Transporting Crude Oil by Rail in Canada

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# TABLE OF CONTENTS

1. Introduction ........................................................................................................... 1

2. Rail Capacity and Outlook in Canada .................................................................. 3
   2.1 Western Canada Rail Loading Capacity ...................................................... 3
   2.2 Crude by Rail Throughput .............................................................................. 6
   2.3 Factors Impacting Capacity and Throughput .............................................. 7
   2.4 Western Canada Capacity Summary ........................................................... 8

3. Market Reach for Rail ......................................................................................... 9
   3.1 Track Capacity .................................................................................................. 11
   3.2 Economics of Rail Transport ........................................................................ 12
   3.3 Market Summary ............................................................................................. 13

4. Developments in Rail Safety ................................................................................ 14
   4.1 Classification .................................................................................................... 14
   4.2 Rail Tank Cars .................................................................................................. 16
   4.3 Emergency Response ...................................................................................... 22
   4.4 Liability and Compensation Regime ............................................................... 23
   4.5 Safety Summary .............................................................................................. 25

GLOSSARY ..................................................................................................................... 26

APPENDIX A: Acronyms, Abbreviations, Units and Conversion Factors ................. 27
APPENDIX B: Chronology of Significant Crude by Rail Events in Canada ............... 28
APPENDIX C: Links to Additional Information ...................................................... 30
APPENDIX D: Detailed DOT Specification ............................................................... 32
LIST OF FIGURES AND TABLES

Figures

Figure 1-1 Originated Carloads of Crude Oil on US Class 1 Railroads ......................................................... 1
Figure 1-2 Canadian Fuel Oil and Crude Oil Moved by Rail: Car Loadings & Tonnage .............................................. 1

Figure 2-1 Rail Loading Terminals in Western Canada .......................................................................................... 4
Figure 2-2 Western Canada Terminal Uploading Capacity vs Throughput Forecast ............................................. 6

Figure 3-1 Rail Distances and Cycle times to Major Markets .............................................................................. 11
Figure 3-2 North American Rail Network ........................................................................................................ 12

Figure 4-1 Sample Specification: DOT111A60ALW1 ........................................................................................... 17

Tables

Table 2-1 Major Existing and Proposed Crude Loading Terminals in Western Canada ........................................ 4
Table 3-1 Crude Specifications and Destination Markets ...................................................................................... 10
Table 3-3 Estimated Netback Costs by Market ................................................................................................ 13

Table 4-1 Class 3 Packing Group Criteria .......................................................................................................... 15
Table 4-2 Safety Feature Development of DOT111 tank cars ............................................................................ 18
Table 4-3 DOT-111 Tank Car Fleet Breakdown (As Q3 2013) ............................................................................. 19
Table 4-4 Existing Tank Car Compliance with CPC-1232 (As of Q3 2013) ......................................................... 19
Table 4-5 Average Cost of Safety Enhancements ............................................................................................... 21
1 Introduction

Historically, crude oil in North America has been primarily transported by pipelines, however pipeline capacity from the major supply regions to markets is currently tight. The Canadian crude oil industry faces a 3 to 5 year period of constrained pipeline capacity given the current status of proposed major crude oil expansions such as Keystone XL, the Trans Mountain Expansion, Enbridge’s Northern Gateway Project and TransCanada’s proposed Energy East Pipeline. None of these projects are yet in the construction phase and some still face protracted regulatory proceedings. As a result, the use of rail tank cars to transport crude oil has increased rapidly over the past several years and growth in demand for rail capacity is expected to continue in the near future with significant loading capacity coming into service before 2016.

Most crude oil transported by rail in the U.S. originates on U.S. Class I railroads. As reflected in Figure 1-1, in 2012, crude delivered by rail in the U.S. reached almost 234,000 carloads of crude oil on US Class I Railroads. This number surged to over 400,000 carloads in 2013. In Canada, the scale of crude oil transportation by rail has been significantly smaller but has similarly exhibited strong growth. The number of Canadian rail car loadings of crude oil and petroleum products reached over 16,000 carloads in December 2013 (Figure 1-2).

In Canada, with respect to crude oil, the Canadian rail industry is evolving from a manifest system, in which trains might have to make multiple stops to deliver different products, to a unit system, in which trains go directly from the point of origin to the point of destination. Most of the large scale facilities that can load a unit train will be moving heavy oil, dilBit, rail bit or raw (undiluted) bitumen. Unit trains are more efficient because the need for switching of rail cars in intermediate yards is eliminated, making the overall duration of a given trip much shorter.

1 U.S. Class I railroads are freight railroads with annual operating revenues in excess of $400 million. There are seven railroads in the U.S. and two in Canada that fall under this classification.

2 For reference, assume that each tank car carries 600 barrels of crude oil; then 233,698 carloads in a year would translate into approximately 384,200 b/d, which is roughly the capacity of a major crude oil pipeline.
The rapid growth in rail traffic for crude oil transportation and a number of high profile train incidents has elevated public concern related to safety with this mode of transportation. As a result, regulatory agencies in both the U.S. and Canada have taken steps to address such concerns and are expected to impose new standards in the near future directed towards improving safety associated with transporting crude oil by rail. It is anticipated that there will be a harmonization of any new regulations in both Canada and the U.S. due to the cross border movement of railcars. The safety review will focus on two priorities 1) accident prevention and 2) preparedness and response in an event of an accident.

Advantages of Crude Transportation by Rail

Pipelines are the most efficient means of connecting large supply basins to large market areas. In the absence of adequate capacity in western Canada, rail has now become a significant method of transporting crude oil. Pipelines have the advantages of generally lower cost, containment and continuous service, but rail transportation does have a number of advantages that enhance the attractiveness and viability of this option.

**Speed to Market:** A unit train averages 28 km/hr. Getting oil to the refinery quickly means producers are paid sooner and refiners receive feedstock sooner. Also note that a unit train loading terminal can be constructed in about 12 months.

**Optionality/Flexibility:** Rail tracks are already in place to multiple destinations throughout North America. Existing rail routes have capacity to reach East and West Coast markets in the U.S.

**Diluent:** Less or no diluent is required when transporting bitumen in rail cars, representing a significant cost savings in diluent costs. However, producers have continued to transport dilbit because raw bitumen can become too viscous as a result of cold temperatures en route which may lead to longer unloading times as the bitumen would then need to be heated to flowing temperatures.

**Scalability:** To meet markets requirements, producers have the flexibility to adjust the volumes being shipped with manifest trains. Unit trains provide economies of scale but require larger volumes to be shipped. Manifest trains are individual cars or small groups of cars, and need to wait for additional cars to collect together before being shipped to one or multiple destinations. Unit trains are a group of rail cars, typically 70-120 railcars that move from one destination directly to another. The new loop track uploading facilities are being standardized and are typically being built to accommodate 120 cars.

**Product integrity:** Commodity isolation in separate rail cars gives you no loss of quality at destination, because the crude oil loaded at origination is not mixed with other grades of crude during transportation.

**Low Capital requirements** –Typical costs to build unit train terminals range between $30 to $50 million with a capital payout of 5 years or less.
2 Rail Capacity and Outlook in Canada

The level of transportation of crude oil by rail in Canada was almost 200,000 b/d by the end of 2013. In comparison, the North Dakota Pipeline Authority estimated rail transportation from North Dakota to have reached around 760,000 b/d during the same period, which is an indication of the potential size of rail capacity. There is evidence of significant investments in infrastructure occurring in western Canada suggesting growth in capacity. Several large unit train loading facilities have been announced for western Canada that could be operational by the end of 2015. In addition, there is the potential for future additional phases to these projects that would add further to capacity.

