarm management
  - Fatigue risk management
Safety Performance - LTIF and TRIR
(OGP Safety Performance Indicators 2014)
Rate of nonfatal injuries resulting in DAW
(Center for Construction Research and Training - CPWR 2016)

FTE - Full-time Equivalent workers
DAW – Days Away from Work

Injuries per 10,000 FTEs

Year

2003 2005 2007 2009 2011 2013 2015

- 236 - Construction of buildings
- 237 - Heavy & civil engineering
- 238 - Specialty trade contractors
- All construction
Occidental Petroleum
Injury & Illness Incidence Rate (IIR)

Injury & Illness Incidence Rate

Rate per 200,000 Exposure Hours


- Blue line: Employee
- Orange line: Contractor
Fatal Accidents
(OGP Safety Performance Indicators 2014)

Fatal incident rate is decreasing but leveling off
The number of serious incidents have decreased but the severity of those occurring has increased over past 10 years.
Trend in Total Losses by Year (all industry sectors) (Refineries, Petrochemicals, Gas processing, Terminals and distribution, Upstream)

Distribution of the 100 Largest Losses by Year (in 2013 values)

Trend line = the trend of the total losses by year 1974–2013

Source: Marsh & McLennan: The 100 Largest Losses 1974-2013 – Large Property Damage Losses in the Hydrocarbon Industry

No fall in major incidents over the past two decades.
The Safety Triangle of Accident Prevention

- Inherent assumption: Correlation between the bottom and the top of the pyramid
- A reduction of low consequence incidents will reduce the number of high consequence incidents
Is this a Dangerous Assumption?

Are the root causes of low and high consequence incidents very different?
Safe Operations?

Low incidents rates are not an indication of safe operations.

Deep Water Horizon operator Transocean had a great safety record in the years leading up to the 2010 incident that killed 11 people.
The Nature of Fatal Accidents

• Anomalies / outliers
  • Do not follow a pattern that can be identified, predicted & prevented
  • Cannot be prevented by reducing non-fatal incidents

• Not a failure of prevention systems

• Are a failure of preparation and recovery mechanisms

• Reduction requires a different focus to overall safety management
Reducing the Number of Fatal Incidents

• PSM KPI metrics are necessary but not sufficient to drive overall safety performance further
  – Tier 3 and 4 metrics are driving these improvements
  – Fewer incidents are occurring but severity is increasing

• Approach: Implement a tool that operators better understand and relate to
  – Based on equipment performance
  – Based on positive outcome measure (presence of controls)
Trends in Process Safety Enhancement

Existing PSM programs are insufficient to promote step-change improvements. A new approach is needed to achieve and maintain the health of critical plant component barrier systems.
Barriers Types – OGP

• Active barriers
  – Hardware
  – Human performance

• Inactive / Support System barriers
  • Management System components

Hardware Barriers – OGP Definitions

Category 1: **Structural Integrity**
Category 2: **Process Containment**
Category 3: **Ignition Control**
Category 4: **Detection Systems**
Category 5: **Protection Systems – including deluge and firewater systems**
Category 6: **Shutdown Systems – including operational well isolation and drilling well control equipment**
Category 7: **Emergency Response**
Category 8: **Life-Saving Equipment – including evacuation systems.**

Category 1: Operating in accordance with procedures
• Permit to Work
• Isolation of equipment
• Overrides and inhibits of safety systems
• Shift handover, etc.

Category 2: Surveillance, operator rounds and routine inspection

Category 3: Authorization of temporary and mobile equipment

Category 4: Acceptance of handover or restart of facilities or equipment

Category 5: Response to process alarm and upset conditions (e.g. outside safe envelope)

Category 6: Response to emergencies.

Management System Barriers

- Permit to work (Element 8)
- Management of Change (Element 5)
- Emergency Response Procedure (Element 7)
- Competency Management (Element 3)
- Contractor Management (Element 3)
- Technical Integrity (Element 6)
- Corrosion Management (Element 6)
- Equipment Isolation (Element 8).

