Process Safety in Chevron

History and Evolution of Process Safety in Chevron
What is Process Safety?

1. Helps prevent very serious/catastrophic process-related accidents. Also includes activity-related events with catastrophic potential.

2. Applies structured, formal management systems to key accident prevention elements, encompassing critical areas of plant design, construction, maintenance and operations.
A Major Incident Viewed From a Process Safety Perspective: *Piper Alpha*

- Operated by Occidental Petroleum
- Located in North Sea, generated almost 10 percent of UK oil revenues
- 226 people on the structure
- Maintenance work being performed
- On July 6, 1988, platform burned to the sea, killing 167 people, including two attempting rescue
- Generated significant regulatory response, including extensive requirements for “Safety Cases” in the UK
Piper Alpha
Sequence of Events

- Light hydrocarbon **Pump A** isolated for maintenance on day shift. **Relief Valve A** removed for testing.
- Work permits showing out-of-service equipment not clearly communicated to nightshift.
- On the nightshift, light hydrocarbon **Pump B** shut down and could not be restarted.
- Nightshift recommissioned **Pump A**, without noticing that **Relief Valve A** had been removed.
- Upon **Pump A** start, light hydrocarbon was released, followed by an explosion that failed the crude oil export piping.
- Fire water pumps were on manual (a safety measure for divers) and could not be activated. Crude oil fire continued until high-pressure gas export piping failed.
- With access to muster area blocked, platform personnel gathered in accommodation module awaiting instruction that never came.
- A second gas export line failed.
Safe Work Practices

- Work permits on the same or related systems were normally not cross-referenced and were often signed without “field” checking the job.
- The work permit required blinds to be installed when the relief valve was removed. Blinds were not installed, per accepted platform practice.
- The fact that the Relief Valve A was removed should have appeared in three separate shift handover notes (operations, maintenance, engineering). It was in none.
- The contractor supervisor, and most platform personnel, had received no training on the work permit system (Contractor HES Management—CHESM).

Management of Change

- A gas compression system had been installed near the accommodation without an analysis of potential fire/explosion impacts to the control room and accommodation, or an evaluation of potential impacts to platform evacuation.
Hazard Identification and Risk Analysis

- During initial designs, fire walls had been installed on Piper Alpha, but blast walls were not considered.

- A risk assessment conducted 12 months earlier had evaluated the possible consequences of a high-pressure gas piping failure. No action had been taken on the study recommendations.

Operating Procedures

- Other platforms had the policy of putting the fire water pumps on “manual” only when divers were working near the pump suction piping. The Piper Alpha platform manager extended this practice to include any work involving divers, in the belief that this would bring added protection for the divers.

Competency

- The platform manager had never been trained in platform emergency response procedures.
Emergency Management

- There had been no training or emergency drills conducted for inter-platform emergencies.
- The managers of the adjacent platform assumed the Piper Alpha would bring their fire under control, and therefore they did not need to shut down.

Auditing

- The Piper Alpha platform permit-to-work system had undergone a significant number of audits. Every day, one operator had the only task of monitoring the work permits. There was never a report to management indicating the work permit system was not being followed properly.
- Six months before the accident, an internal company audit looked at the permit-to-work systems and found no deficiencies.

Culture

- The responsibility for safety was seen as belonging to the Safety Department rather than line management.
## Context of Piper Alpha

<table>
<thead>
<tr>
<th>Year</th>
<th>Location</th>
<th>Deaths</th>
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*Industry Drove Conceptual Development*

Collaborative Efforts

- Four parallel industry development projects (Organization Resources Counselors, American Institute of Chemical Engineers/Center for Chemical Process Safety (CCPS), API and American Chemical Council) led to the creation of process safety.
- Subsequent U.S. government regulations based upon industry concepts.

Partial list of Participants

- Du Pont
- Exxon
- Imperial Chemicals
- Shell
- Chevron
- Eastman
- British Petroleum (BP)
- Amoco
- Rohm and Haas
- Mobil
- Unocal
- Marathon
- Dow
- 25+ others

*The fundamental concepts of process safety were developed by industry and not by regulating authorities, as is commonly presumed.*

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<th>CCPS Elements of Process Safety</th>
<th>“Common Sense” Practices Based Upon Accident History</th>
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<td>Process Safety Culture*</td>
<td>Safe Work Practices*</td>
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<td>Stakeholder Outreach</td>
<td>Operating Procedures*</td>
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<td>Workforce Involvement</td>
<td>Emergency Management*</td>
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<td>Process Safety Competency*</td>
<td>Conduct of Operations</td>
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<td>Compliance with Standards</td>
<td>Operational Readiness</td>
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<td>Hazard Identification and Risk Analysis*</td>
<td>Management of Change*</td>
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<td>Process Knowledge Management</td>
<td>Management Review and Continuous Improvement</td>
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<td>Training and Performance Assurance</td>
<td>Auditing*</td>
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<td>Contractor Management</td>
<td>Measurement and Metrics</td>
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<tr>
<td>Asset Integrity &amp; Reliability</td>
<td>Incident Investigation</td>
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*Piper Alpha System Failures
Operational Excellence in Chevron (OEMS)

