RAILROAD SAFETY RISK ASSESSMENT

Montana Public Service Commission

Report No.: 1Q5L0AT-2, Rev. 0
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August 15, 2016	DNV GL Doc No: 1Q5L0AT-2	Docket No: N2015.11.84

Railroad Safety Risk Assessment

Dear Docket Manager:

DNV GL appreciates the opportunity to provide comments on Montana Public Service Commission's (MPSC) initiative for improving railroad safety in the State of Montana.

Our comments are intended to provide relevant information to the Montana Public Service Commission staff for the development and execution of a state railroad safety risk assessment and associated action plan.

We have organized our comments with a brief summary of rail safety in general, followed with a brief overview of DNV GL's qualifications. Then, we have presented our recommendations on these two main topics, risk assessments and safety management, that are interrelated, in two major, but equally important, main categories: Section III on Safety Management and Section IV on Risk Assessments.

We hope these comments are helpful to the MPSC and the industry as guidance in formulating the State's Railroad Safety Action Plan.

Sincerely,

Vijay Raghunathan
Principal Engineer, Risk Advisory Services

I. INTRODUCTION

DNV GL appreciates this opportunity to submit the following comments on the investigative docket to examine railroad safety by the Montana Public Service commission (MPSC). In general, we commend the MPSC's initiative in this area to address critical rail safety issues. In doing so, our overarching recommendation is that any MPSC rail safety regulations or safety action plans should be consistent with the Federal Railroad Administration (FRA) requirements as well as other stakeholder concerns for any impact to the general public, key waterways and the environment.

Today, there are numerous prescriptive safety initiatives in the railroad industry and we believe this new undertaking could be an opportunity to advance regulatory effectiveness while considering rapidly developing technologies, new and emerging risks and shifting more accountability for safe operations from the regulator to the owner/operator by adopting more performance based regulations. We also recognize that some aspects of any new initiative may be challenging for industry, but we believe an approach that is both operationally and commercially viable will be the best working solution.

Crude oil production in the U.S and its transport by rail has been on the rise over the last few years. Trains transporting these hazardous materials for different customers may go over tracks owned by several companies, resulting in a complex and connected array of prescriptive regulations, responsibilities and compliance challenges. In fact, several recent and serious rails accidents in North America have raised public awareness that the risks of rail transportation have not been adequately addressed and there are gaps in rail safety requirements.

Regulators have been attentive to the need for improving rails safety. For example, the Federal Railroad Administration's (FRA) proposed HM-251 rulemaking suggests measures such as *Changes in Rail Tank Car design, Oil Conditioning, Enhanced Braking to Mitigate Damage in Derailments, Speed Limit changes, Positive train control, Train manning when*. Also, FRA's proposed rulemaking on Risk Reduction Programs should be also be considered by the MPSC.

MPSC's Notice of Commission Action, Docket No. N2015.11.84, dated 27 April 2016, identified 5 actions. Two of the main tasks are the risk assessment and safety action plan, but we have noted that previous meetings have also identified actions related to *blocked railroad crossings, setting safety goals & conducting risk assessments, emergency planning, and inspections* as areas of concern. To address these challenges, we have outlined some best practices for safety risk management that includes safety management systems, safety culture and risk assessment drawn from our global experience.

II. DNV GL'S EXPERIENCE IN BRIEF

As a global leader in risk management, DNV GL delivers unique competence and technological expertise across many industries, particularly Maritime, Oil & Gas, and Transport, including Rail, offering an unprecedented depth and breadth of services and innovative solutions. Pursuing our purpose: Safeguarding life, property and the environment, and our vision to make a global impact for a safe and sustainable future, risks and challenges pertaining to the rail safety are indeed a focus area in DNV GL.

DNV GL is the author for the original textbook on quantitative risk assessment (QRA) issued by the Center for Chemical Process Safety (CCPS) and we are currently working on a new CCPS book on how to apply bow-tie theory and barrier risk management techniques in high risk, high consequence industries.

We are one of the top 2 global audit companies for ISO management system certification – ISO 9001 (Quality), ISO 14001 (Environment), and OHSAS 18001 (Safety) with tens of thousands of audits and certificates issued. We are one of only 4 companies approved for auditing Safety and Environmental Management Systems (SEMS) (for offshore oil drilling and exploration in Gulf of Mexico.) SEMS, now a regulatory requirement introduced by the Bureau of Safety and Environmental Enforcement (BSEE) after the Deepwater Horizon accident, is specifically intended to improve safety in another high risk, high consequence industry, offshore drilling and exploration. We also develop sophisticated software for risk assessments, including the PHAST consequence modeling tool, one of the 3 software tools approved by Pipeline and Hazardous Materials Safety Administration (PHMSA) and Federal Energy Regulatory Commission (FERC) for LNG dispersion.

