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# Canadian Crude Oil Transportation

## Comparing the Safety of Pipelines and Railways

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# I. Introduction

Canadian crude oil and related products are transported primarily by pipelines and railways. As the volume of crude oil carried by rail has increased in recent years, some industry analysts have raised questions about the relative safety of different modes of transport for crude oil. Some of these analyses have presented an incomplete picture, leading to unwarranted conclusions about the overall safety of one mode compared to another. To provide a balanced perspective on this issue, this paper briefly reviews recent statistical data on pipeline and rail crude oil spills – both the number of incidents and the volume spilled. Based on this data, it is our contention that, with current regulation and investment, both rail and pipeline have comparable safety records and are safe means of transporting crude oil.

It should be noted that this paper presents crude oil data for Canada's two largest "Class I" railways, Canadian National Railway Company (CN) and Canadian Pacific Railway Limited (CP). These two carriers together transport more than 99 percent of the Canadian crude oil that is transported by rail (Exhibit 1).[1]

**Exhibit 1: Canadian Crude Oil Transport by Railway Type, 2012-2014[2]**

| | Millions of Revenue Ton-Miles | | | Percent Share of Total | |
|---|---|---|---|---|---|
| | Class Is | Short Lines | Total | Class Is | Short Lines |
| 2012 | 6,900 | 50 | 6,950 | 99.3% | 0.7% |
| 2013 | 15,830 | 65 | 15,895 | 99.6% | 0.4% |
| 2014 | 22,157 | N/A | N/A | N/A | N/A |

# II. Canadian Production and Transport of Crude Oil

Canada has the world's third largest proven oil reserves,[3] and development of these resources has accelerated in recent years. Between 2004 and 2009, Canadian crude oil production grew on average by just 1.2 percent per year. Between 2009 and 2014, however, production expanded rapidly, growing on average by 6.8 percent per year, from 41.4 billion gallons to 57.5 billion gallons annually.[4]

Historically, most of this oil moved by pipeline, not rail. Prior to 2012, rail moved less than 6,000 carloads (that is, filled tank cars) of fuel oil and crude oil per year (Exhibit 2).[5] Beginning in 2012, however, the amount of crude oil transported by rail began to grow (as did the amount

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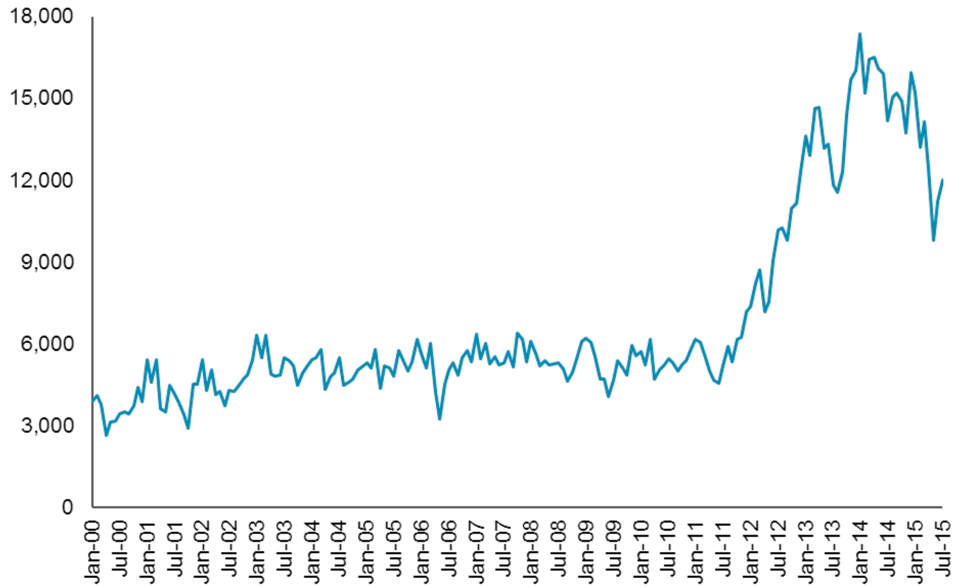
[1] The data includes the Lac-Mégantic accident in 2013, under the "short line" category.
[2] Canadian National, Canadian Pacific, the Railway Association of Canada.
[3] BP Statistical Review of World Energy, June 2015, p. 6.
[4] National Energy Board, "Estimated Production of Canadian Crude Oil and Equivalent" (https://www.neb-one.gc.ca/nrg/sttstc/crdlndptrlmprdct/stt/stmtdprdctn-eng.html).
[5] Canadian Association of Petroleum Producers, "Transporting Crude Oil by Rail in Canada," March 2014, p. 1.

transported by pipeline), as new sources of production in Canada became available. By 2014, more than 15 percent of Canadian crude oil (in gallon-miles) was being transported by rail.[6] This growth in the use of rail for the movement of crude oil has been due primarily to the need to connect new oil fields with refineries in certain regions where pipelines either are not present or lack sufficient capacity.