2.1 Western Canada Rail Loading Capacity

As a result of a number of new facilities and minor expansions coming into service throughout 2013, the rail loading capacity originating in western Canada has now increased to 300,000 b/d. At the beginning of 2013, capacity was only about 180,000 b/d. The first capacity additions involved smaller facilities that loaded crude oil along with other commodities on manifest trains directly from truck to rail car. Some later projects incorporate storage capacity which helps movement of larger shipments of oil since it is logistically more efficient for truck shipments to be loaded to storage tanks and then from storage tanks to rail. Other recent developments are for dedicated unit train facilities. These facilities can directly fill unit trains via pipeline or out of tank farm storage.
By the end of 2015, western Canadian rail uploading capacity for crude oil is expected to exceed 1.0 million b/d. Several proposed facilities can be further expanded beyond the initial stated capacity so it is conceivable that rail capacity could be expandable to 1.4 million b/d.

Table 2-1 lists all the major existing and proposed rail terminals for uploading crude in western Canada.

The earliest loading terminal facilities in western Canada were constructed in the Bakken play areas located in Saskatchewan and Manitoba and were built for shipping light crude oil out of the region. The newer projects being announced are generally larger facilities and are located closer to the oil sands producing areas and consequently will provide heavy crude uploading capacity.

Table 2-1 Major* Existing and Proposed Crude Loading Terminals in Western Canada

<table>
<thead>
<tr>
<th>Operator</th>
<th>Location</th>
<th>Status</th>
<th>Expanded/Proposed Capacity** (thousand b/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Altex</td>
<td>Falher, AB</td>
<td>Operating; Expansion in Q4 2014</td>
<td>20</td>
</tr>
<tr>
<td>Altex</td>
<td>Lashburn, SK</td>
<td>Operating; Expansion in Q1 2015</td>
<td>90</td>
</tr>
<tr>
<td>Altex</td>
<td>Lynton, AB</td>
<td>Operating; Expansion in Q4 2015</td>
<td>20</td>
</tr>
<tr>
<td>Altex</td>
<td>Reno, AB</td>
<td>Proposed – date unknown</td>
<td>24</td>
</tr>
<tr>
<td>Altex</td>
<td>Unity, SK</td>
<td>Operating</td>
<td>19</td>
</tr>
<tr>
<td>Canexus</td>
<td>Bruderheim, AB</td>
<td>Operating; Expansion Q3 2014</td>
<td>65</td>
</tr>
<tr>
<td>Ceres Global</td>
<td>Northgate, SK</td>
<td>Proposed Q2 2014</td>
<td>35 (expandable to 70)</td>
</tr>
<tr>
<td>Crescent Point</td>
<td>Dollard, SK</td>
<td>Operating; Expansion Q2 2014</td>
<td>27</td>
</tr>
<tr>
<td>Crescent Point</td>
<td>Stoughton, SK</td>
<td>Operating</td>
<td>45</td>
</tr>
<tr>
<td>Gibsons/USDG</td>
<td>Hardisty, AB</td>
<td>Proposed Q2 2014</td>
<td>120 (expandable to 240)</td>
</tr>
<tr>
<td>Gibsons</td>
<td>Edmonton, AB</td>
<td>Proposed Q3 2015</td>
<td>20 (expandable to 40)</td>
</tr>
<tr>
<td>Grizzly</td>
<td>Conklin, AB</td>
<td>Proposed Q2 2014</td>
<td>18</td>
</tr>
<tr>
<td>Keyera/Enbridge</td>
<td>Cheecham, AB</td>
<td>Operating</td>
<td>32</td>
</tr>
<tr>
<td>Keyera/Kinder Morgan</td>
<td>Edmonton, AB</td>
<td>Proposed for Q3 2014 – in construction</td>
<td>40 (expandable to 120)</td>
</tr>
<tr>
<td>Kinder Morgan/Imperial</td>
<td>Strathcona County, AB</td>
<td>Proposed for Q4 2014 – in construction</td>
<td>100 (expandable to 250)</td>
</tr>
<tr>
<td>Pembina</td>
<td>Edmonton, AB</td>
<td>Operating</td>
<td>40</td>
</tr>
<tr>
<td>Torq Transloading</td>
<td>Kerrobert, SK</td>
<td>Proposed Q3 2014</td>
<td>168</td>
</tr>
<tr>
<td>Torq Transloading</td>
<td>Lloydminster, SK</td>
<td>Operating</td>
<td>22</td>
</tr>
<tr>
<td>Torq Transloading</td>
<td>Unity, SK</td>
<td>Operating</td>
<td>36</td>
</tr>
<tr>
<td>Tundra</td>
<td>Cromer, MB</td>
<td>Operating; Expansion Q2 2014</td>
<td>60</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td>1.0 million; further expandable to 1.4 million b/d</td>
</tr>
</tbody>
</table>

* Facilities with less than 15,000 b/d are not shown.
** Capacities of facilities are not exactly comparable due to differences within factors used to determine capacity such as terminal operating hours, available car spots, contracts in place.
Figure 2-1 Rail Loading Terminals in Western Canada
2.2 Crude by Rail Throughput

Actual volumes of crude oil being moved by rail are generally lower than design capacity at loading facilities. However, it is important to note that the definition of capacity is not very standardized and there are a number of limiting factors on actual capacity that include: supply connections, system bottlenecks, operational inefficiencies, limited hours of operation, and ramp up time required to achieve full utilization. CAPP forecasts crude oil volumes transported by rail will increase from about 200,000 b/d in late 2013 to 700,000 b/d by the end of 2016. It is important to note that most of the large scale terminals are underpinned by long term take or pay contracts which should encourage utilization. Constraints on capacity include unloading time and weather. The load factor utilization should improve over time, however, particularly as producers and operators become more experienced with this mode of transportation. The schedule for future expansion phases of capacity is flexible and dependent on a number of factors including the timing of securing supply contracts for the facilities which may be influenced by the pace of pipeline expansion.

Figure 2-2 Western Canada Terminal Uploading Capacity vs Throughput Forecast

In the medium term, the level of throughput will be impacted by two key factors: the approval and timing of new pipeline projects and future environmental and safety regulations related to rail transport (see Chapter 4). Some producers may elect to hold take or pay contracts on both rail and pipeline projects.
### 2.3 Factors Impacting Capacity and Throughput

A number of factors determine the amount of crude oil that can be transported in a given rail car:

- **Terminal setup:** New terminals are generally more efficient than older terminals. However, new terminals may be constructed as a loop track or a ladder track each coming with certain advantages and disadvantages.

<table>
<thead>
<tr>
<th></th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Loop Track</strong></td>
<td>• Seemless loading</td>
<td>• Greater land requirement</td>
</tr>
<tr>
<td></td>
<td>• One loading manifold</td>
<td>• Higher front end capital costs</td>
</tr>
<tr>
<td></td>
<td>• Lower operational costs</td>
<td>• Cannot accommodate simultaneous loading of multiple crude oil types</td>
</tr>
<tr>
<td><strong>Ladder Track</strong></td>
<td>• Lower front end capital costs (~10-20% lower)</td>
<td>• More switches required</td>
</tr>
<tr>
<td></td>
<td>• More easily rescaled (unit train sizes continually change)</td>
<td>• Breaking up car blocks (requires more time for decoupling and recoupling cars)</td>
</tr>
<tr>
<td></td>
<td>• Add as many loading tracks and manifolds as needed</td>
<td>• More engines required</td>
</tr>
<tr>
<td></td>
<td>• Can simultaneously load multiple crude oil types</td>
<td>• Higher operational costs</td>
</tr>
</tbody>
</table>

- **Hours of operation:** Some terminal sites may not operate 24 hours a day, 7 days a week.

