Cheddar or Swiss?
How Strong are Your Barriers?
Bayan Saab, Process Safety Consultant, FVC

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Bio – Bayan Saab

• 20 years Process/Operations and consulting experience in the Petrochemical Industry
• BS in Chemical Engineering, Texas Tech University
• MBA, Texas Tech University
• Present Position: Process Safety Consultant Fuel Value Chain
Background

Existing Process Safety Metrics (examples)
- Major Incident, HiPo Near-Miss, LOPC and lower severity incidents
- Overdue inspections and tests
- Major accident risk assessments, action closure
- Elimination of risks: portable buildings, atmospheric blowdown stacks

Independent (Baker) Panel Findings
- Lagging PS metrics are insufficiently utilized by Industry
- General lack of corporate - but especially site - management focus on leading PS metrics
- The Panel called for BP to:
  - Introduce lagging index addressing fires, explosions, releases and PS injuries/fatalities
  - Develop an integrated set of lagging & leading PS indicators *ahead of industry* and work with industry to gain consensus on PS metrics
  - Make this part of a systematic review & improvement process

Working with Industry - CCPS, API, USW, UK H&SE, EPSC, CONCAWE, OGP etc
CCPS PS Metrics Project

- Pamphlet published
  http://www.aiche.org/ccps/
  - Recommendations in three areas:
    - Common Industry-Wide Lagging Metric
    - Near-Miss or Other Lagging Metrics
    - Leading Metrics

- Guideline Book to be published in 2009
Metric #1: Count of Process Safety Incidents (PSI)

Criteria:

- Any releases of material or energy from a process unit resulting in:
  - Employee/contractor lost time injury(s), or
  - Fire or Explosion resulting in $25,000 of direct cost to the company, or
  - Chemical release from the primary containment (i.e., vessel or pipe)*, greater than chemical release threshold quantities, linked to global UNDG criteria

* Excluding releases to designed control device specifically designed for that event (e.g., flare, scrubber, or PSV designed per API 521 or equivalent)
Common Lagging Metric Thresholds

Material Hazard classification as defined by United Nations Dangerous Goods definitions:

“Process Safety Incident TQ”

All TIH Class A materials 5 kg (11 lbs.)
All TIH Class B materials 25 kg (55 lbs.)
All TIH Class C materials 100 kg (220 lbs.)
All TIH Class D materials 200 kg (440 lbs.)
Packing Group I (Flammable Gas) 500 kg (1100 lbs.)
Packing Group II (Flammable Liquid) 1000 kg (2200 lbs.)
Packing Group III (Combustible Liquid) 2000 kg (4400 lbs.)
& Division 2.2 (Nonflammable, Nontoxic Gases
PS Metrics summarised across a Corporation
Examples: Loss of primary containment, process safety incidents, overdue actions

PS Metrics summarised for a Business Segment (e.g. Refining, E&P)
Examples: Audit action items, process safety training, engineering standards implementation

PS Metrics collected in detail by Operations
Examples: Demands on safety systems, corrosion testing, maintenance findings, operational upsets
Improving the Process – 3 approaches to identifying leading & lagging indicators for each key barrier
Process Safety metric development approached from 3 directions:

- **Proactive** – Identify risks first, then barriers, and finally metrics that measure barriers
  - Example: Process based on H&SE guidance

- **External Learning** – Identify metrics to effectively manage the barriers: (i) used by others in industry, and (ii) required to gauge performance on business strategy
  - Example: Work at Texas City

- **Reactive** – Use past incidents to identify barriers that broke resulting in harm, and then metrics that measure those barriers
  - Example: Analysis of Major Incidents, HiPo Near-Misses, Large Releases

The preferred model is a combination of all three performed at various stages of the business cycle.
Proactive Approach

- Workshop of experienced people led by H&SE - duration 2 days
- Based on H&SE guidance (HSG 254)
- Sources:
  - Hazard identification
  - COMAH Safety Report
- Process:
  - List undesired CONSEQUENCES (immediate causes)
  - Identify PRIMARY CAUSES
  - Prioritize list of BARRIERS *(risk control systems)*
## Proactive Approach – example metrics at UK site

<table>
<thead>
<tr>
<th>Barrier</th>
<th>Lagging Indicator</th>
<th>Leading Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment Overpressure</td>
<td>No. of high pressure alarms</td>
<td>No. of times condition of pressure control loops falls below set standard</td>
</tr>
<tr>
<td>Accidental Leakage</td>
<td>No. of Hi &amp; Med priority leaks</td>
<td>% completion of planned Process Technician routines</td>
</tr>
<tr>
<td>Equipment Overfill</td>
<td>No. of high level alarms</td>
<td>No. of times condition of level control loops falls below set standard</td>
</tr>
<tr>
<td>Corrosion</td>
<td>No. of times corrosion rate exceeds predicted rate</td>
<td>No. of UT thickness checks not completed on time</td>
</tr>
<tr>
<td>Management of Change</td>
<td>No. of incidents with MoC as a root cause</td>
<td>No. of risk review comments added at approval stage</td>
</tr>
</tbody>
</table>
External Learning Approach

Activity flow to define the content

Identify key Business Drivers (framework)

Small groups focus on each key Business Driver, e.g. safety, asset performance.