**Exhibit 2: Canadian Fuel Oil and Crude Oil Moved by Rail, January 2000 to July 2015[7]**
In carloads




# III. Evaluating Safety Metrics for Oil Transportation

Both railways and pipelines in Canada have made significant efforts to minimize spills and ensure the safe transport of crude oil. These efforts have included investments and improvements in training, engineering processes, safety culture, and technology. Between 2012 and 2014, Canadian pipelines and railways together transported 252.7 *billion* gallons of crude oil[8]; of this, 729,700 gallons were reported spilled. This means that together railways and pipelines delivered 99.9997 percent of the gallons they transported without spillage.[9]

Some industry studies have examined the number of oil spill incidents involving crude oil and related products and drawn the conclusion that pipelines provide a safer alternative for moving

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[6] Statistics Canada, Table 133-0005, Operating Statistics of Canadian Pipelines, product = "crude oil"; Railway Association of Canada, Oliver Wyman analysis.
[7] Statistics Canada. Table 404-0002, Railway Carloading Statistics, by Commodity, Monthly.
[8] Statistics Canada, Table 133-0005, Operating Statistics of Canadian Pipelines, product = "crude oil"; Railway Association of Canada, Oliver Wyman analysis. Updated December 2015.
[9] Spillage may be slightly understated. Data on spills from intra-provincial pipelines in Alberta is not available for February to June, 2013, due to the transition of incident monitoring responsibility from the Energy Resource Conservation Board to the Alberta Energy Regulator.

these products. These analyses have used as their basis of comparison what is known as the **"incident rate,"** which is based on how many separate release incidents each mode has experienced. Using a different metric, known as the **"spill rate,"** which is based on the total volume of oil each mode has released, would have led these studies to the opposite conclusion: that railways provide the safer alternative. Thus, the most balanced view involves looking at these two sets of figures together, to determine what story they tell about the safety characteristics of each mode and their relative levels of risk.

## A. Incident Rate

The incident rate involves three data points:

- The total number of incidents for each mode (number of crude oil releases per year)
- The total volume of crude oil the mode transports (annual gallons)
- The total distance the crude oil is moved (annual miles)

Gallons are then multiplied by miles, which gives the total volume moved over total distance, known as gallon-miles. This is important, as both distance transported and volume increase the potential for spills. The number of incidences are then divided by gallon-miles to derive the incident rate for the year:

*Incident rate = Number of incidents / (total volume x total miles)*

Exhibit 3 shows pipeline crude oil incident data for 2004-2014 and available Class I rail crude oil incident data for 2012-2014. Many years of data for both modes would enable the best comparison of safety track records. Limited data however is available on Canadian Class I rail crude oil incidents, as only limited amounts of crude oil were moved prior to 2012.

Class I railroad data is presented as these railroads move more than 99 percent of crude oil in Canada, and there is even less data available on short line railroads: only two years, including 2013 when the Lac-Mégantic accident occurred. This accident involved a small railway that used operating practices not employed by either CN or CP, and which no longer transports crude oil.

Exhibit 3 makes two things clear: the incident rate for both modes is very small: less than 0.2 incidents per billion gallon-miles. And the incident rate for both modes varies slightly from year to year. Overall, railways and pipelines had virtually the same number of incidents per billion gallon-miles in 2012 and 2014. (Data for 2013 cannot be properly compared, as 4.5 months of pipeline crude oil data had to be excluded due to the unavailability of some data.)