- **Type of crude:** Given the maximum allowable weight for a tank car and since heavy crude oil is more dense and has a higher viscosity than light crude, if all other factors are the same, lower volumes of heavy crude can be transported in a given car. Note that there is also more time required in the process to unload raw bitumen off a heated and coiled rail car. Steam must be passed through the coils for up to 24 hours to enable the bitumen to flow. Consequently, the movement of shipment of heavy crude oil would require a longer cycle time for the rail cars.

- **Type of tank car:** Fully loaded tank cars have a weight restriction of 286,000 lbs. Older cars built prior to October 2011 were constructed based on a gross rail load (GRL) of 263,000 lbs. Heater coils & insulation also add to the empty weight of the tank car. Viscous crude also requires coiled and insulated cars and special loading and unloading equipment in order to heat the crude in order to enable it to flow.

- **Terminal Location:** The level or frequency of service from the railroad will impact the logistics and ultimate capacity.
2.4 Western Canada Capacity Summary

Insufficient rail car supply and rail loading facilities are the current constraints on the ability for Canadian oil producers to move more of their oil production to markets by rail but these constraints are being addressed. A number of manifest and unit train loading facilities have been completed in Western Canada and more projects have been announced. As major pipeline expansions are not likely to be in place in the next few years, rail transportation is poised to play a more significant role in the near term. In the longer term, as crude oil production from western Canada is expected to grow significantly, even with new pipeline projects in operation, rail is expected to continue playing a role in niche markets and as such will continue to offer a valued transportation alternative as producers seek to expand market access.
3 Market Reach for Rail

The US PADD I (covering inter alia the Atlantic Seaboard states) and Eastern Canada markets represent over 2 million b/d of crude oil demand. Since the refineries in these markets have limited access to North American crude oil supplies via pipelines, the transport of crude oil by has grown noticeably as midcontinent supplies have increased. In general, East Coast refineries are primarily configured to process light crude oil. However, several refineries, including PBF for its Delaware refinery and the NuStar Energy refinery in New Jersey, have invested in rail unloading capacity specifically for heavy crude oil.

US PADD III (which includes the US Gulf Coast) is currently the largest destination market for crude oil by rail. The region comprises the largest most complex refining centre in the world and there are many options to deliver crude oil including pipeline to refineries, pipeline to terminals for waterborne exports or to terminals for ultimate delivery to refineries. There are currently only limited options for offloading of heavy crude but capacity is growing and this constraint is expected to ease in the next few years. Table 3-1 summarizes the specifications for select crude types and their major destination markets.
Figure 3-1 shows the rail distances to major markets and approximate cycle times (i.e. time taken to deliver product from origin to market and to return rail car to point of origination).

Table 3-1 Crude Oil Specifications and Destination Markets

<table>
<thead>
<tr>
<th></th>
<th>Light US Crude (Bakken, Eagle Ford, Permian)</th>
<th>Cdn Crude (Light conventional and light synthetic)</th>
<th>Canadian Crude (DilBit)</th>
<th>Canadian Crude: RailBit/Raw (Undiluted) Bitumen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Origin</td>
<td>N. Dakota, Montana, Texas</td>
<td>Alberta or Saskatchewan</td>
<td>Alberta</td>
<td>Alberta</td>
</tr>
<tr>
<td>Sulfur Content</td>
<td>&lt;0.5%</td>
<td>&gt;1%</td>
<td>&gt;1%</td>
<td>&gt;1%</td>
</tr>
<tr>
<td>Density</td>
<td>6.2 to 7.0 lb/gal</td>
<td>7.2 lb/gal (average)</td>
<td>7.8 lb/gal (average)</td>
<td>8.4 lb/gal (average)</td>
</tr>
<tr>
<td>Viscosity</td>
<td>&lt;5</td>
<td>5-15</td>
<td>130-220</td>
<td>&gt;250</td>
</tr>
<tr>
<td></td>
<td>(cSt at moderate temperature)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Destinations</td>
<td>US East Coast (PADD I), Eastern Canada, Western Canada</td>
<td>US East Coast (PADD I), Eastern Canada, Western Canada</td>
<td>US Gulf Coast (PADD III)</td>
<td>US Gulf Coast (PADD III)</td>
</tr>
<tr>
<td>Optimal Car</td>
<td>31,800 gallon 286 GRL Non coiled/Non insulated tank</td>
<td>28,300 or 29,200 gallon</td>
<td>Coiled and insulated</td>
<td>Coiled and insulated</td>
</tr>
<tr>
<td>Additional Offload infrastructure</td>
<td></td>
<td></td>
<td></td>
<td>Required for raw bitumen</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• steam assist</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• nitrogen assist</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• heated storage</td>
</tr>
</tbody>
</table>
Figure 3-1 Rail Distances and Cycle times to Major Markets

3.1 Track Capacity

Figure 3-2 shows the market reach by CP and CN for crude oil, depicted in red and blue, respectively. CP has direct access to the Alberta Industrial Heartland, the pipeline and storage hub at Hardisty, Alberta and the Bakken production area located in Saskatchewan and Manitoba. In addition, CP connects to other rail networks that shippers can utilize to expand market access to regions not directly served by CP. The CN network directly connects Western Canadian crude oil supplies to markets in Eastern Canada, the west Coast of Canada, the US Midwest, and the US Gulf Coast. In addition, CN provides access to tidewater so that producers may reach offshore markets in Europe and Asia.

At this time, the availability of rail track does not present a constraint on capacity for moving oil by rail. However, as the demand for this mode of transportation grows, the availability of track might form a constraint since CN and CP have to share traffic time on their own and other railway company owned tracks. In addition, there is competition with the movement of other commodities for track time. According to AAR, in 2012 crude oil consisted of approximately 0.8 percent of all freight rail traffic. New regulations proposed to reduce the speed of railcars traveling on track routes through major urban centers could also have an impact. Slower cars would mean more time on the track and increased cycle times. In turn, increased cycle times could lead to an increase in the number of shipments required for the same volume of crude.
3.2 Economics of Rail Transport

In general, the opportunity to ship by rail is greatest when the price differential between the market at a point of origin and the market price at the destination exceeds the transportation cost by rail. Recently, this has meant that the economic driver for crude by rail has been between landlocked production and coastal markets where higher world oil prices can be accessed.

There are a number of factors which could impact the economics of shipping crude oil to market via rail. These include prices available in various markets that can all be accessed by rail and cost. The type of crude being moved is a key determinant of cost as the heavier the crude oil slate, the more rail cars are required to transport a given volume of crude. Heavy crude is typically transported in steam coiled and insulated cars in order to reduce the viscosity of the crude oil to facilitate the unloading process. The steam line and insulation also adds to the weight of the railcar and therefore limits the amount of the commodity that can be transported before meeting the tank car’s weight limitation. In addition, more time is required for loading and unloading heavy crude which thereby adds to cycle times and, in turn increases cost.

