BENCHMARK ANALYSIS
ON-LAND PIPELINE SAFETY SYSTEMS

Elise DeCola, Nuka Research and Planning Group, LLC

Interspill 2015

Abstract

Onshore pipelines provide a critical transportation mode for liquid petroleum products. With several major pipeline projects proposed or pending, North American regulatory agencies have focused renewed energy on pipeline safety and oversight.

A benchmarking analysis evaluated regulatory and legislative approaches across twelve peer jurisdictions from North America, South America, Europe, and Asia. Regulatory or legal requirements that exceed a given benchmark were highlighted, and trends were explored by benchmark category and by jurisdiction. Past performance of peer jurisdictions was also considered by comparing leak rates and examining case studies of past oil spills; however, no conclusions were drawn about peer jurisdiction performance.

The results of this study provide a systematic method for comparing approaches to on-land pipeline regulation. All but three jurisdictions achieved or exceeded at least 60% of the benchmarks, and all jurisdictions were above 40%, which suggests that there is some harmony in terms of baseline approaches across international jurisdictions. Regulatory approaches across European Union nations are most significantly harmonized due to a number of common directives. No single jurisdiction stands out across all categories.

Introduction

To inform current oversight and potential future rulemaking, a study was conducted to compare key aspects of on-land pipeline safety systems. The study objectives were:

1. Examine the pipeline safety regimes in peer jurisdictions.
2. Determine which pipeline safety elements are common among peer jurisdictions, and group the elements into a framework of prevention, preparedness and response, and liability and compensation.
3. Attempt to assess performance of peer jurisdictions.

This study was performed for internal use by a small consortium of North American regulatory agencies.[1] Nuka Research was the lead author and analyst; a team of seven technical reviewers from government and industry provided peer review of the analysis and observations. This paper focuses on

[1] This paper is presented with the permission of the funding agency as a general overview of the process and findings.

the process and observations of the benchmarking study without specifically identifying the jurisdictions evaluated.

Approach

The study focuses on national regulatory approaches to cross-country on-land pipeline systems by comparing twelve peer jurisdictions from across the globe (one North American country, two South American Countries, two Australasian countries, and six European nations). Factors considered in selecting peer jurisdictions included total length of pipelines, strong regulatory approaches as reported in published literature, and the availability and quality of information in the public domain.

Benchmark Analysis

Benchmarks were established in three core areas:

- Pipeline safety and prevention;
- Emergency preparedness and response; and,
- Liability and compensation.

Within each of the three core areas, benchmarking categories were established, and benchmarks were developed as a means to assess and compare regulations across peer jurisdictions. Benchmarks are presented as affirmative statements regarding a specific regulatory threshold or the presence or absence of a certain type of requirement. The benchmark is achieved when the threshold is met or the requirement is present. The benchmark is exceeded when specific requirements stand as going beyond the benchmark. The benchmark is not achieved if the threshold is not met or the requirement is not present.

Table 1 lists the benchmarks compared in this study. The benchmark analysis examines components of pipeline safety regimes across the twelve peer jurisdictions and focuses on regulations or practices that stand out against the landscape of regulations. In some cases, there was not sufficient information available to assess the benchmark, which is also noted in the results.