**Exhibit 3: Canadian Crude Oil Incident Rates for Pipelines and Class I Railways**[10]

| | Pipelines | | | Class I Railways | | |
|---|---|---|---|---|---|---|
| **Year** | **Number of Incidents** | **Gallon-Miles Transported** (billions) | **Incident Rate** | **Number of Incidents** | **Gallon-Miles Transported** (billions) | **Incident Rate** |
| **2004** | 301 | 19,533.1 | 0.0154 | | | |
| **2005** | 336 | 17,876.7 | 0.0188 | | | |
| **2006** | 299 | 20,054.2 | 0.0149 | | | |
| **2007** | 335 | 20,273.5 | 0.0165 | | | |
| **2008** | 293 | 20,694.0 | 0.0142 | | | |
| **2009** | 250 | 20,588.6 | 0.0121 | | | |
| **2010** | 262 | 20,950.3 | 0.0125 | | | |
| **2011** | 277 | 26,105.5 | 0.0106 | | | |
| **2012** | 291 | 28,627.3 | 0.0102 | 19 | 1,918.3 | 0.0099 |
| **2013**[11] | *41* | *18,262.5* | *0.0022* | 50 | 4,400.7 | 0.0114 |
| **2014** | 122 | 33,933.1 | 0.0036 | 21 | 6,159.9 | 0.0034 |
| **Total** | 2,807 | 246,899.4 | 0.0114 | 90 | 12,478.9 | 0.0072 |

Most important, the table demonstrates that both pipelines and railways have excellent safety records for crude oil transport overall. It is important to note also that the total number of rail incidents includes not only "accidental" releases, that is, caused by a derailment, collision, or other rail-related accident, but "non-accidental" releases, or minor splashes and spills.

## B. Spill Rate

The spill rate also involves three data points:

- The total volume of crude oil spilled by each mode (annual gallons)
- The total volume the mode transports (annual gallons)
- The total distance the crude oil is moved (annual miles)

As above, gallons are then multiplied by miles, which gives the total volume moved over total distance, known as gallon-miles. This is important, as both distance transported and volume increase the potential for spills. The total volume of crude oil spilled in a given year is then divided by gallon-miles to derive the spill rate:

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[10] Statistics Canada, Table 133-005, Operating Statistics of Canadian Pipelines Carriers; Railway Association of Canada; Oliver Wyman analysis.

[11] Note table excludes pipeline volumes and incidents for February 1 to June 15, 2013, due to the lack of availability of Alberta incident data during the transition of incident monitoring responsibility from the Energy Resource Conservation Board to the Alberta Energy Regulator.

*Spill rate = Volume spilled / (total volume x total miles)*

Exhibit 4 shows pipeline crude oil spill data for 2004-2014 and available Class I rail crude oil spill data for 2012-2014. The table shows that, as in the case of the incident rate, the relative performance of railways and pipelines varies slightly by year, but both modes have excellent safety records. In addition, the safety of pipelines has improved significantly in recent years.

**Exhibit 4: Canadian Crude Oil Spill Rates for Pipelines and Class I Railways[12]**

| | Pipelines | | | Railways | | |
|---|---|---|---|---|---|---|
| Year | **Gallons Spilled** (000's) | **Gallon-Miles Transported** (billions) | **Spill Rate** | **Gallons Spilled** (000's) | **Gallon-Miles Transported** (billions) | **Spill Rate** |
| **2004** | 932.4 | 19,533.8 | 47.7 | | | |
| **2005** | 612.0 | 17,876.7 | 34.2 | | | |
| **2006** | 660.5 | 20,054.2 | 32.9 | | | |
| **2007** | 500.8 | 20,273.5 | 24.7 | | | |
| **2008** | 234.7 | 20,694.0 | 11.3 | | | |
| **2009** | 830.2 | 20,588.6 | 40.3 | | | |
| **2010** | 189.4 | 20,950.3 | 9.0 | | | |
| **2011** | 1,465.7 | 26,105.5 | 56.1 | | | |
| **2012** | 403.4 | 28,627.3 | 14.1 | 13.5 | 1,918.3 | 7.0 |
| **2013[13]** | *51.0* | *19,262.5* | *2.6* | 88.5 | 4,400.7 | 20.1 |
| **2014** | 126.5 | 33,933.1 | 3.7 | 46.8 | 6,159.9 | 7.6 |
| **Total** | 6,006.6 | 246,899.4 | 24.3 | 148.8 | 12,479.0 | 11.9 |

The total volume of oil spilled by rail in 2012 and 2014 was less than that released by pipelines. (Data for 2013 cannot be properly compared, as 4.5 months of pipeline crude oil data had to be excluded due to the unavailability of some data.) Rail release volumes are lower because: 1) railways move less oil than pipelines overall, and 2) in any given rail incident, such as a derailment, generally only a few cars at most are involved. (Each car carries an average of 30,000 gallons of product.)