A number of uncontrollable factors such as weather or mechanical issues, may also impact cycle times and affect producers’ netbacks. The opportunity for diluent backhaul can also be considered when evaluating the costs. Table 3-2 shows an estimated breakdown of the cost of rail transport to various destination markets from western Canada. The range is based on the movement of dilBit vs bitumen and the distance from markets. The actual costs for each component can fluctuate beyond the ranges shown due to changes to cycle times. Railcar leasing costs are negotiated and are subject to change depending on a number of factors, including the length of the lease.
### Table 3-2 Estimated Costs by Market

<table>
<thead>
<tr>
<th>Item</th>
<th>West Coast</th>
<th>Gulf Coast</th>
<th>East Coast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trucking (to loading terminal or to refinery from unloading terminal)</td>
<td>if applicable</td>
<td>$0.52 to $0.60</td>
<td>if applicable</td>
</tr>
<tr>
<td>Loading Fee(^2)</td>
<td>1.50 to 1.75</td>
<td>1.50 to 1.75</td>
<td>1.50 to 1.75</td>
</tr>
<tr>
<td>Rail Freight</td>
<td>$5.82 to $14.37</td>
<td>$14.88 to $17.07</td>
<td>$14.60 to $17.82</td>
</tr>
<tr>
<td>Tank-car Lease</td>
<td>Dilbit: $0.56 @ 8.5 cycle days</td>
<td>Dilbit: $1.03 @ 15.5 cycle days</td>
<td>Dilbit: $0.93 @ 14.5 cycle days</td>
</tr>
<tr>
<td>$1,200/month with 7 year lease</td>
<td>Bitumen: $1.06 @ 14 cycle days</td>
<td>Bitumen: $1.29 @ 17 cycle days</td>
<td>Bitumen: $1.29 @ 17 cycle days</td>
</tr>
<tr>
<td>EstTank car capacity (bbls / tank car)(^3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raw Bitumen: 500 to 550</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RailBit 550 to 575</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DilBit 600 to 625</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light Crude 650 to 700</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unload/Terminal Fee</td>
<td>1.50 to 1.75</td>
<td>1.50 to 1.75</td>
<td>1.50 to 1.75</td>
</tr>
<tr>
<td>Total Cost</td>
<td>$9.38 to $18.93 /bbl</td>
<td>$19.43 to $22.44/bbl</td>
<td>$18.53 to $22.61/bbl</td>
</tr>
</tbody>
</table>

\(^1\) All rates are estimates only. Actual rates could vary depending on the density of the crude which limits the volume per carload; weather and logistical factors that could increase cycle times. Trucking costs vary depending on density of crude and distance from loading/unloading terminal.

\(^2\) Railcar loading and unloading costs are estimated based on ICF and Hellerworx experience.

Source: Keystone XL Final Supplemental Environmental Impact Statement

### 3.3 Market Summary

In the short to medium term, rail can provide the ability to access world oil higher prices if there are constraints in available pipeline capacity. The role of rail will continue to evolve over the longer term with supply characteristics (eg. rail-bit), market diversity and the development of the oil transportation system overall, particularly the capacity and timing of pipeline infrastructure.

Rail provides Canadian crude oil producers the flexibility to reach a number of key markets throughout North America. Several refinery owners are building unloading facilities to complement rail transportation from the supply regions. Capacity for unloading heavy crude oil, which requires some additional equipment, is growing but large scale facilities that would provide economies of scale are not yet available.
4 Developments in Rail Safety

The tragic incident which occurred in Lac Mégantic, Québec in July 2013 as well as other rail incidents has resulted in significant public concern regarding the safety of shipping crude oil by rail. Consequently, Transport Canada and the US Department of Transportation have initiated a review process that will lead to potential changes in a number of regulatory requirements in an effort to increase safety. The focus has been directed towards four key areas: 1) Classification; 2) Tank car standards; 3) Emergency Response; and 4) Liability and Insurance. Government response by way of changes in regulations could have significant implications for the shipping of crude oil by rail. Beyond possible cost implications that could affect the competitiveness of this mode of transportation, regulatory changes could present challenges in the ability to meet market demand through capacity additions.

4.1 Classification

The US, Canada and many other countries throughout the world have developed the Globally Harmonized System for the Classification and Labeling of Chemicals. Hazardous or dangerous goods or products containing such goods cannot be transported unless they have been classified.

The US Department of Transportation (DOT) and Transport Canada classify dangerous goods for the transportation of hazardous materials within one of nine classes. The commodity is further identified by Divisions within each class, which provides a more precise identification of the danger associated with the particular good within the general class. The Division may also have reference to the flashpoint of flammable liquids, the sensitivity of explosives or the danger associated with compressed gasses.

Dangerous Goods/Hazardous Materials Classification System

- Class 1: Explosives;
- Class 2: Gases
- Class 3: Flammable and Combustible Liquids
- Class 4: Flammable Solid, Spontaneously Combustible, and dangerous when wet
- Class 5: Oxidizer and Organic Peroxide
- Class 6: Poison (Toxic) and Poison Inhalation Hazard
- Class 7: Radioactive
- Class 8: Corrosive
- Class 9: Miscellaneous

Crude oil is generally classified as Class 3 Flammable Liquid. There is also a Packing Group (PG) designation or division that is a part of the Class 3 classification and is noted as PG I, II or III. The packing group indicates the level of hazard within a classification, with PG I representing the greatest risk of danger. The main concern is that misclassification of a crude oil shipment as a Packing Group III can lead to the use of transport containers that may not include the safety enhancement requirements for the safe transport of PG I & II materials. Furthermore, misclassification could result in improper handling and the development of inadequate safety and security plans and the communication of inaccurate information to emergency responders.
The Packing Group classification of flammable liquids is based on the flash point and boiling point of the liquid. Refer to Table 4-1 for the classification.

**Table 4-1 Class 3 Packing Group Criteria**

<table>
<thead>
<tr>
<th>Division</th>
<th>Flashpoint</th>
<th>Initial Boiling Point</th>
<th>Hazard Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 3 Flammable Liquid, Packing Group I</td>
<td>Any</td>
<td>≤ 35°C @ 101.3 kPA</td>
<td>High</td>
</tr>
<tr>
<td>Class 3 Flammable Liquid, Packing Group II</td>
<td>&lt; 23°C</td>
<td>&gt; 35°C @ 101.3 kPA</td>
<td>Medium</td>
</tr>
<tr>
<td>Class 3 Flammable Liquid, Packing Group III</td>
<td>≥ 23°C ≤ 60°C</td>
<td>&gt; 35°C @ 101.3 kPA</td>
<td>Low</td>
</tr>
<tr>
<td>Class 3 Combustible Liquid, Packing Group III*</td>
<td>≥ 38°C ≤ 93°C</td>
<td>&gt; 35°C @ 101.3 kPA</td>
<td>Low</td>
</tr>
</tbody>
</table>
*49CFR §173.150 - US DOT Classification only. In Canada presently, crude oil with a flashpoint greater than 60°C would be unclassified.

Source: Transport Canada and US DOT

The following properties of various crude oil types may be relevant when considering the appropriate classification for the crude shipment:

- Dissolved gases content
- Sulfur content/Corrosive properties to steel and aluminum
- Toxic properties
- Flammability
- Blending of crude from different sources (this could change properties)

For crude oil, minimum properties to properly test, characterize and classify the material include:
flash point, corrosivity, specific gravity at loading and reference temperatures, and the presence and concentration of compounds such as sulfur and hydrogen sulfide.

**Recent Developments**

On March 6, 2014 the US Department of Transportation issued an amended emergency order that required mandatory testing and classification of crude oil. All crude should be classified accordingly as Packing Group (PG) I, Packing Group II, or Packing Group III following testing for purposes of hazardous material communications. However, for purposes of the tank cars used, all crude oil in PG III should be treated as if it were PG I or PG II. Transport Canada on October 17, 2013 had implemented Protective Directive 31, which required that crude oil being offered for transport would have to be immediately tested and classified if the classification testing had not been conducted since July 7, 2013. Until testing was done, a crude oil shipment on rail should be automatically classified as a Class 3 Flammable Liquid PG I. Note, if crude oil is correctly classified under PG III in Canada and the shipment does not cross the border, tank cars deemed appropriate for PG III can be used. A shipper violating the Emergency Order is subject to penalties of up to $175,000 for each violation or for each day they are found to be in violation.
Issues around testing for Classification

- Sampling and lab tests provide varying results depending on sampling method and testing procedures applied.
- Generally accepted and applied testing methods are primarily designed to assess stable and refined substances like gasoline so may not be accurately measuring the actual initial boiling point (IBP) and flashpoints of crude oils, which are multi-component substances.
- Crude oil types with significant light ends (C4, C3, C2 – butane, propane, ethane etc) are most at risk of being mischaracterized.
- Light ends tend to be gaseous at normal temperatures, leading to higher reported IBPs than are actually characteristic of the substance.
- Standard flashpoint tests also potentially compromise the light end integrity of the sample, leading to higher flashpoint results than might be actually in the substance. This is due to evaporation during the sample transferring process.