Table 1. Benchmarks used in this study

	Benchmarking Categories
Pipeline Safety & Prevention	***Technical Standards for Pipeline Design***
	Regulations establish siting requirements for pipeline route and location
	Regulations require operators to take actions to reduce potential 3rd party damage
	Regulations establish design life requirements
	Regulations establish design factor standards
	Technical Standards for Pipeline Operations and Maintenance
	Regulations establish pipeline corrosion monitoring, control, and mitigation standards
	Regulations establish leak detection standards
	Regulations establish standards for emergency shutdown
	Safety and Integrity Management
	Regulations establish organization and personnel requirements
	Regulations incorporate risk-based or risk-informed approach
	Regulations establish requirements for operator inspection and repair activities
	Regulations establish requirements for management and control of changes
	Oversight and Enforcement
	Regulations establish reporting requirements
	Regulators conduct inspections and audits
	Regulations establish enforcement mechanisms and compliance standards
Emergency Preparedness & Response	***Emergency Preparedness and Response***
	Regulations require operator emergency response plans
	Regulations require government emergency response plans
	Regulations require community and stakeholder notification of emergency plans and procedures
	Oil Spill Preparedness, Contingency Planning, and Response
	Regulations require onshore pipeline operator oil spill contingency plans
	Government oil spill contingency plans address on-land spills
	Regulations establish worst case spill response planning volumes or standards
	Regulations require sensitive area planning
	Regulations require minimum spill response equipment levels
	Regulations require minimum levels of trained responders
	Regulations require use of standard incident management system
	Regulations require regular oil spill response training and exercise programs
Liability & Compensation	***Legal and Political Environment***
	Jurisdiction has an established rule of law
	Jurisdiction has the authority to enforce regulations that penalize spillers
	Jurisdiction has demonstrated ability to enforce oil regulations through past incidents
	Jurisdiction has laws and regulations specific to terrestrial oil spills
	Liability, Compensation, and Recovery
	Jurisdiction has regulations establishing strict liability for response and clean up costs
	Jurisdiction has established a dedicated oil spill fund to cover terrestrial oil spills
	Jurisdiction has regulatory standards for evaluating damages and requiring compensation for losses
	Jurisdiction has regulations or mechanisms in place that recognize pure environmental loss

Peer Jurisdiction Performance

Assessing the performance of peer jurisdictions in the three core areas proved challenging, and no single methodology was identified that could accurately evaluate or compare the performance of pipeline safety regimes across

nations. Instead, a mix of qualitative and semi-quantitative approaches was applied to gain insight into the performance of pipeline safety regulations.

Pipeline spill incident rates and trends were explored as lagging indicators of pipeline safety and prevention measures, although significant cautions are applied to interpreting this data. An on-land US pipeline case study is presented as a means to interpret the performance of preparedness and response regulations. The nuances associated with measuring performance of liability and compensation regimes are explored. Unlike the benchmark analysis, the performance measure discussions do not systematically analyze or compare all of the twelve peer jurisdictions, and no conclusions are drawn about peer jurisdiction performance.

Results

Benchmark Analysis

Table 2 shows an example of the benchmarking summary for Technical Standards for Pipeline Operations and Maintenance (part of the Prevention category). Similar matrices were produced for each individual benchmark in the Prevention, Emergency Response, and Liability/Compensation areas.

Table 2. Example of benchmarking analysis summary

Bench-mark	Country A	Country B	Country C	Country D	Country E	Country F	Country G	Country H	Country I	Country J	Country K	Country L
Technical Standards – Pipeline Operations and Maintenance												
Corrosion control	◒	●	?	◒	◒	◒	●	◒	?	●	◒	●
Leak detection	○	◒	?	◒	◒	○	◒	◒	?	◒	◒	◒
Emergency shutdown	◒	◒	?	○	◒	○	◒	◒	?	●	◒	●

KEY: ○ Does not achieve benchmark ◒ Achieves benchmark ● Exceeds benchmark ? Unable to determine

Raw results were analyzed for trends by category and country, with particular focus on areas where benchmarks were exceeded.

Analysis by Category

Figure 1 shows the cumulative percentage of countries that either meet or exceed preparedness benchmarks. In this case, it shows only four categories where one or more peer jurisdictions had a regulatory requirement in place that exceeded the benchmark. For these preparedness and response benchmark categories, it is important to recognize that the measurement focuses on regulatory requirements, and does not assess the quality or content of actual preparedness plans or response capacity. This is a very indirect measurement and does not account for areas where operators may exceed the requirements. A review of the actual contents of government and industry plans could be the next step to identifying exceptional practices or capabilities.