DNV GL has also completed many railroad projects for organizations, regulators and industry bodies, mainly in Europe. These have ranged from safety assessments for passenger and freight traffic, developing prescriptive, performance based (goal-setting) safety standards, complex risk assessments, cost-benefit analysis, management systems auditing and performance forecasting.

We believe that our comments, derived from our knowledge and experience in risk and safety management that we have acquired over more than 150 years will be helpful to the Montana PSC and industry.

III. SAFETY RISK MANAGEMENT

Safety risk management can be broadly classified into four main categories as shown below (Figure 1) according to the Center for Chemical Process Safety (CCPS). Each of these categories can be associated with working processes, safety critical equipment, human and organizational elements.

Figure 1 Pillars of Safety Management

These categories have been adopted globally for the last 30 years in the oil and gas and chemical industries with increasing levels of success. The safety focus in many industries has traditionally been focused on occupational safety (slips, trips and falls) with little attention to process safety, which when poorly managed, leads to major accidents. As shown below in Figure 2, for the oil and gas sector, occupational safety measured by injury rates, etc. has improved by a factor of 10, however major

accidents[1], which may have been prevented or minimized with process safety management, have not shown any major decline in the last 20 years.. Without attention on process safety management, any trends towards safety improvements throughout industry, including rail transport, are not expected to prevent major accidents from happening.

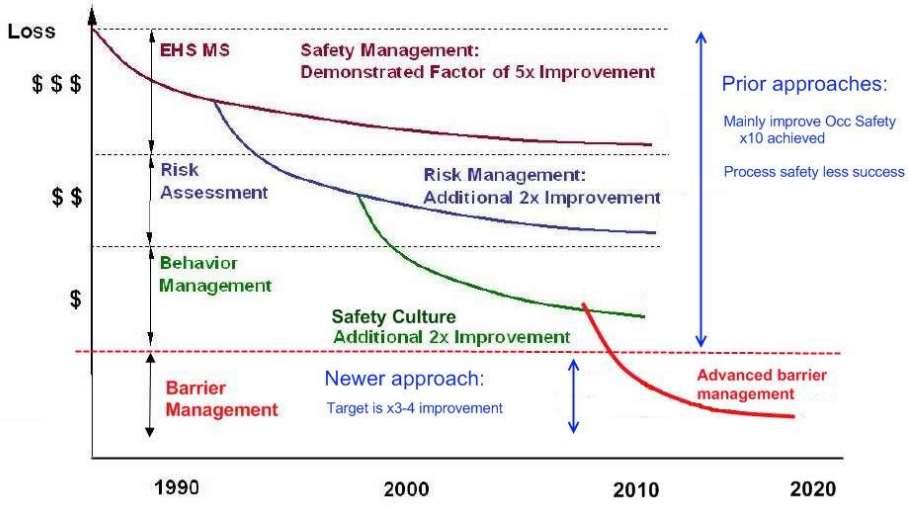

Figure 2 Safety Risk Management Approaches.

Major Accident Events that involve multiple human injuries, fatalities, extensive asset, and environmental damage are classified as process safety incidents. Occupational safety metrics or safeguards should not be applied to address process safety issues.

A. Safety Management Systems

The four pillars of Safety Management Systems (SMS) are illustrated in Figure 1 above and each pillar has several associated elements. When CCPS first issued its guidelines on SMS[1], they had an important comment in the introduction:"Every element was important and that it is better to have a basic program in place for every element than to be excellent in some and have no program in others." This is because every element can be traced back to different accidents and omitting some elements, leaves a company vulnerable to accidents of those types, regardless of the effectiveness of the other elements.

During the early 2000's, the Mineral Management Service (MMS) had discussions with the Gulf of Mexico offshore industry about implementing a safety and environmental management system (SEMS). The industry argued that it would be sufficient to address only the 4 Pillars of a Safety Management System, including management of change. The MMS reluctantly agreed; however, before regulations were developed, the Deepwater Horizon accident occurred. The successor regulator, BSEE, recognized that this was insufficient and insisted that all element must be included, leading to the SEMS regulation currently in place today. DNV GL agrees with BSEE that only a full management system containing all important elements is effective for management of safety. We recognize that these elements can be organized differently, but the holistic approach is the vital and key success factor. In fact, this view is

[1] Center for Chemical Process Safety, "Guidelines for Technical Management of Chemical Process Safety", American Institute of Chemical Engineers, 1992.

also embedded in various international safety, quality and environmental standards, such as ISO 9001, ISO 14001, and OHSAS 18001.