Industry and the railways are exploring and implementing enhanced classification processes and standards for crude oil properties with the objective of clear classification of the risks associated with the behaviours of different crude oil types as they pertain to tank car design.

4.2 Rail Tank Cars

Tank Car Classification and Specifications

All railroad tank cars are built to specifications, standards and requirements published by the US Department of Transportation (DOT), Transport Canada (TC) or set by the American Association of Railroads (AAR). The tank cars are designed and constructed differently depending on the type of product that they are intended to contain.

With a tank car specification, the first three letters indicates the designating agency under whose authority the specification was issued. The 3-digit code following the authorizing agent is the class designation. Sometimes a letter will follow the 3 digit class designation. For specification 111 tank cars, the letter “A” has no significance but other letters would indicate the type of retrofit that has been performed. “S” means a headshield was added. “J” indicates the tank car has jacketed thermal protection and tank headshields. “T” indicates spray-on thermal protection and tank headshields.
Crude oil is transported by rail primarily in tank cars classed as Specification 111 by the US Department of Transportation, (known as DOT-111) or Transport Canada (known as TC-111). For simplicity and the purposes of this report, the term “DOT-111” will be used in reference to all specification 111 tank cars. There are also a small number of Class AAR-211 tank cars (described below) that are used for transporting crude oil.

The current regulated specifications for DOT-111 type tank cars are non-pressure cars, and can be insulated or non-insulated. They do not have head shields and are pressure tested at relatively low pressures (60 pounds per square inch (psi) to 100 psi, depending on the type). They can be constructed from carbon steel, aluminum alloy or stainless steel (steel alloy). They do not have protective housings to safeguard the top fittings from impact damage. The capacity can vary in the range from 10,000 gallons to 34,500 gallons.

Class AAR-211 tank cars are similar to Class DOT-111 tank cars. The main differences are:

- Class AAR-211 tank car tanks require only partial post-weld heat treatment at the time of construction. Class DOT-111 carbon and allow steel tanks and welded attachments must be post-weld heat treated as a unit. Tank car tanks made of aluminum alloy are not allowed to be post-weld heat treated.
- Class AAR-211 tank cars constructed from carbon and alloy steel do not require radioscopic examination of welded joints; however, welded joints of aluminum tanks must be examined.
Following a number of accidents involving DOT-111 cars, the AAR developed higher safety standard specifications. These specifications were adopted by industry and have been applied to all newly built Specification 111 tank cars since October 2011 used for the transport of Class 3 Flammable Liquids in Packing Group I and II. These features were described in the AAR’s Casualty Prevention Circular 1232 (CPC 1232). Additional safety features beyond those referenced in CPC 1232 are currently being contemplated by regulatory authorities in both Canada and the US. Refer to Table 4-2 for a comparison of the safety features of legacy DOT-111 cars with subsequent higher industry standards and additional safety features being proposed.

Table 4-2 Safety Feature Development of DOT111 tank cars

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Thicker steel and/or jacket</td>
<td>Carbon or alloy (stainless): 7/16”</td>
<td>Normalized TC-128 Grade B steel: ½” shell thickness for non-jacketed tanks</td>
<td>Normalized A516-70 steel: 9/16” for non jacketed tanks</td>
<td>Normalized TC-128 Grade B steel: 7/16” for jacketed tanks</td>
<td>✓</td>
</tr>
<tr>
<td>½” Half height headshield</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>Retrofit option only</td>
</tr>
<tr>
<td>Top fitting protection – fitting protection for the tallest fittings in use</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>Only for coiled &amp; insulated cars</td>
</tr>
<tr>
<td>Insulation</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>1/8” thick</td>
</tr>
<tr>
<td>Jacket</td>
<td>Min ½” tank OR 1/8” jacket</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Thermal (Fire) Protection System (thermal blanket or thermal coating)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>Practical only for new build not retrofit</td>
</tr>
<tr>
<td>Modified Pressure Relief Device*</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>27,000 SCFM, 75 psi pressure relief valve</td>
</tr>
<tr>
<td>Removable Bottom outlet handle</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>½” Full headshield</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

*Pressure Relief Device with higher exit flow and lower trigger point
Size and Components of North American Tank car Fleet

There are over 272,000 DOT-111 tank cars in the North American fleet. About 37 per cent of these cars are used to transport Non-Hazardous materials and the remaining majority of 63 per cent are used to transport hazardous materials. A little more than half of the tank cars in hazardous material transport are used for flammable liquids, which is a subset category that includes crude oil and ethanol. (Table 4-3).

Table 4-3 DOT-111 Tank Car Fleet Breakdown (As Q3 2013)

<table>
<thead>
<tr>
<th>DOT-111 Tank Cars</th>
<th>Total Cars</th>
<th>Percent of the Entire DOT-111 Tank Car Fleet</th>
</tr>
</thead>
<tbody>
<tr>
<td>All DOT-111</td>
<td>272,119</td>
<td>100.0%</td>
</tr>
<tr>
<td>Non-Hazmat DOT-111s</td>
<td>101,360</td>
<td>37.2%</td>
</tr>
<tr>
<td>Hazardous Material DOT-111s*</td>
<td>170,759</td>
<td>62.8%</td>
</tr>
<tr>
<td>Other Hazardous Materials Service</td>
<td>76,769</td>
<td>28.2%</td>
</tr>
<tr>
<td>Flammable Liquids Service</td>
<td>94,178</td>
<td>34.6%</td>
</tr>
<tr>
<td>CPC-1232 Compliant Tank Car – FL Service</td>
<td>14,160</td>
<td>5.2%</td>
</tr>
<tr>
<td>(Jacketed and Non-Jacketed)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jacketed Tank Car – FL Service</td>
<td>14,677</td>
<td>5.4%</td>
</tr>
<tr>
<td>Non-Jacketed Tank Car (Existing Base Car) – FL Service*</td>
<td>65,341</td>
<td>24.0%</td>
</tr>
<tr>
<td>Existing Base Car, Ethanol Service</td>
<td>28,970</td>
<td>10.6%</td>
</tr>
<tr>
<td>Existing Base Car, Crude Oil Service</td>
<td>21,646</td>
<td>8.0%</td>
</tr>
<tr>
<td>Existing Base Car, Other Flammable Liquid Service</td>
<td>25,703</td>
<td>9.4%</td>
</tr>
</tbody>
</table>

*These figures are not additive of the subcategories because some of the tank cars carry loads in more than one commodity category

Source: Railway Supply Institute Committee on Tank Cars

The availability of rail cars presents a significant limitation on the volumes of crude that can be transported by rail. According to the Railway Supply Institute, the North American tank car fleet in crude oil service consists of approximate 38,679 tank cars of which, 11,549 or 30 per cent, are compliant with the higher safety standards that were voluntarily adopted by industry since October 2011 (Table 4-4). The current crude-by-rail capability in North America is estimated to be 1 to 1.5 million b/d while rail shipments from North Dakota and Western Canada combined by the end of 2013 were slightly below 1 million b/d.