Barrier Health (BH) Assessment

• Focus on “critical” equipment / hardware barriers
• Components provide positive control of operating risks
  – Mitigation elements identified in PHA studies
    • PSVs, ESDVs, F&G D&P systems, PCSs, etc.
  – High-value components
  – Rigorous Preventative Maintenance registered in Maintenance Management System
• Assess the health of critical components in real-time assessments against performance standards
Hardware Barrier Health Models

• Real time BH models have been developed and are in place in a number of operating facilities
• Consultant advanced models in place
  – RiskPoynt
  – Petrotechnics
• Adopt OGP hardware barrier categories
• In-house development at Oxy
Simultaneous area-level view allows operations to view the barrier condition and include permit and isolation information from external permit systems. **Advantage** – a clear view of operations hazards with information that is collected daily and stored for future reference.
API standard process safety KPIs are listed and tracked based on integration from external sources. **Advantage** – reduces reporting time and administration of data collection, and provides a consistent approach to industry related process safety performance measures.
Petrotechnics Barrier Health Model (mapping systems data to barriers)

Mapping systems data to barriers

<table>
<thead>
<tr>
<th>Data / Information</th>
<th>Structural Integrity</th>
<th>Process Containment</th>
<th>Ignition Control</th>
<th>Detection Systems</th>
<th>Protection Systems</th>
<th>Shutdown Systems</th>
<th>Emergency Response</th>
<th>Life Saving</th>
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</thead>
<tbody>
<tr>
<td>Status of safety critical equipment</td>
<td>X</td>
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<td>Pipe and vessel wall thickness inspections</td>
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<td>Overdue PM's on Safety Critical Equip.</td>
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<td>Corrective WO's on Safety Critical Equip.</td>
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<td>MOC – impacting barriers</td>
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<td>HAZOP / PHA Action Items</td>
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Mapping work activities to barriers

<table>
<thead>
<tr>
<th>Activity</th>
<th>Structural Integrity</th>
<th>Process Containment</th>
<th>Ignition Control</th>
<th>Detection Systems</th>
<th>Protection Systems</th>
<th>Shutdown Systems</th>
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<th>Life Saving</th>
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<td>Hot Work</td>
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<td>Breaking Containment</td>
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<td>Heavy Lifting</td>
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<td>Non Standard Isolations</td>
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</table>
Focus at the plant level
Full engagement of O&M staff
Near real time assessment of barriers health against performance standards
Focus on managing consequences
Allows work execution plans to be optimized
Management access to output
Safety Differently

- Balancing prevention, execution and recovery to reduce chances of serious incidents
  - Implement a bottom-up approach
  - Engage and empower of plant staff
  - Focus on consequence (not hazard) management

- Combine “Stop work” authority with “do not start” work authority
  - Ensure that all the safeguards are in place to “fail safely”
  - Focus on identifying and maintaining controls

- Rigorous risk management focused at the work site
Conclusions

- PSM KPIs have driven improvements in non-fatal and fatal incident rates

- Number of incidents has decreased but the severity of those occurring has increased

- Barrier Health models offer the potential to further reduce number and costs of incidents

- Different focus on safety is needed to help reduce the number of fatal incidents
References

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4. “National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, Report to the President, January 2011

5. “Buckets to Disaster: Guidance to Improve the Outcome of Critical Technical Decisions”, Behie, Mannan et al, presented at the 20th International PSM Symposium, Mary Kay O’Connor Process Safety Center, Texas A&M University, October 2017


12. “Becoming the Worlds Safest Company, Tesla’s Journey”, Laurie Muse Shelby, EHS Vice President, Tesla, Inc., Keynote Address at the MKOPSC International Symposium, October 2018
The End

Thank you for your attention

Questions?
References

Measuring the Positives
Active Barriers

Plant Risk Sources

- **Examples:**
  - Hot Work
  - Confined Space Work
  - Heavy Lifting
  - Breaking Containment
  - Excavation

- **Examples:**
  - Construction / Project work
  - Adjacent Units
  - Export Loading

- **Examples:**
  - Plant/Equipment Start Up
  - SOL Excursions
  - Unstable Plant
  - Non-standard Isolations
  - Temporary Defeats

- **Examples:**
  - Excessive Heat / Cold
  - Wind
  - Visibility
  - Rain / Hail / Snow
  - Electric storm

- **Examples:**
  - Deferred Inspections
  - Test Failures
  - Inoperable SCE Equipment
  - Temporary Repairs

- **Examples:**
  - Competence
  - Fatigue
  - Inexperience
  - Distractions
  - Understaffing
  - Discipline
  - Single Worker
Reduce FAR Need to See Safety Differently

People are the problem

Safety is the absence of negatives

Safety is a bureaucratic activity

People are the solution

Safety is the presence of positives

Safety is an ethical responsibility

Sidney Dekker, Oil and Gas Safety in a Post-Truth World, May 2018
Safety Culture Ladder

- **PROGRESSIVE**: Safety is key and is fully integrated into our work
- **PROACTIVE**: We are working on the problems we still find
- **CALCULATING**: We have the system in place
- **REACTIVE**: Safety is important, and we do a lot if something happens
- **PATHOLOGICAL**: We're not worried as long as we do not get caught

_INCREASE IN BEING INFORMED_

_INCREASE IN TRUST AND RESPONSIBILITY_