Leadership Accountability

Management System Process

OE Expectation Elements
1. Security of Personnel & Assets
2. Facility Design & Construction
3. Safe Operations
4. Management of Change

1. Reliability & Efficiency
2. Third Party Services
3. Environmental Stewardship
4. Product Stewardship

8. Incident Investigation
9. Community Awareness and Outreach
10. Emergency Management
11. Compliance Assurance
12. Legislative & Regulatory Advocacy
Process Safety in Operational Excellence

Leadership Accountability

Management System Process

2. Facility Design & Construction
   - Corporate Standard Technical Codes and Standards
   - Operational Readiness and Pre-Start-up Procedures

3. Safe Operations
   - Corporate Risk Management Process
   - Corporate Standard Process Safety Information

4. Management of Change
   - Management of Change Process
   - Corporate Standard Operating Procedures
   - Managing Safe Work Process
   - Training for Process Safety Competency

5. Reliability & Efficiency
   - Corporate Standard Asset Integrity Management
   - Reliability and Asset Integrity Process

6. Third Party Services
   - Contractor HES Management Process

9. Incident Investigation
   - Incident Investigation Process

11. Emergency Management
   - Emergency Management Process

12. Compliance Assurance
   - Corporate Compliance Assurance Process
Changing Landscape/Business Drivers for Increasing Risk Assessment Rigor

- **Changing risk portfolio:**
  - Increased operational complexity
  - Increased consequences of an accident
    - Liquefied natural gas (LNG) manufacturing and handling
    - Deepwater oil exploration and production
    - Public reaction to environmental and health impacts

- **Diminishing societal tolerance:**
  - Increased visibility and reaction to “small” accidents
  - Worldwide trend demanding incident-free operations

**Many Facilities have increasing potential for larger accidents, and society has increasingly less tolerance for any accident.**
BP, Post Texas City
The Long-Term Cost of Major Accidents?

Texas City Explosion

BP Chairman resigns

Gulf of Mexico Well Blowout

Since April 20 when the Gulf oil spill began, BP shares have tumbled about 40%.

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Process Safety in Chevron

Management of Process Safety in Chevron & Creating a Process Safety Culture
Catalyst Loading System

Valve Set to Manual and Closed

Nitrogen Purge

To Oxygen Analyzer

Oxygen Meter

Oxygen

Meter

Tote Bin

Occasional Flange Leaks of Catalyst

Breather Vent Valve

Odor Gas

Hopper

Catalyst Hazards

- Dry power is flammable
- Dust is an explosion hazard
- Dust is a static electricity generator
- Reacts with water to form $\text{H}_2\text{S} / \text{acid}$
Incident Summary

Background
- Occasional small leaks of catalyst from the gaskets in the hopper system generated \( \text{H}_2\text{S} \) due to the humidity causing frequent \( \text{H}_2\text{S} \) odors and occasional alarms in the hopper area
- Nitrogen purge valve set to manual and closed from the DCS console (creating a slight vacuum of \(-5\text{mm H}_2\text{O}\))
- Though air was entering the system, there was no \( \text{O}_2 \) alarm

Sequence of Events
- Unloaded one tote bin at 9 am
- Explosion in hopper while unloading second tote bin at 4 pm
- Tote bin fell on nearby employee. Fire seriously injured another employee
- Production stopped. System redesigned, and new HAZOP conducted
Contributors to Incident

- **Self-managed teams** (in fashion in 1990s) encouraged teamwork and collaboration. Lack of an assigned, accountable supervisor may have contributed to normalization of deviation allowing closed N2 valve

- **One of a kind** tote bin–hopper design added to system complexity

- **O₂ analyzer sample point** not optimally located. O₂ entered at opposite side of hopper allowing pockets of flammable material. Potential hazard not identified in initial HAZOP

- **Low pressure gaskets** were not properly sealed

- **Frequent H2S odors** did not trigger a comprehensive management review

- **Possible consequences of an impaired N2 blanket system** not included in operating procedures and training
Process Safety in Operational Excellence
Example of Corporate Process Safety Requirements
Chevron’s Accident Model

Figure 1 – Hybrid Accident Model

Process Safety Culture

Process Safety Management Systems

Specific safeguards (procedures, training, inspection, alarms, design integrity, etc.)