Compile existing, enhanced and proposed metrics

“Long list” of metrics

Review with SMEs to confirm applicability

Refined list of metrics

Reviews are specific to sub-sets of metrics, follow a standard methodology, target each level of organization and area – determine applicability, purpose, additions, and how information would be used

Break-out sessions focused on the metrics for each key business driver to determine completeness and actionability

Conduct challenge session on content

Carry forward metrics
External Learning – example metrics at Texas City

**PS Metrics from ‘Process Safety / Loss of Containment’ Category**

- Total Near Misses*
- Operating Envelope Exceedences*
- Safety / Environmental PSM Action Items Overdue Rolling %*
  - Action Item Closure Quality
  - Average Action Item Closure Time
- Incident Investigation Action Items Overdue Rolling %*
  - Action Item Closure Quality
  - Average Action Item Closure Time
- Primary Loss of Containment*
- Overdue Policies and Procedures Update and Review*
  - Action Item Closure Quality
  - Average Action Item Closure Time
- Total Number of Fires
- LDAR Missed Inspections*
- Integrity Management Inspections and Tests Overdue*
- HSE Audit Action Items Overdue Rolling %*
  - Action Item Closure Quality
  - Average Action Item Closure Time
- PS Minimum Expectation Action Items

*Potential Leading Indicator

**PS Metrics from Other Areas**

- Communication Effectiveness
- Leadership Team Collaboration Ratio
- Executive Stability
- HSE Investment
- Follow-up Rate to Procedural Non-conformances
- Training effectiveness
  - Training Completion Rate
  - Quality of Training
  - Training Impact
- Turnover Rate
- Personnel Fatigue
- HiPo – MIA
- Preventive Maintenance Compliance
- Control of Work Action Items
  - Action Item Closure Quality
  - Average Action Item Closure Time
- Contractor Conformance with Contracts Audit Action Items

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**Key lessons learned:** Be comprehensive and ensure data integrity
Training, procedures, and engineering design & standards were the most prevalent barriers.

### Top 10 Barriers

<table>
<thead>
<tr>
<th>Barriers</th>
<th># of Appearances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering Design and Standards</td>
<td>77</td>
</tr>
<tr>
<td>Staff Training Program</td>
<td>75</td>
</tr>
<tr>
<td>Operating, Startup, and Shutdown Procedures</td>
<td>65</td>
</tr>
<tr>
<td>Emergency Response</td>
<td>45</td>
</tr>
<tr>
<td>Inspections</td>
<td>44</td>
</tr>
<tr>
<td>Routine Maintenance</td>
<td>43</td>
</tr>
<tr>
<td>Oversight and Supervision</td>
<td>42</td>
</tr>
<tr>
<td>Interlocks and Protective Systems</td>
<td>38</td>
</tr>
<tr>
<td>Hazard Recognition and Situational Awareness</td>
<td>35</td>
</tr>
<tr>
<td>Alarms</td>
<td>35</td>
</tr>
</tbody>
</table>
Identifying Metrics at Corporate Level

• Metrics were then matched to key barriers, based on experience from:
  - BP existing metrics, UK sites, Texas City, and BP compliance efforts
  - Guidance from CCPS, API, UK H&SE and others
  - Review and research of 14 scientific journals & 13 industry / professional organizations
  - Additional metric information obtained from the Chemical Industry, Nuclear Industry, and Air Traffic Control.
## Corporate PS Metrics - initial ideas (work in progress)

<table>
<thead>
<tr>
<th>Barrier</th>
<th>Leading Indicator</th>
<th>Lagging Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspections, Equipment Tests, Preventative</td>
<td>No. of Inspections and Tests</td>
<td>No. of Inspections and Tests</td>
</tr>
<tr>
<td>Maintenance</td>
<td>No. of Inspections and Tests Requiring Remedial Actions</td>
<td>Overdue Inspections and Tests</td>
</tr>
<tr>
<td>Engineering Design and Standards, Site</td>
<td>No. of Group ETPs</td>
<td>No. of High Priority STPs</td>
</tr>
<tr>
<td>Technical Practices (STP)</td>
<td>No. of High Priority STPs assessed and approved for alignment with the ETPs</td>
<td>Equipment conforms (Fully meets STP or authorized by EA) to High Priority STPs</td>
</tr>
<tr>
<td>Staff Competency and Task Understanding</td>
<td>No. of people in safety critical roles</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No. of people assessed to be competent in safety critical roles</td>
<td></td>
</tr>
<tr>
<td>Operating, Start-up, and Shutdown Procedures</td>
<td>No. of Procedures Documented/Up To Date</td>
<td>No. of Incidents where inadequate procedures is a contributing factor or cause</td>
</tr>
<tr>
<td></td>
<td>No. of Procedures Not Documented/Up To Date</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Procedures in place meeting Quality Criteria</td>
<td></td>
</tr>
<tr>
<td>Institutional Learning Process</td>
<td>Percentage of Priority Incidents with Lessons Learned Report (overdue &gt;30 days)</td>
<td>“Database Repeat Indicator” rolling year versus previous three years</td>
</tr>
<tr>
<td></td>
<td>% of Reports that meet Quality Criteria</td>
<td>No. of practices, procedures or standards updated as a result of High Value Learnings</td>
</tr>
</tbody>
</table>
In summary

- BP has adopted a lagging Process Safety Index aligned to CCPS guidance
- BP has developed a process at site and corporate level for selecting Process Safety Indicators
  - The UK H&SE guidance is a good model but can be improved, e.g. to benefit from learning from incidents and external experience
- As a result of applying this process, BP has introduced leading and lagging indicators for Process Safety into their corporate level reporting based on key barriers, such as:
  - Inspection/Testing/Preventive Maintenance, and Competency (pilot), and is considering introducing future leading and lagging indicators for:
    - Procedures, Learning and Engineering Practices
- Carefully selected and managed metrics can lead to stronger, more robust barriers

**In essence, changing ‘Swiss’ to ‘Cheddar’**