Risk Management and Assessment in the Oil and Gas Industry

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Summary

- Risk application in oil and gas industry: safety, design, O&M
- Facility risk assessment
- Pipeline integrity management
- Dependability and risk management
- Conclusions
Oil and Gas = RISK

Steam turbine and hydrogen compressor

Natural gas pipeline

Construction at a refinery

Oilfield operators receiving training in gas compression

Gas turbine overhaul shop
Risk in Oil and Gas

- **Financial**
- **Regulatory and political**
- **Project**
  - Exploration and drilling
  - Major facilities
  - Construction practices, contracts and cost
- **HSE – Health, Safety and Environment**
- **Design**
- **Operation and maintenance**
Facility Risk Assessment

- **PSM - Process Safety Management**
- **Hazard identification**
  - Hazardous materials
  - Electrical
  - Process conditions (high pressure, temperature, etc.)
  - Radiation
  - Mechanical equipment
  - Failures
  - Work activities
Hazard Analysis

- Hazard analysis methods
  - HAZOP – Hazard and Operability Studies
  - What if / Checklists
  - LOPA – Layer of Protection Analysis
  - SIL – Safety Integrity Levels
  - HACCP – Hazard Analysis and Critical Control Points
  - JSA – Job Safety Analysis
# Integrated Risk Matrix

Consequence categories

<table>
<thead>
<tr>
<th>Severity point scale</th>
<th>Health and safety</th>
<th>Environment</th>
<th>Production</th>
<th>Financial</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Loss of life (10)</td>
<td>Widespread pollution</td>
<td>Major outage more than 1 week</td>
<td>Financial impact less than $10 million</td>
</tr>
<tr>
<td>1</td>
<td>Loss of life (1)</td>
<td>Major spill with cleanup</td>
<td>Major outage up to 1 week</td>
<td>Financial impact less than $1 million</td>
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<tr>
<td>0.1</td>
<td>Major injury</td>
<td>Minor spill with cleanup</td>
<td>Financial impact less than $100k</td>
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<tr>
<td>0.01</td>
<td>Minor injury</td>
<td>Small spill or release</td>
<td>Financial impact less than $10k</td>
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<tr>
<td>0.001</td>
<td>First aid</td>
<td>Minor outage less than 1 day</td>
<td>Financial impact less than $1k</td>
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</tr>
<tr>
<td>0.0001</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
Risk Control

- Safety of personnel
  - Formal safety policies and procedures
  - Personal Protective Equipment
  - Job planning and hazard analysis
  - Work permits
  - Tag and lockout procedures
  - Training and certification
Risk Control

- Emergency response planning and exercises
  - Documented and approved procedures
  - Response planning and exercises

- Design
  - Standard proven design
  - Protective equipment (e.g. relief valves, overspeed)
  - Alarm and shutdown instrumentation and controls
Risk Control

- Operation
  - Standard operating procedures
  - Training and certification

- Maintenance
  - Standard maintenance procedures
  - Training and certification
  - Maintenance task development (RCM)
  - Maintenance planning and scheduling
Risk Management

- Risk-based inspection - static equipment such as pressure vessels
- Integrity management - pipelines
Integrity Management

Identify Hazards

Estimate Probability of Failure

Estimate Consequences of Failure

Estimate Total Operating Risk

Identify Targeted Segments

Repeat for All Hazards
Integrity Management

1. Identify Integrity Maintenance Options
2. Estimate Effect of Maintenance Strategy on the Probability of Failure
3. Calculate Risk reduction
4. Calculate Cost of Implementation
5. Select Optimal Integrity Maintenance Strategy

Repeat for All Options
Probability Analysis

- Minimum operating pressure
- Data on pipe properties and dimensions
- Inspection intervals
- Maximum model and test results
- Data from repetitive inspections
- Failure probability as a function of time

Annual Failure Rate by Small Leak, Large Leak and Rupture Segment 3 - Pipeline 1

Failure Rate Due to Corrosion Before and After Inline Inspection Pipeline 1 at 471.99832 km

- System
- In-line

Failure Rate (failure/year)

Time (years)