Initiating Event

Major Incident

Effectiveness of process safety prevention systems drives the likelihood and consequences of potential incidents
“(He) showed no passion, no curiosity, no interest (for safety). Considered safety strictly something for the line to handle”  

“(He) did not know how process safety was managed. (He) did not review process safety because “it’s all about net margin.”  

“Did not regularly ask fundamental questions which might have highlighted operational risks at refinery”  

“He was, or should have been aware of critical symptoms such as unreported fires, leaks, emergency shutdowns”  

“Did not appreciate the increasingly critical issues related to process safety, but rather continued the emphasis on personal safety”  

Too new on job to be accountable, however, was initiating improvements.  

“..failed to check the competencies of the people….Was accountable to ensure his mangers carried out a unit start-up following proper procedures,”
Chevron’s Process Safety Journey

Process Safety Fluency and Effectiveness Shaping History

- **<1980s**
  - Procedures; Engineering Standards; risk assessments; API 14C for offshore

- **1990’s**
  - The Chevron Way
  - Process Safety Systems at High Risk Facilities; Protecting People & the Environment; safety part of Chevron Way

- **2001-2004**
  - OEMS aligned with industry PSM standards; continuous improvement process through MSP; OPCO’s responsible for implementing Process Safety;

- **2005-2009**
  - Risk assessment across company; Loss of Containment (LOC) Metric introduced to improve tracking; SERIP & URIP * implemented

- **2010**
  - Corporate Standards
  - Drive best practices from the center; 4 Standards for key aspects of Process Safety; fluency focus; operational discipline culture

* Chevron Asset Integrity Programs

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Three Truths About Major Incidents

**Truth 1: Little Things Lead to Big Incidents**

- Major incidents are often chains of events linked by seemingly minor failures or discrepancies (for example):
  - A small part with the wrong metallurgy
  - One step of a procedure not followed
  - A valve not fully closed
  - A safety device not tested
  - A simple change not documented and communicated

- The Bhopal tragedy (3000+ fatalities) was enabled by a $50 piping modification.

- Because of the complexity of many of our large systems, the interconnectedness of “small” failures is difficult to detect ahead of time and only becomes apparent when an event occurs.
Three Truths About Major Incidents, (Continued)

Truth 2: *Low Probability Events Can, and Do, Occur*

- When a major accident happens, there is always an element of surprise that such an accident *could* actually happen:
  - “You’ve got to remember that this is the first time that anything like this has happened to one of our rigs in the North Sea.” Armand Hammer, CEO Occidental Petroleum, following Piper Alpha tragedy
  - An “unprecedented combination of failures … industry will need to reevaluate its paradigms.” Tony Hayward, CEO British Petroleum
- Effective accident prevention undermines effective accident prevention.
  - Organizational memory fades over time, along with a sense of vulnerability.
  - Most people never experience a major accident event in their lifetimes.
  - The absence of apparent negative consequences can increase risk taking.
Truth 3: Most Major Incidents Are Characterized by Remarkably Uninteresting Similarities

“I wouldn't put it (Piper Alpha) above or below other disasters. There is, actually, an awful sameness about these incidents. They’re nearly always characterized by lack of forethought, lack of analysis and nearly always the problem comes down to poor management. It’s not just due to one particular person not following a procedure or doing something wrong. You always come back to the fact that things are sloppy, ill organized and unsystematic (up and down the organization).”

Dr. Tony Barrel, Head of UK HSE Offshore Safety Division
One Way of Looking at Accidents

Figure 2 – Graphical Representation of Little Details
Dynamic Nature of Managing “The Dots”

- The effectiveness of safeguards can change;
  - Safety systems can degrade, go untested, be compromised, or improve in functionality
  - Corrosion mechanisms can increase or decrease, or be introduced to previously unaffected areas

- Process safety management systems change;
  - Critical controls such as management of change can get overwhelmed, allowing higher risk changes to “sneak” through
  - If not planned for, personnel movements can lead to lost understanding of risks, or bring new, beneficial approaches

- Overriding process safety culture can degrade or strengthen with changes like retirements and reassignments of key personnel, acquisitions or external pressures.
Process Safety in Chevron

Risk Management
Risk Assessment Defined

- Qualitative or quantitative procedure that answers:
  - What can fail or go wrong?
  - What are the consequences of each event?
  - What is the likelihood of each event?
  - How do the likelihood and severity combine to give an overall statement of the risk?
Risk Management Defined

“The systematic application of management policies, procedures and practices to the tasks of analyzing, assessing and controlling risk in order to protect employees, the general public, the environment and company assets while avoiding business interruptions.”