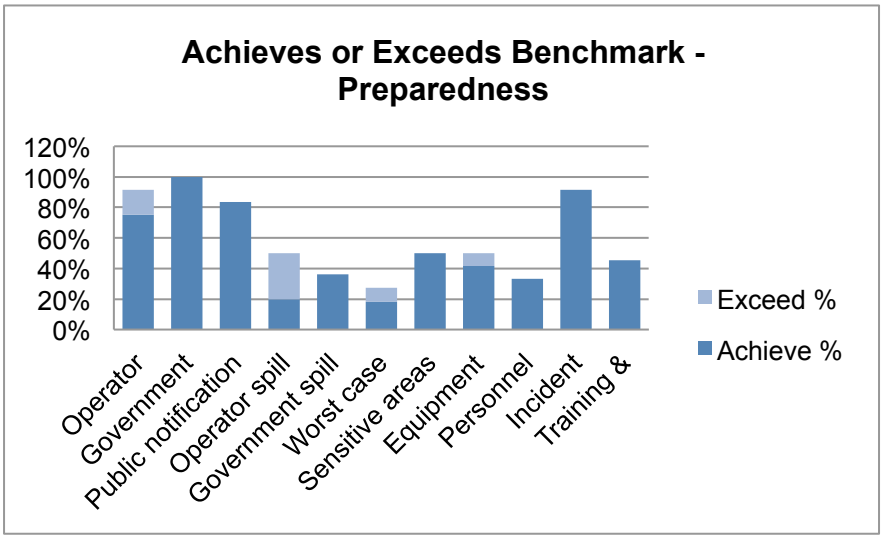
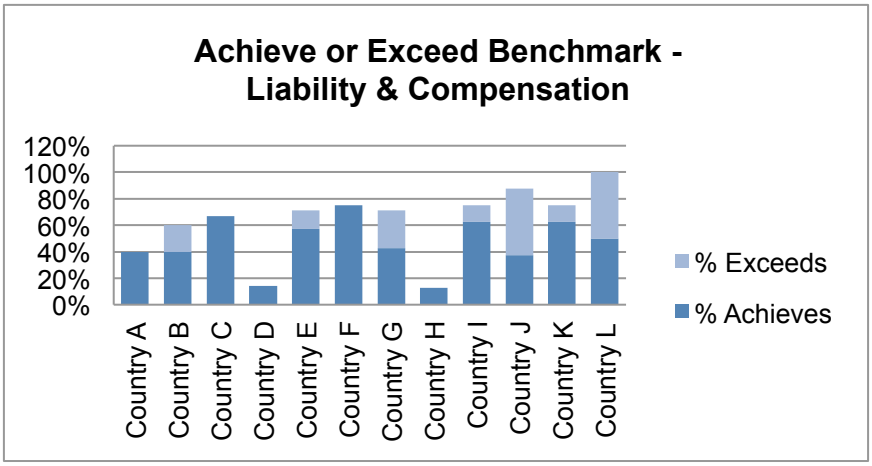


Figure 1. Percentage of jurisdictions with found regulations that either achieve or exceed emergency response and preparedness benchmark, by category

Analysis by Country

The benchmarking results were also analyzed by jurisdiction. Figure 2 shows an example of a stacked bar graph that displays information about regulatory categories where jurisdictions achieved or exceeded the benchmark as a percentage of all scores (discarding benchmarks where no information was available). Only a single country – Country I – achieved or exceeded all of the liability and compensation benchmarks evaluated. All but five countries exceeded at least 10% of the benchmarks for liability and compensation.

Figure 2. Percentage of jurisdictions with found regulations that either achieve or exceed liability and compensation benchmark, by country



Results were also synthesized across all countries and all benchmarking categories to examine overall trends.

Regulatory Practices that Exceed the Benchmarks

The benchmarking analysis generated a list of regulatory practices that exceeded the benchmark for each category. Table 3 highlights those practices that were identified as exceeding the benchmark. The authors made benchmarking determinations on the basis of professional judgment and a significant review of published literature. Benchmarks were set

purposefully, based on an initial scan of regulations across peer jurisdictions, so that there were no cases where all peer jurisdictions failed to achieve the benchmark. However, there were a few benchmarks where no regulations stood out as exceeding the benchmark.