- Total
- Small Leak
- Large Leak
- Rupture

2008-10-15
IEC/TC56 Dependability Seminar
Copenhagen, Denmark
Analysis Results

Risk ranking of segments by total cost

Risk profile before and after a maintenance action

Cost optimization with safety constraint

Benefit-cost ratio
Risk and Dependability

- Dependability is a key performance characteristic in risk-based systems
- Dependability approach to risk assessment assures that the risk exposure to a product or system under control remains at an acceptable level within the confines of a tolerable region
- Dependability focuses on risk assessment methods
Risk management process being defined by new standard ISO 31000

Risk assessment methods to focus on new joint standard ISO/IEC 31010
Risk Definitions

- ISO Guide 73 (latest draft): effect of uncertainty on objectives

NOTE 1 An effect is a deviation from the expected positive and/or negative
NOTE 2 Objectives can have different aspects such as financial, health and
  safety, and environmental goals and can apply at different levels such as
  strategic, organization-wide, project, product and process
NOTE 3 Risk is often characterized by reference to potential events, a
  consequence, or a combination of these and how they can affect the
  achievement of objectives
NOTE 4 Risk is often expressed in terms of a combination of the
  consequences of an event or a change in circumstances, and the
  associated likelihood of occurrence

- ISO Guide 51: combination of the probability of
  occurrence of harm and the severity of that harm
Risk Concepts

- Risk is uncertainty
- Risk is always present under all circumstances
- Elimination of all risks is not always possible or economical
- Risk should be reduced to a level as low as reasonably practicable to achieve a desirable benefit
Risk Reduction

Residual risk

Tolerable risk

Necessary risk reduction

Actual risk reduction

Actual risk achieved by all risk reduction approaches

Partial risk reduced by dedicated risk control mechanisms + Partial risk reduced by technology applications + Partial risk reduced by external risk avoidance means

Risk exposure to a product or system requiring control

IEC/TC56 Dependability Seminar Copenhagen, Denmark
Selection of Methods

External, Internal Context and Criteria

Resources and capability

Nature and degree of uncertainty

Complexity

High
Medium
Low

High
Medium
Low

High
Medium
Low

Select approach to Risk Assessment
### Assessment Methods

<table>
<thead>
<tr>
<th>Tools &amp; Techniques</th>
<th>RISK ASSESSMENT PROCESS</th>
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<tbody>
<tr>
<td></td>
<td>RISK IDENTIFICATION</td>
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<tr>
<td></td>
<td>CONSEQUENCE</td>
</tr>
<tr>
<td>Failure mode and effect analysis (IEC 60812)</td>
<td>SA</td>
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<tr>
<td>Failure mode, effect and criticality analysis (IEC 60812)</td>
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<td>Fault tree analysis (IEC 61025)</td>
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<td>Hazard and operability studies (HAZOP) (IEC 61882)</td>
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<td>Reliability centred maintenance (IEC 60300-3-11)</td>
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<td>Markov analysis (IEC 61665)</td>
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<td>Human reliability analysis</td>
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<td>Preliminary hazard analysis</td>
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<td>Event tree analysis</td>
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<td>Brainstorming</td>
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<td>Structured or Semi-Structured Interviews</td>
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<td>Delphi Techniques</td>
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<tr>
<td>Checklists</td>
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<td>Consequence/Likelihood Matrix</td>
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<td>LOPA</td>
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<td>SWIFT</td>
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<td>Decision Tree</td>
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<td>Bow Tie Analysis</td>
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<td>Monte Carlo</td>
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<td>Root Cause Analysis</td>
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<td>HACCP</td>
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<td>Business Impact Analysis</td>
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<td>Cause and effect analysis</td>
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<td>Sneak Circuit Analysis</td>
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<tr>
<td>Bayesian Analysis</td>
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</table>

**Notes:**
- **SA**-strongly applicable
- **A**-applicable
- **NA**-not applicable

_2008-10-15_
Conclusions

- Risk management and assessment is critical to the oil and gas industry
- Risk is closely tied to dependability and has to be considered over the entire life cycle
- Dependability risk assessment methods are widely applicable to all industries
- Integrated ISO/IEC standards are under development to meet industry needs