We note that MPSC's safety action plan must be integrated with federal regulations and risk reducing programs which have been promulgated or proposed. Our view is that the multiplicity of regulations and programs, especially between States and the Federal Government, is understandable, but it creates a potential for SMS elements to be duplicated or overlooked in the gaps between State and Federal Regulations. Therefore, we recommend holistic safety management systems that can be mapped to different regulatory requirements.

B. Safety Culture

In our experience there are numerous definitions of safety culture in circulation. Consequently, it is important for an organization or industry to adopt a standard definition in regulations and industry best practices to be consistent and allow for interpretation of data, results and accident and incident investigations.

At a minimum, we recommend that a safety culture is defined to include "shared attitudes, values and beliefs of workers towards safety".

III.B.1 Safety Culture Measurement

We recommend that organizations should be allowed to choose the methods that fit best their own organizational culture and circumstances for measurement methods, but that any measurement method includes validated data that can be used repeatedly over time to consistently and reliably measure safety culture over time. An approach DNV GL has used successfully is to combine a survey with interviews. The survey asked respondents to answer questions which provide both quantitative and quantitative data and interviews to allow issues to be explored in more depth, giving even deeper qualitative insights. DNV GL also recommends that safety culture assessments should consider both leading and lagging safety indicators and outcomes.

A good Safety Management System (SMS) forms the foundation for creating and developing a solid safety culture, but some aspects that affect culture go beyond the SMS, such as how personal goals are set, who is promoted, how bonuses are determined, actions following safety violations, training and use of safety equipment and procedures, accident and incident (near miss) reporting, etc. Indeed, some regulatory agencies, such as BSEE, have recently decided to promote the nuclear industry safety culture program and adapt it to offshore facilities. Those principles, of course, are equally applicable for the rail industry.

The following two recent findings from the Lac-Megantic investigation report also reinforce the importance of a comprehensive SMS and a strong safety culture:

- Montreal, Maine & Atlantic (MMA) Railway's safety management system was missing key processes, hence were not able to effectively manage risk.
- MMA's weak safety culture contributed to the continuation of unsafe conditions and unsafe practices, and compromised their ability to effectively manage safety.

IV. RISK ASSESSMENT AND MANAGEMENT

A. Quantitative Risk Assessment (QRA) for Rail Operations

DNV GL recommends that quantitative risk assessments (QRA) are used to assess the risks of transporting hazardous materials in rail tank cars, especially at railroad crossing, and while in rail yards.

A typical QRA consists of the five steps illustrated in Figure 3. It also shows, once the risks have been estimated, how risk assessment and management are used to identify and evaluate risk reduction measures. Risk criteria is defined and used to determine if estimated risks are tolerable.

Figure 3. Risk Assessment Methodology.

Hazard identification, is usually the first step where all credible threats that could manifest into a major accident, such as a loss of containment (for example, loss of crude) are identified.

For railcars, release frequencies can be obtained from an analysis of 10-year railroad accident history (2005-2015) published by the Federal Railroad Administration (FRA) Office of Safety Analysis. The FRA database updates the accident records each month, including listing the accident by region, state, type of accident, type of track, track class, cause of accident, casualty subset, hazard material involved or not, and asset damage level.

Next, potential leak scenarios are processed through consequence models to evaluate the potential hazard zones. All flammable and explosive consequence zones are calculated for a specified endpoint (*e.g.*, flammable concentration, thermal radiation) and the escalation potential to other rail cars or adjacent facilities can also be estimated. Specialized software tools, such as DNV GL's software Phast Risk v.6.7, are then used to compile the consequences, likelihood of each event occurring based on the frequency analysis, background data and the resulting impacts (vulnerability) to estimate risk. A

risk analysis then takes into account the probability of ignition of a release, wind direction and the various outcomes of a release in an event tree to determine the final outcome. The risk is presented as Individual Risk per annum in the form of contours as shown in Figure 4. Societal Risk in the form of aggregate risk metric per annum can also be estimated.