Table 3. Examples of Peer Jurisdiction Regulations that Exceed the Benchmark[2]

Regulation Area	Category	Examples of Regulations that Exceed Peer Jurisdiction Benchmark
SAFETY & PREVENTION		
Technical Standards – Pipeline Design	***Pipeline Routing***	• Rigorous process for selecting pipeline routes, including public safety, environmental impacts, terrain and subterranean geotechnical and hydrographic conditions, existing and future land use, access, and security • Stakeholder consultation requirements • Risk-based approach for evaluating hazards and selecting route • Continuous evaluation of changes to risks for life of operations
	Third Party Damage	• Specific additional measures to be taken to protect against third party interference based on identified risks • Minimum requirements for third party safety measures based on risk • Data-driven approach – using information from past incidents to inform risk
	Design Life	• Adjust operating practices based on changes to design life • Specific data requirements to review "remaining design life" and decision-making factors to consider when operating life extends beyond design life
	Design Factor	• Lower design factor thresholds compared to other jurisdictions
Technical Standards – Pipeline Operations and Maintenance	***Corrosion Monitoring, Control & Mitigation***	• Emphasis on preventive actions and monitoring for potential defects • Hierarchical approach to prioritizing repair and mitigation of defects • Specific techniques and technologies for corrosion control
	Leak Detection	• No peer jurisdictions exceeded benchmark with national regulations • Specific leak detection thresholds in sub-national regulations
	Emergency Shutdown	• Specific, measurable requirements • Manual controls, remote locations, and other redundancies • Clear management and command and control structure • Accountability, fatigue management, and other requirements focused on reducing potential for human or organizational failures • One hour time limit to stop the flow in the event of a pipeline leak (sub-national requirement).

[2] This table is based upon the regulations reviewed for the twelve jurisdictions included in this study and is not exhaustive.

Table 3 (continued). Examples of Peer Jurisdiction Regulations that Exceed the Benchmark

Regulation Area	Category	Examples of Regulations that Exceed Peer Jurisdiction Benchmark
SAFETY & PREVENTION		
Safety and Integrity Management	*Organization & Management Responsibilities*	• Strict accountability across company organization (from licensee to management to individual employee) with duty to participate in safety & management systems • Decision-making criteria and threshold conditions with corresponding repair timeline requirements • Strict competency requirements and accountability for professionals
	Risk-based or Risk-informed Approach	• Harmonize risks across pipeline route • Application of best available technologies and precautionary principle • Establish acceptance criteria for major accident and environmental risks, and manage risk within those criteria • Prevent the potential for a single error or failure to cause a major accident by using redundant and independent risk reduction measures
	Inspection & Repair	• Specific methods or technologies for pipeline inspection (e.g. smart pigs) • Prescribed intervals for line inspections based on inspection methods and/or risks by pipeline segment • Government-reviewed plans that establish inspection intervals. • Risk-based inspections
	Management & Control of Change	• Change control plan outlines management of change procedures, and requires documentation and recordkeeping any time a change to design condition occurs
Oversight & Enforcement	*Reporting Requirements*	• Operators report incidents to external (government) databases; data compiled to benefit all operators • Publicly searchable incident databases • Public notification incorporated into incident reporting • Operators required to publicly release about local hazards at facility
	Regulator Inspections & Audits	• Risk-based approach (targeted inspections) based on specific parameters • Aggressive inspection intervals • Operator accountability to inspectors • Sufficient number of independent inspectors
	Enforcement & Compliance	• Clear expectations for compliance with regulatory requirements. • Written guidance to clarify expectations for regulators and operators about how key regulatory provisions can be met • Regulator review of operator plans; creates accountability • Enforcement penalties as deterrent • Compilation and publication of violation and enforcement data; public accessibility to information about operator records
PREPAREDNESS AND RESPONSE		
Emergency Preparedness & Response	*Operator Emergency Response Plans*	• High level of specification for information and level of preparedness • Detailed checklists or guidance documents specify expected emergency response plan contents and operator practices
	Government Emergency Response Plans	• No peer jurisdictions exceeded benchmark • Efforts to coordinate response planning and management and share knowledge across jurisdictions (local, state, national) important
	Pubic Notification	• No peer jurisdictions exceeded benchmark with national regulations

Table 3 (continued). Examples of Peer Jurisdiction Regulations that Exceed the Benchmark