As shown in Exhibit 5, since 2012, the first year that Canadian Class I railways carried significant amounts of crude oil:

- 93.3 percent of derailments involving release of product have involved only one car.

[12] Statistics Canada, Table 133-005, op. cit. ; Railway Association of Canada; Oliver Wyman analysis.
[13] Note table excludes pipeline volumes and incidents for February 1 to June 15, 2013, due to the lack of availability of Alberta incident data during the transition of incident monitoring responsibility from the Energy Resource Conservation Board to the Alberta Energy Regulator.

- 38.9 percent of spills involved quantities of less than one gallon of oil (and in some cases, as little as half a cup.)
- Some 86.7 percent involved spills of less than 25 gallons.

The average gallons per spill for pipelines, by comparison, during 2004-2014 was 2,139.86 gallons.

**Exhibit 5: Number of Railcars Releasing Crude Oil in Canadian Class I Derailments[14]**

| | Number of Cars Releasing Crude Oil | | | | | Number of Cars Segmented by Gallons Released | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4+ | Total | < 1 | 1-5 | 5-25 | 25-100 | 100 |
| 2012 | 19 | - | - | - | 19 | 6 | 3 | 6 | 3 | 1 |
| 2013 | 47 | 2 | - | 1 | 50 | 16 | 15 | 13 | 2 | 4 |
| 2014 | 18 | 2 | 1 | - | 21 | 13 | 4 | 2 | - | 2 |
| Total | 84 | 4 | 1 | 1 | 90 | 35 | 22 | 21 | 5 | 7 |

Clearly, each of the metrics described above tells a part of the story. The number of incidents and the volume of product spilled vary by year and by metric, with railways achieving a slightly better record in some years and pipelines in others. Overall, however, the incident and spillage rates for both modes are low.

## C. Rail Transport of Dangerous Goods

While railway data for crude oil transport only goes back three years, the results are consistent with the railways' safety record for transporting similar commodities, known as "dangerous goods."[15] As Exhibit 6 demonstrates, Canadian railways not only have safely transported a wide range of dangerous goods for many years but continue to improve on safety even as shipments of such materials have risen.

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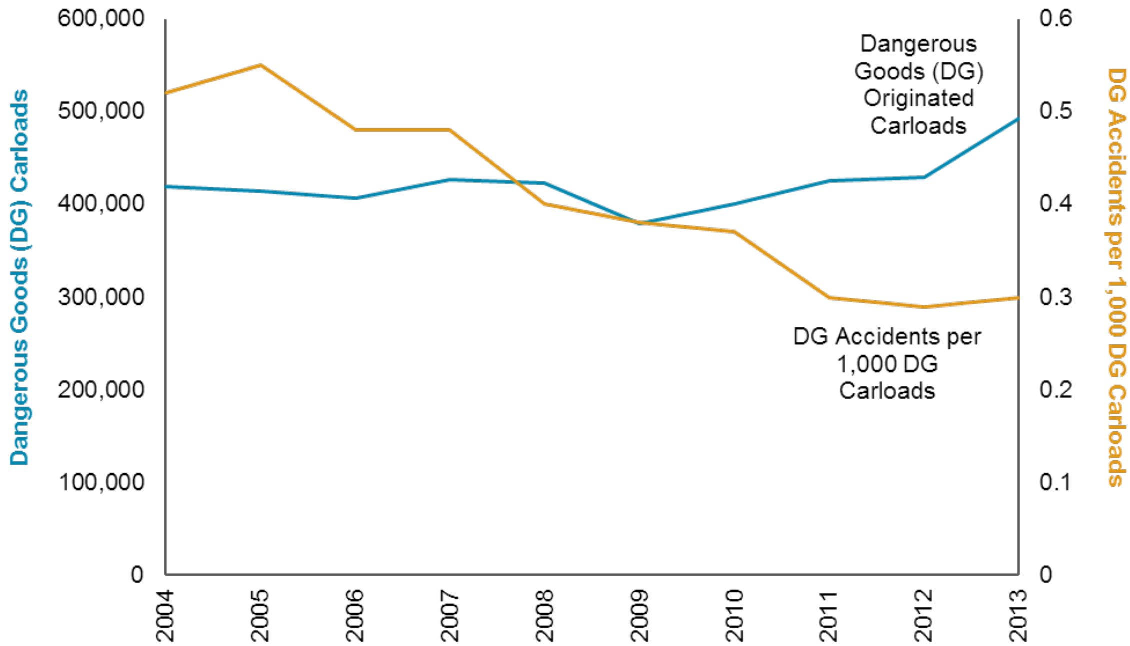
[14] Canadian National, Canadian Pacific, Oliver Wyman analysis.