A few applications of the QRA are as follows:

- Quantify Public, Asset and Environmental Impact at Railroad crossings
- Risk Benchmarking of Railroad crossings, Transit Routes/Yards
- Cost Benefit Analysis for selecting Mitigation Measures and Safeguards
- Risk Compliance

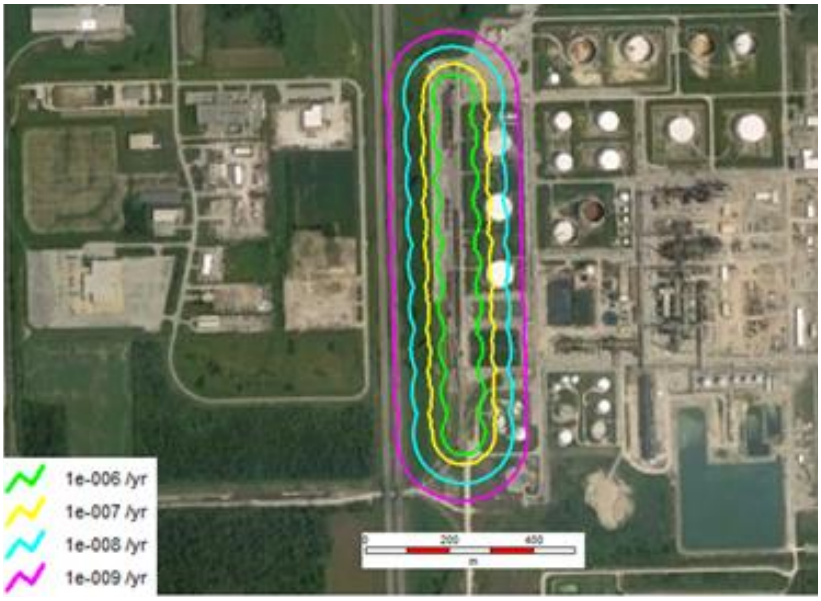

Figure 4. Example Individual Risk Contour for Rail Tank Car Yard.

IV.A.1 Uncertainties in Risk Analysis

All quantitative risk analyses are subject to some uncertainty. A QRA can, for instance, be compared to a weather forecast; based on models and available data it attempts to predict what can be expected. The quality and accuracy of the "weather forecast" is dependent on knowledge, available calculation models, data quality, and degree of detail. All risk assessments are, in general, aiming to give a "best estimate". Uncertainty in a QRA can arise due to many factors, such as assumptions regarding design and operations, statistical uncertainty in data sources, limitations of the tools and methods used and engineering judgment. Uncertainties can be managed, however, by picking realistic assumptions in discussion with stakeholders, where possible and conservative assumptions based on prior experience in other cases. This helps grossly under predicting risk especially when it involves public exposure.

For all practical purposes, it is not possible to eliminate or to quantify the uncertainty of a risk analysis. It is, however, important to identify and discuss parameters that are both uncertain and may have a large influence on the risk results.

B. Barrier Based Risk Assessment

Barrier based risk management is a proven and often used methodology for risk assessments and accident analysis. Based on the nuclear industry's defense in depth philosophy,it can be a very effective methodology for both Risk Assessment and Incident Analysis. Barrier based risk management is often explained using the Swiss cheese example. In this example, it is noted that most accidents can be prevented by a series of barriers, such as technical devices, automatic shutdowns, operating procedures, etc. – in which each barrier can be visualized as a slice of Swiss cheese. However, a single barrier is never completely effective as they may degrade over time, due to maintenance oversights or errors, human error, etc. So, if the holes in each Swiss cheese slice, or barriers, line up, a hazard may lead to an accident. Therefore, multiple barriers are used, rather than relying on a single barrier to be 100% effective, 100% of the time.

Maintaining safety barriers through effective barrier management systems is essential to ensure an effective safety regime. All barriers degrade over time if not properly maintained and preventive barriers, in particular, may be neglected in hectic day-to-day operations.

IV.B.1 Operational Risk Assessment using Bowties

While safety barriers are critical to preventing, mitigating, and controlling accident pathways, bow ties are equally helpful in risk assessments. Barrier function in relation to major accidents is often illustrated by the bowtie model as shown below in Figure 5.