Regulation Area	Category	Examples of Regulations that Exceed Peer Jurisdiction Benchmark
PREPAREDNESS AND RESPONSE		
On-land Pipeline Oil Spill Contingency Planning & Response	*Operator Oil Spill Contingency Plans*	• Specific requirements for oil spill contingency plans, including worst case planning volumes, equipment capacity requirements, sensitive area planning, and training and competency • Layered requirements (national, state, local/regional) • Rigorous government and public review of oil spill contingency plans • Demonstrate worst case spill response capacity through plans and scenarios
On-land Pipeline Oil Spill Contingency Planning & Response	*Government Oil Spill Contingency Plans*	• No peer jurisdictions exceeded benchmark
	Worst Case Discharge	• Regulations require operators to calculate their credible worst case spill volume, based on pipeline size, throughput, location, and other parameters • Operators are required to demonstrate that they have access through owned or contracted equipment and resources to achieve the capacity needed to respond to a worst case spill volume • Operators are required to prepare for a range of potential spill types and locations, and to consider factors like adverse weather
	Sensitive Area Planning	• No peer jurisdictions exceeded benchmark
	Equipment Requirements	• Response capability standards in regulation define the level to which operators must demonstrate access to resources to respond to specified spill volumes within time frames (specific to terrestrial spills)
	Trained Personnel	• No peer jurisdictions exceeded benchmark
	Incident Command System	• No peer jurisdictions exceeded benchmark
	Training & Exercises	• No peer jurisdictions exceeded benchmark
LIABILITY AND COMPENSATION		
Legal and Political Environment	*Rule of Law*	• Jurisdictions ranked in the top 10% of independently assessed rule of law • Low corruption rate, consistent application of laws and regulations, open government, transparent enforcement
	Enforcement Authority	• Enforcement programs adequately funded and staffed • Risk-based enforcement informed by data • Enforcement data available to stakeholders and public, create transparency • Strict permitting system to promote compliance and discourage violation • Rational system for applying penalties as deterrents
	Enforcement Past Performance	• Past experience holding operators accountable for spill response costs and damages.

Table 3 (continued). Examples of Peer Jurisdiction Regulations that Exceed the Benchmark

Regulation Area	Category	Examples of Regulations that Exceed Peer Jurisdiction Benchmark
LIABILITY AND COMPENSATION		
Liability, Compensation & Recovery	*Terrestrial Oil Spill Laws*	• Oil pollution laws apply specifically to inland spills to land or water
	Terrestrial Oil Spill Fund	• Government trust fund available to support response and clean up for terrestrial oil spills, regardless of funding mechanism (e.g. appropriations vs. levies).
	Damage Assessment & Compensation	• Regulatory framework outlines types of damages that may be compensated (both to government and private parties). • Specific loss categories, such as lost of services, commercial and non-commercial use, subsistence. • Established body of practice. • Swift and efficient compensation process. • Designate trustees to evaluate natural resource and habitat damages.
	Pure Environmental Loss	• No peer jurisdictions exceeded benchmark.

Conclusions

Observations

The process of evaluating this wide body of regulations across a sample of national governments yielded several observations.

Approaches to Pipeline Regulations

Among the peer jurisdictions included in this study, regulatory approaches range from prescriptive to process-oriented to performance-based, with some jurisdictions applying multiple approaches across their body of regulations, or sometimes combining approaches. For example, regulations may specify threshold limits for certain operating practices, but provide flexibility in terms of the technology or approach that operators apply to stay within the threshold value.

Performance-based approaches rely on a level of trust between regulator and regulated community and are contrasted with a more prescriptive approach, where regulators take more of a "command and control" approach, setting concrete standards and taking enforcement actions when standards are not met. As a broad generalization, North and South American regulations tended toward prescriptive standards, while certain European nations favoured a performance-based approach.

This study concluded that there is no single, best approach to pipeline safety regulations, although some jurisdictions that have historically applied prescriptive approaches to pipeline safety appear to be adopting performance-based standards, particularly in the realm of integrity management. The regulations that were identified as achieving and exceeding the benchmarks in this study fell into both categories (prescriptive

and performance-based), emphasizing that flexibility and agility in regulatory design and implementation is important.