AIChE Center for Chemical Process Safety
# Review of Terms

## Risk
The probability that a hazard will result in a specified level of loss.

- Defined mathematically as: 
  \[ \text{Risk} = \text{[Severity]} \times \text{[Frequency]} \]

## Risk Assessment
The application of a procedure that asks:

- What can fail or go wrong?
- What are the consequences?
- What is the likelihood?
- How do the likelihood and consequences combine to give a statement of risk?

## Qualitative Risk Assessment
A team of experienced personnel judge the consequences and likelihoods of events of concern based upon their experiences.

## Quantitative Risk Assessment
Qualified analysts apply validated modeling tools, data and mathematical techniques to quantify the consequences and likelihoods of events of concern, which are then combined in risk statements.
Context for HES Risk Assessments

The Chevron Way

Company Values  Protecting People and the Environment  Organizational Capability

CSOC/CPDEP
Decision Quality
Identify & Select Opportunity
Generate & Select Alternatives
Develop the Preferred Alternative
Execute
Operate & Evaluate

Company Design Standards
Industry Standards & Practices
Risk Assessment
Project Development & Construction
Operating Standards & Procedures
Selection of Personnel
Training & Competency Verification
Maintenance
Reliability Programs
Human Factors & Behaviors (RBL-IIF)
Emergency Response

OE Management System
Security
Facilities Design and Construction
Safe Operations
Management of Change
Reliability & Efficiency
Third-Party Services
Environmental Stewardship
Product Stewardship
Incident Investigation
Community Awareness & Outreach
Emergency Management
Compliance Assurance
Legislation & Regulatory Advocacy

Zero Incidents
Chevron Corporate HES Risk Management Process

- Structured process
- Clearly stated objectives
- Enterprise-wide scope
- Mapped to specific OE expectations
- Defined roles and responsibilities
- Specific leading and lagging measures reported annually at the corporate level
- Common risk assessment and management procedure: RiskMan2
Qualitative to Quantitative Transition

- Increasing Consequences
- Increasing Uncertainty

Numbers of Facilities

- Increasing Rigor of Risk Assessment

Level of Risk Assessment Effort

Quantitative Risk Assessment
RiskMan2 Procedure

Starting Point
Asset/Project With Widely Varying Types of Facilities and Hazards

Sub-Procedure 1
Identify, Group and Prioritize

Sub-Procedure 2
Perform High-Level Risk Assessment to Identify HES Risks and Determine Further Risk-Assessment Needs

Sub-Procedure 3
Perform Targeted Detailed Risk Assessments

Sub-Procedure 4
Develop and Implement Risk Reduction Plan and Document Closure of Actions

Sub-Procedure 5
Periodically Revalidate

Risk Following Mitigation

Health  Safety  Environment

High-Level HES Risk Profile

1  2  3
Examples of Detailed Safety Studies

Qualitative:
- Checklists
- What-if checklist
- HAZOP (HAZard and OPerability) Study
- Failure modes and effects analysis (FMEA), semi-qualitative
- Other qualitative reviews (layout studies, essential system survivability analyses [ESSAs], etc.)

Quantitative assessments:
- Consequence modeling:
  - Flammable release
  - Toxic release
  - Fire/radiant heat
  - Explosion (vapor cloud explosion [VCE], rapid phase transition [RPT], pressure volume [PV] rupture, etc.)
- Full quantitative safety risk assessment
Corporate Requirements

- Undertake periodic HES risk assessments of all existing facilities, activities and capital projects.
- Follow the RiskMan2 procedure including the use of Qualified Facilitators and Environmental/Health/Social Facilitators and other competent personnel.
- Maintain and implement a plan for conducting assessments consistent with the Corporate implementation timeline.
- Maintain and implement an HES risk-reduction plan and document closure of all recommendations.
- Revalidate assessments at a minimum of every five years.
- Provide representative HES risk-assessment documentation to the Risk Management Center of Excellence for quality assurance review.
- Submit an OPCO annual summary report.
Context for Risk Decision Making

Means of Calibration
- Codes and Standards
- Verification
- Peer Review
- Benchmarking
- Internal Stakeholder Consultation
- External Stakeholder Consultation

Significance to Decision Making Process
- Codes & Standards
- Good Practice
- Engineering Judgement
- Risk Based Analysis
  e.g. QRA, CBA
- Company Values
- Societal Values

Decision Context Type
A
- Nothing new or unusual
- Well understood risks
- Established practice
- No major stakeholder implications

B
- Lifecycle implications
- Some risk trade-offs/ transfers
- Some uncertainty or deviation from standard or best practice
- Significant economic implications

C
- Very novel or challenging
- Strong stakeholder views and perceptions
- Significant risk trade-offs or risk transfer
- Large uncertainties
- Perceived lowering of safety standards