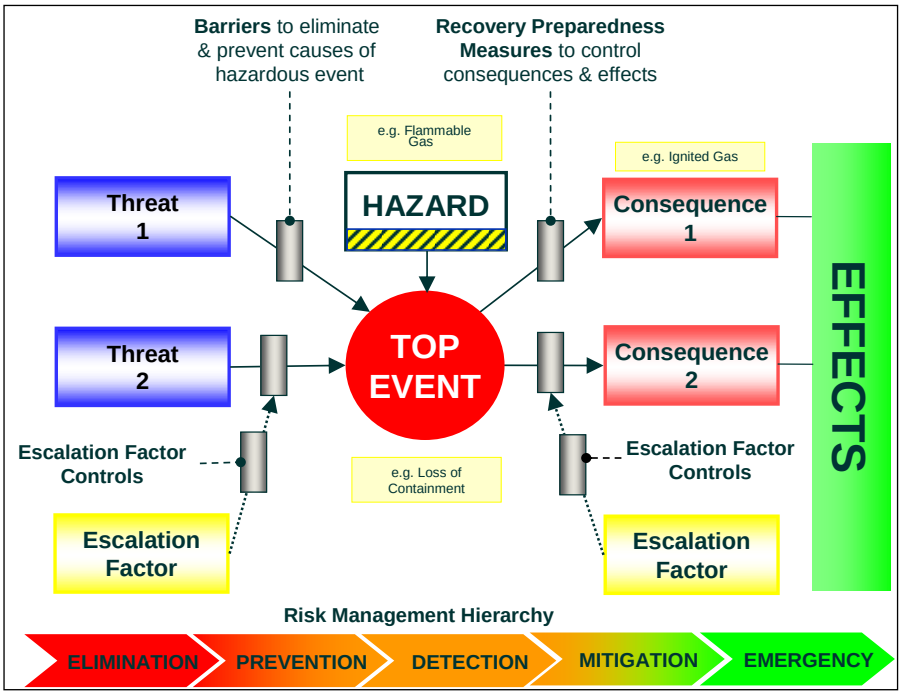

Figure 5 Bowtie Diagram.

Bowtie risk assessments are used already to some extent within the railroad industry to clearly depict how the current barriers relate to major accident hazards.

A few applications of the barrier based approach are as follows:

- Auditing by management and regulatory bodies
- Risk communication tool for all stakeholders
- Training staff on threats and safeguards
- Budgeting and prioritizing barrier resources

IV.B.2 Risk Assessments for Rail Operations

DNV GL recommends the combination of barrier based risk management and the use of bow ties. A hazard identification workshop is most commonly the first step to develop qualitative bowties for each top event or major accident. A few top events can be picked for the most critical operations and a bowtie can be constructed as shown below in Figure 6 to represent the full range of threats, including the safeguards to prevent those threats from leading to undesirable consequences.

As an example, Figure 6 shows the threat of incorrect procedures being followed during a loading operation could result in a loading arm failure and loss of containment. The corresponding safeguard "written loading ops manual" needs to be available, updated with correct procedures, personnel trained and so on in order to be counted as a working barrier. If this manual is not available or not updated, is incorrect or personnel are not trained, the barrier will have to be considered degraded. Therefore, a barrier "owner" should be assigned to ensure that there are systems, processes, checks and communications in place to ensure that the barrier is maintained. In the event the barrier is not maintained or otherwise not available, preventive actions must be taken, especially communicating the status of the degraded barrier to operations management and others.

The relevant factors from the Railroad 27 point risk analysis methodology, for example, such as the volume of hazardous material, train control systems, emergency response capability that are relevant to rail yard operations can be easily assessed using barrier management and bow tie diagrams.