Differences between marine and on-land oil spill regulations

Of the three key elements examined, only safety and prevention regulations are discretely tied to pipelines, and even so, regulations often overlap for onshore and offshore pipeline systems and for oil and natural gas pipelines. Emergency preparedness and response regulations, including oil spill and emergency contingency planning, are rarely specific to pipelines, and generally address a range of potential incidents from different types of operations. In many peer jurisdictions, the oil spill preparedness and response regulatory regimes were strongly biased toward marine spills. Terrestrial pipeline spill response and liability often fall under the umbrella of general environmental laws. Liability and compensation regimes do not necessarily incorporate distinct requirements for on-land incidents, and in some cases, it was unclear whether marine oil spill liability regimes and funding mechanisms could or would be applied to on-land pipeline incidents.

Pipeline Safety Regulatory System Performance

One of the study objectives was to attempt to assess the performance of peer jurisdiction on-land pipeline safety regulations. Assessing the performance of regulations is a complex process, and this study did not draw any conclusions about which jurisdiction's pipeline safety regulations were most or least effective.

Pipeline leak rates from North America and Europe were analyzed and found to show a general downward trend in leak rates, although a 2010 major US oil pipeline spill provides an anomaly that biases the past five years' data. This spill was considered as a case study that shows how regulatory weaknesses across multiple areas can influence the magnitude of a release and the effectiveness of the cleanup. For example, lapses in oversight of pipeline integrity were cited as a contributing factor to the spill, as was lack of emergency preparedness for control center operators and insufficient response resources.

The US pipeline spill case study and the body of analysis both suggest that the chain of events involved in major pipeline accidents are complex, and typically require the alignment of multiple failures in such a way as to result in a significantly adverse outcome. In ordinary operation of a well-designed system, the gaps or weaknesses rarely align, making such incidents highly unlikely.

Conversely, pipeline safety regulatory systems function like a safety net, and may "catch" small problems or defects before they have the chance to align with other forces and cause a major incident. The strength of the individual "strands" of the net is important, but so is the overall composition and resilience of the entire system of strands and regulations.

This study focuses on individual regulatory requirements, and does not address the full scope of each peer jurisdiction's safety net, which is influenced by the interplay between regulations, the relationship between regulators and operators, and the larger social, legal, political, and cultural context in which regulatory regimes function.

The aggregation of benchmarking scores does not necessarily tell the full story for any individual jurisdiction. While the benchmarking convention provides a construct for comparing and contrasting specific requirements, it would be incorrect to assume that the highest scoring peer jurisdictions are "best" or the lowest "worst."

Challenges of Benchmarking Across Jurisdictions

Several other published studies have compared regulatory approaches to oil pollution regulation or pipeline safety, but none to the extent of this report. The nature and scope of the subject matter and methodology presented some challenges and limitations, which are acknowledged as follows:

- Regulatory interpretation is subjective, and this study takes regulatory language at face value and presumes general operator compliance.
- This study does not necessarily capture industry practices that exceed regulatory requirements.
- The jurisdictions included in the study vary significantly in politics, governance, geography, culture, and pipeline infrastructure.
- Oil and gas pipeline regulations vary in scope. Some jurisdictions separate on-land and offshore pipeline regulations, others do not. Some have separate regimes for oil and gas pipelines, others do not.
- National laws vary in significance; some jurisdictions have strongly centralized (national) regulations, while others emphasize sub-national governance. Sub-national regulations were not systematically reviewed in this study.
- Practical application of regulations varies by jurisdiction.
- Pipeline safety, preparedness, and liability regulations are constantly changing, and this study takes a snapshot of their present status (2014) only.
- Significant time lags may occur between the implementation of regulatory requirements and their impact on pipeline safety.

Potential Next Steps

This study provided a very broad scan, but did not consider any single issue in depth. Research focused on written regulations and published literature, and did not include extensive interviews. Next steps could include:

- In-depth analysis of specific regulatory or practice areas;
- Analysis of sub-national (provincial or state) regulations;
- Engaging peer jurisdictions and others in an active dialogue (e.g. workshop or roundtable) to compile and compare knowledge and regulatory approaches to improve pipeline safety.

www.nukaresearch.com
contact@nukaresearch.com
+1 508.746.1047