Table 4-4 Existing Tank Car Compliance with CPC-1232 (As of Q3 2013)

<table>
<thead>
<tr>
<th>Cars with CPC-1232 Safety Features</th>
<th>Total Cars</th>
<th>As a % of Flammable Liquid 111s</th>
<th>As a % in Hazmat Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude Oil 111s</td>
<td>11,549</td>
<td>38,679</td>
<td>41%</td>
</tr>
<tr>
<td>All Flammable Liquid 111s</td>
<td>14,160</td>
<td>94,178</td>
<td>100%</td>
</tr>
<tr>
<td>All 111s in Hazmat Service</td>
<td>16,165</td>
<td>170,759</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: Railway Supply Institute Committee on Tank Cars
Freight car builders reported to the Railway Supply Institute that in 2013 there were 36,276 orders for new railroad tank cars and 28,996 new tank cars were delivered. There is a current backlog of orders of tank cars of about 55,386 tank cars, a significant portion of which will go into crude oil transportation service. This would imply that it likely takes approximately 18 months for a new tank car to be put into service from the date it was ordered.

**Recent Developments**

It is clear that legislated changes to tank car standard specifications will be implemented. The US DOT, PHMSA received comments on their proposed regulations on December 5, 2013 while Transport Canada has also received comments from the railroad companies and industry regarding the proposed changes to standards on January 31, 2014.

In this interim period, both governments have issued a number of emergency orders and protective directions. Most recently on February 25, 2014, the DOT issued an emergency order requiring all crude oil be classified as either Class 3, PG I or II only. This order was subsequently amended on March 6, 2014 to allow for the classification of crude oil as Class 3, PG III for hazard communication provided there was proof of recent testing and proper classification. However, all crude oil must be transported in tank cars for PG I and PG II materials. This means that AAR-211 tank cars cannot be used for crude transportation across the Canada/US border. The penalty for non-compliance with this order is a fine of up to $175,000 for each violation or for each day of violation. In more severe cases, criminal prosecution may be charged, which may result in additional fines and/or imprisonment of up to 10 years.

CN and CP have announced that they will be charging higher rates to transport using older tank cars. CP stated that it would charge $325 on each car of crude that is shipped in any container that is not CPC-1232 compliant, effective March 12, 2014. CN further announced on March 25, 2014 that it will phase out its fleet of 183 older DOT-111 tank rail cars over the next four years as part of a safety improvement plan. CP announced that it is in the process of retrofitting the less than 200 older DOT-111 tank cars that it is using. A number of refineries have also announced either that they are already using the CPC-1232 standard cars or have committed to do so within the first half of 2014.

A number of potential options have been proposed for the legacy DOT-111 tank cars. The timing for phasing out these cars or the time required to retrofit these cars may affect that ability to increase crude oil transportation by rail particularly in the short term. Also relevant is whether any tank cars can be reassigned to lower hazard service.

There are also concerns and uncertainties for the CPC-1232 compliant cars including:

- Will the proposed safety features that exceed CPC-1232 standards be required?
- Are some of the additional proposed features not practical for retrofitting?
- If retrofitting is required, what is a reasonable time frame considering shop capacity, the number of cars and the type of retrofit?
- Will there be a differentiation of crude types such that not all types would need to be shipped in the higher standard cars?
Other considerations that could impact future regulations

- High sulfur and/or water content in the crude oil could impact the need for lining and stainless fittings, which could either impact the life of the tank car or require additional safety features
- There is concern that the safety benefit from the new features would not be realized if old and new tank cars are commingled
- New safety features could mean lower capacity and therefore more cars needed to transport the same volume of crude. According to the AAR, the capacity of a tank car decreases by 1 gallon for every 7 lbs of added weight. A half-height head shield adds approximately 1,000 lbs; top fittings protection adds 1,260 lbs; and jackets add approximately 9,500 lbs. Adding each feature would mean an additional 11,760 lbs, or a loss of 1,680 gallons of capacity.
- What is the capacity of the tank car manufacturers to produce new tank cars and for retrofitting services?

Table 4-5 shows an estimate of the costs for various modifications to older DOT-111 cars. Note that not all cars in the existing legacy fleet would need modification and the degree of modifications necessary could vary. Industry estimates the costs of retrofitting would be in excess of $1 billion.

<table>
<thead>
<tr>
<th>Modification</th>
<th>Costs to Existing Cars (on a Per Car Basis)</th>
<th>Out-of-Service Time for Each Car</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Capacity Pressure Relief Valve</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• If done at Requalification</td>
<td>$2,100</td>
<td>No additional time</td>
</tr>
<tr>
<td>• Not a Requalification</td>
<td>$3,400</td>
<td>5 weeks</td>
</tr>
<tr>
<td>Removable Bottom Outlet Valve¹</td>
<td>$600-$3,000</td>
<td>Under Review</td>
</tr>
<tr>
<td>Trapezoidal/Conforming Head Shield</td>
<td>$17,500</td>
<td>5 weeks</td>
</tr>
<tr>
<td>Top Fittings Protection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Assuming Existing Nozzle²</td>
<td>$6,000</td>
<td>7 weeks</td>
</tr>
<tr>
<td>• Assuming New Nozzle²</td>
<td>$24,500</td>
<td></td>
</tr>
<tr>
<td>Top Fittings Protection – New Nozzle, Jacket, Full Head Shield</td>
<td>$63,500</td>
<td>12 weeks**</td>
</tr>
<tr>
<td>• Thermal insulation</td>
<td>+$3,700</td>
<td></td>
</tr>
<tr>
<td>• Cost of trucks, if upgradable</td>
<td>+16,500</td>
<td></td>
</tr>
</tbody>
</table>

¹Goal – elimination of potential BOV “catch points” during derailments
²Top fittings protection based on AAR Standard Appendix E, Part 10.2. Actual modification used depends on specific tank car design
** The out of service time reflects the time each individual tank car would be required to be removed from service during the phase-in period of any modification program

Source: Railway Supply Institute Committee on Tank Cars
**Next Steps**

Transition timelines need to allow for the appropriate time frame for the replacement and/or retrofitting of the existing tank cars to ensure both safety and logistical requirements are maintained during the transition period. Consideration will need to be given for the range and nature of the crude products, with greatest emphasis on those products which pose a higher risk. The classification work described in section 4.1 will be used as a key input into the development of a framework that enables a risk based implementation strategy.

### 4.3 Emergency Response

Emergency response to the Lac Mégantic incident has been criticized for a number of reasons including: lack of understanding of the nature of the product and how it reacted (flammability) during the incident; lack of proper equipment to handle the spill; lack of co-ordination and authority amongst first responders; and concern over financial accountability. Given this uncertainty, there is consideration being given to declare all crude oil as being subject to the “Emergency Response Assistance Plan (ERAP) process. This would ensure appropriate emergency response capability (trained personnel and equipment) along the rail route regardless of the actions of the rail company. This could have significant resource implications for individual shippers and would likely mean all crude oil would have to be shipped in rail cars subject to the new design standards. Discussions are ongoing as to whether the responsibility to initiate the response should be with the shipper or the carrier.

An ERAP is required by the Transportation of Dangerous Goods Regulations for certain goods that pose a higher-than-average risk when transported in certain quantities. When there is an accident, the handling of these dangerous goods requires special expertise, resources, supplies and equipment. An approved ERAP will describe the specialized response capabilities, equipment and procedures that will be available to local emergency responders and will assist emergency responders in addressing the consequences of the accident.