[15] Dangerous goods are defined in the Schedule to the Transportation of Dangerous Goods Act, 1992 (S.C. 1992, c. 34). In general, these are products, substances, or organisms that could be dangerous to life, health, property, or the environment when handled, offered for transport, or transported. Examples include explosives, flammable and combustible liquids, poisonous and infectious substances, nuclear substances, and corrosives. Transport of dangerous goods requires special safety provisions. Some 12 percent of Canadian rail traffic consists of dangerous goods (see: http://www.railcan.ca/operations/dangerous_goods).

**Exhibit 6: Canadian Railway Accidents Involving Dangerous Goods, 2004-2013**[16]




# IV. Recent Safety Improvements

Both railways and pipelines continue to work to improve crude oil transportation safety. On the rail side, 99.998 percent of chemical and petroleum shipments in North America arrive at destination without a release of product caused by an accident.[17] And total federally regulated railway accidents on Class I railways in Canada (including minor incidents) declined from 1,232 in 2004 to 908 in 2013 (the last year for which statistics are available), a drop of 26 percent.[18]

Railways have taken a number of steps to reduce incidents like derailments. These include:

- Increasing the use of *distributed power* on crude oil trains, in which locomotives are placed both at the head end and in the body of the train
- Adding two-way *end-of-train devices* to every crude oil train, which allow brakes to be applied simultaneously from the front and rear of a train
- Increasing the use of *dynamic braking*, in which the generators on locomotives are used to slow the train more gradually than brakes alone

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[16] Railway Association of Canada, 2014 Rail Trends. Latest year data available.
[17] Railway Association of Canada, "The Movement of Dangerous Goods," (http://www.railcan.ca/safety/dangerous_goods). See footnote 8 for definition of dangerous goods.
[18] Transportation Safety Board of Canada, "Federally Regulated Railway Accidents and Incidents, by Train Operator, 2004-2013" (http://www.tsb.gc.ca/eng/stats/rail/r13d0054/r13d0054.asp).

- Adding *wayside detectors* that monitor the wheels and bearings of passing trains to detect potential defects
- Developing *predictive analytics* to make maintenance of rail equipment and track more proactive
- Investing in *leading-edge detection technologies* to mitigate risk, such as machine vision, tie rating, and ground penetrating radar

In addition, Canada has enacted regulation to implement an improved tank car design for crude oil tank cars. This could lead to further improvements in safety performance.

Pipelines also have made improvements in the safe handling of oil and related products. Between 2009 and 2013, 99.999 percent of crude oil and petroleum products transported via Canada's federally regulated pipelines arrived without any release, and between 2011 and 2013, essentially all liquids released by these pipelines were recovered.[19]

In addition to meeting regulations regarding safe construction and regular inspections, the pipeline industry continually invests in new technology to improve safety. One area of significant research is leak detection. Pipelines already use mechanical devices that detect deviations in pipe walls that might indicate corrosion or damage, and measure pipeline pressure and flow continuously. New technology includes *smart balls* – electronic bowling-ball sized sensors that can be put into pipelines to detect tiny leaks and mark their location. As well, *fiber optic cables* laid alongside pipelines are being used to detect temperature changes that might indicate a leak and sounds associated with unauthorized excavation near pipelines.

In summary, a more nuanced analysis lessens the need to debate the question of what is the "safest" mode for crude oil transport. Available data shows that though differences between the modes vary by metric and from year to year, those differences are small. Both modes have excellent safety records and are taking steps to improve safety further. Most critically, both pipelines and railways are needed to handle Canada's production of crude oil and related products. Both will need to add yet more capacity as Canadian crude oil production grows in the future.

[19] Natural Resources Canada, "Pipeline Safety," (https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/files/pdf/14-0277-%20PS_pipelines_across_canada_e.pdf).

## REPORT QUALIFICATIONS, ASSUMPTIONS, AND LIMITING CONDITIONS

Oliver Wyman was commissioned by The Railway Association of Canada to develop a report that presents a balanced analysis of the comparative safety of railways and pipelines in transporting crude oil and associated products. It is intended for an audience of persons interested in this issue.

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