Using risk assessment to support decision-making for onshore pipelines: safety and environmental risk

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- 15 years of engineering and process safety experience
- Technical expertise includes:
  - Quantitative risk assessment
  - Process safety management in pipelines and utilities
  - Pipeline economic valuation
- Facilitates related training courses for ioMosaic
ioMosaic Corporation offers services in process safety design and risk management

- **Pressure Relief & Flare Systems Design**
  - Emergency relief design meeting risk-management goals, compliance requirements & support sound business practices.

- **Process Safety Management**
  - Meeting regulatory requirements while realizing the benefits of a process safety and risk management program.

- **Process Safety Training**
  - Offering custom training and open enrollment.

- **Laboratory – ISO Accredited**
  - Complete laboratory testing services for chemical reactivity hazards and combustible dust hazards.

- **User & Enterprise Software**
  - Complete, compliance process safety system. All your process safety needs and information at your fingertips, securely in one location.
This presentation considers onshore pipeline investment decision-making – we will cover the following topics:

- Regulating the environmental impacts of pipeline operation
- Assessment and decision-making
- How ioMosaic has helped clients
- Conclusions
Regulating the environmental impacts of pipeline operation
Pipeline safety and environmental management can be more complicated than for other onshore assets

- Pipelines are widely regarded as the safest method of transporting hazardous fluids over long distances

- Safety and environmental management is complicated by the typical absence of secondary containment
  - Bunding, surface water traps and other measures are usually only constructed at key points – such as pump stations and valves
  - Pipeline loss of containment is very likely to contaminate the immediate environment

- Topography and remote isolating valve location can lead to significant volumes of product being released
Visible safety consequences of pipeline failures can be significant – but so can hidden environmental damage

- San-Bruno pipeline explosion (California, 2010)
- 8 fatalities
- Failure of 30 inch natural gas pipeline caused by defective seam welds

Costs of environmental remediation can be significant, irrespective of environmental sensitivity

Remediation costs quoted in the literature are in the range of US $400-800 per m³ for excavation and landfill to $1200 per m³ for soil vapor extraction
Pipeline failure is widely addressed within international good practice and national standards

- Pipelines are regulated using a combination of compliance-based standards and risk-based approaches
- Safety regulation is generally considered to be more comprehensive and prescriptive than environmental regulation
- Where environmental regulations do exist, they may build on safety regulations
  - Concept of High Consequence Areas used for both safety and environmental hazards in North America
  - European environmental risk tolerability criteria are referenced against societal risk acceptance criteria
The UK has introduced environmental risk tolerability criteria, although their application can be complex

- Environmental risk tolerability criteria have been introduced under national Major Accident Hazard regulations (COMAH)

- Operators are required to provide environmental risk assessments for the control of Major Accidents to the Environment (MATTE)

Typical steps in completing a MATTE risk assessment:

1. Assessment to evaluate link from source to receptor – e.g. groundwater, aquifers, air emissions
2. Assessment of unmitigated risk considering initiating frequency and control measures
3. Assessment of mitigation measures (e.g. secondary containment)
Pipeline failure data are widely collected to understand primary failure frequencies by cause.

- Failure type is influenced by primary cause
  - External interference and ground movement lead predominantly to ruptures
  - Corrosion leads predominantly holes and cracks
- It is difficult to predict where failures will occur – understanding failure root causes is key to preventing failure
Assessment and decision-making
QRA techniques are well-established for pipeline risk assessment

1. Obtained through Process hazard analysis (hazard identification)
2. Determined from probabilistic models (e.g. Process Safety Office® SuperChems™)
3. Determined from consequence models (e.g. Process Safety Office® SuperChems™)

- LOC [1]
- Gas release
- Liquid release
- Ignition
- VCE [2]
- Scenario
- Receptor
- Gas cloud
- Fire
- Explosion
- Pool fire
- Unignited pool
- People
- People
- People
- People
- Environment

[1] Loss of containment

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Environmental QRA is more complex given the location-specific nature of environmental impacts

- High consequence area classification recognizes the presence of sites where environmental impacts are considered more severe.

- However, remediation costs are highly dependent on local topography and geography that determine the extent of environmental damage.

- For example, for two similar spills due to failure of pipe supports at a minor river crossing:
  - During periods of low rainfall the clay river bed acted as natural bunding.
  - During a period of greater rainfall the spill was carried some distance to a small lake, requiring extensive cleanup.
A key concern following pipeline loss of containment is liquid spill leading to groundwater contamination.
Operators need to determine expenditure priorities for pipeline inspection and maintenance

- An operator will typically have a risk-based inspection (RBI) programme – for example based on API methodologies

- RBI relates inspection frequency to the risk from equipment failure, based on failure consequences

- Failure consequences can be expressed as the potential loss of life or, in the case of environmental damage, time required for effective remediation and related remediation costs
The challenge is risk equivalence – how do we compare different risks?

- The first step is to convert all risks to equivalent (typically monetary) values, for example:
  - Environmental harm can be related to remediation cost
  - Safety consequences can be related to economic measures such as the Value to Prevent a Fatality (VPF)
  - Equivalent values, when multiplied by their frequency of occurrence will given an equivalent risk score (e.g. $ per year)
Risk matrices can be used to show equivalent values

1. Risks scored separately
2. Equivalent values calculated for all risks (e.g. monetised value)
3. Equivalent risks can be compared on the same risk matrix

Source: ioMosaic Corporation
How ioMosaic has helped clients
Experienced in conducting safety and risk assessment studies for pipelines

**QRA for a large refinery for buried, sub-sea and above-ground pipelines from 8 to 30 inch diameter**

**LPG pipeline study in the Amazon (pipeline location indicated by white arrows)**

Source: ioMosaic Corporation
We have included models within these studies that support estimation of environmental harm.
Conclusions
Risk equivalence is the key to effective decision-making!

- The cost of environmental remediation following pipeline failure can be significant, irrespective of general regulatory compliance.
- Operators must decide appropriate preventative expenditure on inspection and maintenance, based on environmental spill risks.
- Risk equivalence allows environmental risk to be aligned to (more familiar) operational and safety risk metrics.
Questions or Comments
About ioMosaic Corporation

Through innovation and dedication to continual improvement, ioMosaic has become a leading provider of integrated process safety and risk management solutions. ioMosaic has expertise in a wide variety of areas, including pressure relief systems design, process safety management, expert litigation support, laboratory services, training, and software development.

ioMosaic offers integrated process safety and risk management services to help you manage and reduce episodic risk. Because when safety, efficiency, and compliance are improved, you can sleep better at night. Our extensive expertise allows us the flexibility, resources, and capabilities to determine what you need to reduce and manage episodic risk, maintain compliance, and prevent injuries and catastrophic incidents.

Our mission is to help you protect your people, plant, stakeholder value, and our planet.

For more information on ioMosaic, please visit: www.ioMosaic.com