According to the Transportation of Dangerous Goods Regulations in Canada the transportation of large volumes of petroleum crude oil does not currently require an ERAP. Prior to the Lac Mégantic and subsequent derailments and fires, crude oil was not generally considered to be highly dangerous. Since then, there has been evidence that there are certain types of crude oil, such as Bakken crude, that have low viscosity and are highly volatile.
Issues Associated with Emergency Response Currently Under Consideration

- View that all flammable liquids be subject to ERAP requirements
  - ERAPs be required for all PG I and PG II Class 3 Flammable Liquids in accordance to TDG Regulations part 7
  - Packing Group III products may not have the same risk of fire and explosion, they can still present a serious environmental hazard or risk to personnel from gases or vapours that may be present.
  - Studies on properties of PG III to determine if ERAPs should be required
- The Need to design ERAP to assist with initial spill containment
- Costs and inefficiencies if every shipper/importer carrier developed their own ERAP and resource base
- The need to enact legislation to require information provided on dangerous goods by class, volume and frequency that is transported through the community on a monthly basis.
- The capability of carrier emergency response plans to sufficiently and comprehensively capture any response requirements for an incident of dangerous goods on rail.

Next Steps

CAPP is engaged in discussions on this with the Railway Association of Canada and the Canadian Fuels Association with a view to seeking alignment and presenting a common solution to government.

4.4 Liability and Compensation Regime

Governments in both Canada and the US are reviewing their regimes to ensure that sufficient funds are available to adequately compensate potential victims, pay for any clean-up costs, and protect taxpayers in the event of an incident. Currently, Railways are required to have a Certificate of Fitness issued by the Canadian Transportation Agency (CTA), which provides regulatory oversight to assure railway operational capability, proper risk and safety management relative to operations and goods being transported, and to hold railways accountable for holding appropriate liability insurance commensurate with the nature of rail operations and the goods being transported.

The following are a range of factors used to evaluate adequacy:
- Volume of traffic
- Types of population areas served
- Volume of dangerous goods
- Number of level crossings
- Speed of trains
- Overall safety record of the railway
Current regulations do not prescribe a mandatory minimum dollar value of coverage but coverage must be adequate to cover: injury or death to persons; damage or destruction of property (excluding cargo); and named pollution perils (e.g. spill of contaminants and environmental damage) related to railway’s operations. Railway companies are, therefore, accountable for compensating for damages caused by their operations to people and to shipper and a polluter pay principle for damage to the environment. The Petroleum Industry generally supports the “polluter pay” principle, whereby the responsible party pays for any damage done to the natural environment. This is already embedded in many existing liability frameworks. However, gaps within these liability frameworks have recently emerged. To that end, the tragic events in Lac-Mégantic demonstrated that a smaller (short line) rail company did not have the financial capacity to cover the ultimate liability.

**Issues/considerations Around Liability and Compensation**

- Maximum liability insurance available to railways may be inadequate
- The appropriate allocation of risk and costs amongst the parties reflecting relative responsibilities reinforcing incentives for the safe transport of goods by rail
- Can /should best practices for other transportation modes be used as a benchmark?
- Impact on a mandatory minimum level of coverage
- What other options can be used to increase available compensation?
- The extent to which existing regulatory and risk assessment practices (i.e. the process for issuance of certificates of fitness) accurately capture the actual risk
- Whether and to what extent a true risk based approach will be affordable for small carriers and, if the government wants to encourage smaller carriers, whether large carriers will have to underwrite the liability of the less capable;
- Whether a liability cap should be imposed and how compensation should be funded for amounts above the cap (e.g. pooled funds similar to marine tankers)
- Whether and to what extent industry wants to explore risk-pooling options to guard against unanticipated catastrophic events; and
- What is the appropriate balance between additional rules and regulations to constrain risk and liability and the expense of process efficiencies?

**Next Steps**

CAPP is encouraging Transport Canada to explore the concept of a hybrid liability model that would utilize some of the attributes from both the marine and pipeline liability models. This approach would enable smaller (short line) railways to be represented collectively, or by a pooled approach (an attribute associated with the marine model), whereas the larger Class 1 railways can choose a self-insurance approach (an attribute more in line with the pipeline model).
4.5 Safety Summary

Railways are emerging as an important transportation option for crude oil producers given the flexibility that they can offer shippers and in light of the current capacity constraints existing on crude oil pipelines. With the strong demand for increased transportation capacity the rail industry is making great strides in meeting growing demand and is expected to add significant new capacity over the next several years. With the growth in this mode of crude oil transportation, however, has come increased scrutiny on safety that may impact the ability of railways to expand the transportation of crude oil. The safe transportation of crude oil is the primary objective of producers and railway companies alike.

Potential future changes in regulations surrounding tank car specifications could restrict the number of tank cars that are in service and available to transport crude oil. Key questions remain on how new regulations will apply to the existing car fleet as well as new tanker car builds. New safety features could also result in lower capacity of individual tank cars or additional time and investment.
# GLOSSARY

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bottom Outlet Valve</strong></td>
<td>A valve located in the bottom of the tank for loading and unloading</td>
</tr>
<tr>
<td><strong>Bulk loading</strong></td>
<td>At these facilities, crude oil is delivered to a bulk storage facility and the crude oil is then transferred from storage tanks to the railroad tank cars.</td>
</tr>
<tr>
<td><strong>Conditional Probability for release</strong></td>
<td>The probability of a release should a tank car be in an accident.</td>
</tr>
<tr>
<td><strong>Flash point</strong></td>
<td>The lowest temperature at which the application of an ignition source causes the vapour of a sample to ignite near the surface of the liquid or within a test vessel.</td>
</tr>
<tr>
<td><strong>Head Shield</strong></td>
<td>A method of providing tank head puncture-resistance by mounting a metal shield on the end of a tank car to protect against punctures from the coupler of another railcar. Head shields may be separate attachments or may be incorporated into a tank’s jacket.</td>
</tr>
<tr>
<td><strong>Insulation</strong></td>
<td>A material, typically fiberglass or foam, enclosed within a metal jacket, used to maintain or moderate the temperature or aid in the unloading of the product contained within a tank car.</td>
</tr>
<tr>
<td><strong>Jacket</strong></td>
<td>A metal covering surrounding a tank car tank designed to protect and secure the insulation and/or thermal production systems on a car.</td>
</tr>
<tr>
<td><strong>Material safety data sheet</strong></td>
<td>A MSDS is a specification sheet that is required to be completed when transporting dangerous goods to provide workers and emergency personnel with procedures for handling or working with that substance in a safe manner, and includes information such as physical data (melting point, boiling point, flash point, etc.), toxicity, health effects, first aid, reactivity, storage, disposal, protective equipment, and spill-handling procedures.</td>
</tr>
<tr>
<td><strong>Thermal protection</strong></td>
<td>Material or system applied to certain tank cars to limit the transfer of heat to the tank in the event of exposure to pool or torch fires. It is intended to reduce the likelihood of tank failure under such conditions.</td>
</tr>
<tr>
<td><strong>Transloading</strong></td>
<td>The process of moving product from one mode of transportation to another. For crude oil, this could mean from truck to rail tank car or from rail tank car directly to barge or barge to rail.</td>
</tr>
</tbody>
</table>
APPENDIX A: Acronyms, Abbreviations, Units and Conversion Factors

Acronyms

AAR  American Association of Railroads
AARTC Association of American Railroads Tank Car Committee
ANPRM Advanced Notice of Proposed Rulemaking
CAPP Canadian Association of Petroleum
CFR Code of Federal Regulations (US)
CSA Canadian Standards Association
CTC Canadian Transport Commission (replaced by Transport Canada)
DOT Department of Transportation (US)
ERAP Emergency Response Assistance Plan
FRA Federal Railroad Administration
GRL Gross Rail Load
HMR Hazardous Materials Regulations (US)
MSDS Material Safety Data Sheet
PG I, II or III Packing Group
PHMSA Pipeline and Hazardous Materials Administration
PRD Pressure Relief Device
RSICTC Railway Supply Institute Committee on Tank Cars
TC Transport Canada
TDG Transportation of Dangerous Goods (Canada)
U.S. United States

Abbreviations

IBP Initial boiling point
PSIG Pounds per square inch guage
CPR Conditional Probability of Release
lbs Pounds

Conversion Factors

1 cubic metre = 6.293 barrels (oil)
1 imperial gallon = 4.54609 litres
1 US gallon = 3.78541 litres
1 barrel = 42 US gallons
1 kg = 2.20462 lbs
APPENDIX B: Chronology of Significant Crude by Rail Events in Canada

1989  Transport Canada’s Railway Safety Act (RSA) implemented. The RSA sets the regulatory framework for addressing rail safety, security and some of the environmental impacts of rail operations in Canada.