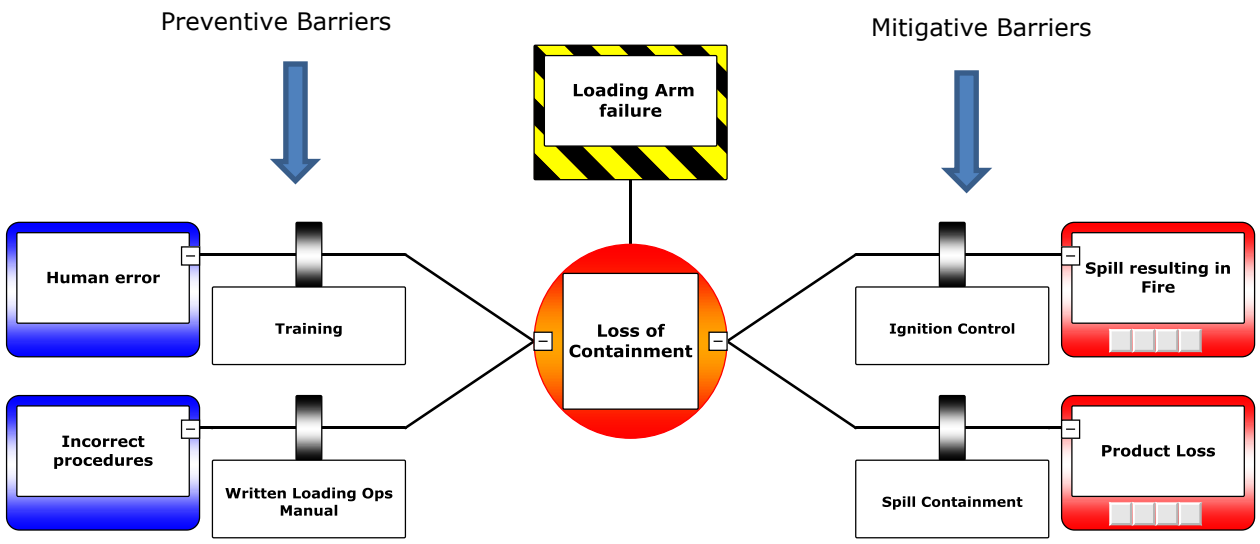

Figure 6 Simple Bowtie for Rail Yard Operation**.**

In a different scenario, inspection procedures could be one of the preventive barriers/safeguards to prevent a derailment threat and emergency response procedures could be a mitigative barrier to minimize the consequence. A safety action plan can be developed to assign personnel, resources who will develop procedures to maintain the functionality of that barrier. Safety action plans can define the performance standards for different barriers in line with industry best practices.

Our experience in risk management shows that it is equally important to understand when risks have been reduced to an acceptable level. Such limits, usually known as "risk criteria" are widely discussed

in other industries[2]. Without such limits, risk assessment becomes a recipe for endless action, with expenditure on successively less worthwhile measures, reaching the point of diminishing returns, which could be more effectively used elsewhere and may even become counter-productive. For example, in Europe there are concerns that the focus on risk reduction on the railroads has resulted in traffic moving to roads, thereby increasing risks to the public. This was addressed in DNV GL's recently published study for the European Commission of risk criteria in hazardous materials transport[3].

Members of the public may consider that their risks are not adequately protected by railroad companies' own risk management plan. For this reason, some authorities[4] specify an overall maximum individual risk of death, which over-rides cost-benefit considerations.

Railroad companies may wish to define a risk threshold below which risks are considered negligible and cost-benefit calculations are not required. This allows risk management effort to be proportionate to the risk and focused on the most important and critical areas.

It is reasonable to assume that railroads may select cost-beneficial or cost-neutral mitigation strategies. Therefore, DNV GL recommends that MPSC to provide some guidance on risk tolerability in Montana.

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[2] Center for Chemical Process Safety, "Guidelines for Developing Quantitative Safety Risk Criteria", American Institute of Chemical Engineers, 2009.

[3] DNV GL, "Harmonized Risk Acceptance Criteria for Transport of Dangerous Goods", Report for European Commission DG-MOVE, 2014 http://ec.europa.eu/transport/modes/rail/studies/doc/2014-03-25-dangerous-goods.pdf

[4] E.g. Health & Safety Executive, *op cit.*

V. CONCLUDING REMARKS

All the different safety topics covered in this document are interrelated and can be tied together by a holistic safety action plan to be developed by MPSC.

- Setting realistic process safety goals is the first step in committing to prevent major railroad accidents.
- All railroads operators in Montana most probably have a working Safety Management System (SMS) in place already. It will be a good start to demonstrate that their SMS elements are in line with industry best practice by conducting a gap assessment.
- A robust safety culture forms the foundation for any successful safety action plan to be effective and defining and measuring it the right way can help strengthen it.
- The QRA approach can be used to identify the high risk receptors (e.g. at blocked grade crossings) and contributors. An assessment of the risk based on the selected risk criteria can feed into a risk mitigation plan.
- A barrier based approach using bowties can be used to identify those safety critical safeguards identified from the QRA to be monitored and maintained in the operational phase.
- Performance based risk management using a realistic risk tolerability criterion is a powerful approach when applied in conjunction with the existing prescriptive standards.

This document only covers best practices for safety risk management; however DNV GL will be able to provide guidance on Emergency Response Planning and Inspection best practices upon request.

About DNV GL

Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. We provide classification and technical assurance along with software and independent expert advisory services to the maritime, oil and gas, and energy industries. We also provide certification services to customers across a wide range of industries. Operating in more than 100 countries, our 16,000 professionals are dedicated to helping our customers make the world safer, smarter and greener.