Aug 2005  Derailment of 43 cars of a CN train at Lake Wabamun, Alberta. About 800,000 litres of heavy oil (Bunker C) and pole treating oil were spilled and approximately 196,000 litres entered the lake.

Apr 3, 2013  CP rail train of 20 freight cars with 2 carrying light crude oil derailed near White River, ON. Spill 63,000 litres of crude oil.

July 6, 2013  An unattended freight train carrying Bakken crude oil derailed and killed 47 people in Lac Mégantic, Québec

July 23, 2013  Transport Canada announced an emergency directive under section 33 of the RSA relating to tightening operating rules to prevent runaways of trains handling dangerous goods.

Aug 2013  PHMSA and FRA initiated Operation Classification, which involved unannounced inspections requesting samples of the transported crude oil and testing the oil samples to verify that offerors of the materials have properly classified the materials.

Oct 17, 2013  Transport Canada announced Protective Direction 31 under the Transportation of Dangerous Goods Act requiring any person who imports or offers for transport crude oil to conduct classification tests on crude oil. Until such testing is completed, when shipping by rail all such crude oil shall be identified as Class 3 Flammable Liquid Packing Group I – the designation with the lowest flash point.

Oct 19, 2013  In Gainford, Alberta, nine tank cars of propane and four tank cars of crude oil from Canada derailed as a CN train was entering a siding at 22 miles per hour. About 100 residents were evacuated. Three of the propane cars burned, but the tank cars carrying crude oil were pushed away and did not burn. No one was killed or injured. The cause of the derailment is under investigation.

Nov 2013  Association of American Railroads (AAR) asked the Department of Transportation to require even higher standards than those recommended by the industry groups in October 2011.
Nov 2013  The Minister of Transport (Canada) asked the Transportation of Dangerous Goods General Policy Advisory Council (CAPP is a member) to provide short- and long-term recommendations aimed at enhancing public safety and strengthening standards for the transportation of dangerous goods. Three industry-led working groups were created to examine classification, emergency response, and means of containment.

Dec 2013  Canada’s first unit train, loaded with MEG crude oil rolled out of Canexus Corp’s Bruderheim, AB terminal

Jan 7 2014  17 cars on a CN train — some carrying propane, crude oil and other goods — derailed due to a sudden wheel or axle failure. Five tank cars carrying crude oil caught fire and exploded near Plaster Rock, New Brunswick. The train reportedly was delivering crude from Manitoba and Alberta to the Irving Oil refinery in Saint John, New Brunswick. About 45 homes were evacuated but no injuries were reported.

Jan 2014  National Transportation and Safety Board (NTSB) recommended to the Federal Railroad Administration (FRA) and the Pipeline and Hazardous Materials Safety Administration that would require hazardous materials to avoid populated areas.

Feb 2014  A 120-car Norfolk Southern Corp. train carrying heavy Canadian crude oil derailed and spilled in western Pennsylvania
APPENDIX C: Links to Additional Information

CANADA


On January 31, 2014, the three working groups developed from the Transportation of Dangerous Goods General Policy Advisory Council submitted their comments to the Minister of Transport

Report and Recommendations from the Classification Working Group

Report and recommendations from the Emergency Response Assistance Plan Working Group

Report and recommendations from the Means of Containment Working Group

January 11, 2014 Proposed Amendments to the TDG Regulations (Canada): RE: Means of Containment (solicited comments due Feb 10, 2014)

September 6, 2013: PHMSA Advanced Notice of Proposed Rulemaking (requested comments by November 5, 2013)

November 15, 2013: AAR submission in response to PHMSA request for comments on the Advanced Notice of Proposed Rulemaking
http://www.regulations.gov/#!documentDetail;D=PHMSA-2012-0082-0090

December 5, 2013: API submission in response to PHMSA request for comments on the Advanced Notice of Proposed Rulemaking
http://www.regulations.gov/#!documentDetail;D=PHMSA-2012-0082-0139

December 5, 2013 RSICTC submission in response to PHMSA request for comments on the Advanced Notice of Proposed Rulemaking

January 23, 2014 NTSB issues recommendation to PHMSA RE: Classification

February 12, 2014: Rail Tank Car Industry Calls for Additional Safety Measures
Railway Supply Institute’s Guiding Principles in Response to the January 22, 2014 Call to Action on Rail Safety Meeting Follow-Up Letter from U.S. DOT Secretary Anthony Foxx

February 21, 2014: Oil and Rail industry Agree to Voluntary Safety Initiatives

February 25, 2014: Emergency Order to Classify Crude Oil as PG I and II only

March 6, 2014: Emergency Order Amendment to allow PG III designation
## APPENDIX D: Detailed DOT Specification

<table>
<thead>
<tr>
<th>DOT</th>
<th>111</th>
<th>A</th>
<th>60</th>
<th>AL</th>
<th>W</th>
<th>1</th>
</tr>
</thead>
</table>

- **Other Car Features**
  - Fittings, Materials, Linings

- **Type of Weld Used**
  - “W” Fusion Welding (most common)
  - “F” Forge Welding

- **Type of Material Used in Tank Construct**
  - “NO LETTER” Carbon Steel
  - “AL” Aluminum
  - “A-AL” Aluminum Alloy
  - “N” Nickel
  - “C” “D” or “E” Stainless Steel (allow/steel)

- **Tank Test Pressure (PSI)**

- **Separator Character**
  - Significant only for Class 105, 112, 113, 114 Tank Cars and some 111 Tank Cars when retrofitted
  - “A” Top and bottom shelf couplers
  - “S” Tank headshields, top and bottom shelf couplers
  - “J” Jacketed thermal protection, tank headshields, top and bottom shelf couplers
  - “T” Spray-on thermal protection, tank headshields, top and bottom shelf couplers

- **Class Designation**
  - The three digit class designation

  **Non Pressure Tank Cars:**
  - DOT 103, DOT 104, DOT 111, DOT 115, AAR 201, AAR 203, AAR 206, AAR211

  **Pressure Tank Cars:**
  - DOT 105, DOT 109, DOT 112, DOT 114, DOT 120

  **Cryogenic Liquid Tank Cars:**
  - DOT 113, AAR 204W, AAR 204XT (inside box car)

  **Miscellaneous Tank Cars:**
  - DOT 106, DOT 110, DOT 107, AAR 207, AAR 208

- **Authorizing Agency**
  - Tank Car specifications start with 3 letters designating the agency under whose authority the specification was issued
  - DOT Department of Transportation
  - AAR Association of American Railroads
  - ICC Interstate Commerce Commission (Regulatory authority assumed by DOT in 1996)
  - CTC Canadian Transport Commission
  - TC Transport Canada (Replacing CTC)