

# Transportation of Dangerous Goods



# NEWSLETTER

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Picture taken by Lac-Mégantic resident Bernard Boulet showing the view from his house, across the lake from the downtown area, on the night of July 6, 2013.

## EXPLOSIVE NEWS: BLEVE VS HIT

By Mylaine DesRosiers, Julie Laurendeau and Chris Powers

The tragic events of Lac-Mégantic have demonstrated why it is important to promptly identify the type of incident that is occurring and what risks are associated with it. In July 2013, fireballs engulfed the downtown area of Lac-Mégantic. First Responders were overwhelmed. Of the train’s 72 tank cars carrying crude oil, 63 had derailed and 62 had caught fire. Seeing the fireballs, many First Responders thought they were the result of **Boiling Liquid Expanding Vapour Explosions (BLEVE)**, when they were in fact caused by **Heat Induced Tears (HIT)**. Both BLEVEs and HITs pose great risks and require specific fire response tactics that may be unfamiliar to many firefighters.

During a BLEVE, a fire impinged or damaged tank car fails to contain its internal pressure and explodes with a sudden product release, propelling tank car fragments with great force and high speed over long distances. In addition, if the product (e.g. liquefied pressure gas such as propane) is flammable, there will also be a fireball and intense heat generated. This catastrophic failure is more likely to occur on damaged pressure tank cars, whether under fire conditions or not.

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This newsletter is also available at the same internet address. Please address comments and inquiries regarding additional information or publications to:

**The Editor,**  
**Transportation of Dangerous Goods Newsletter**  
**Transportation of Dangerous Goods Directorate**  
**Transport Canada**  
**330 Sparks Street, Tower C, 9<sup>th</sup> floor-ASDB**  
**Ottawa, Ontario, Canada**  
**K1A 0N5**

## CONTACTS

### TRANSPORTATION OF DANGEROUS GOODS DIRECTORATE

DIRECTOR GENERAL  
NICOLE GIRARD  
([NICOLE.GIRARD@TC.GC.CA](mailto:NICOLE.GIRARD@TC.GC.CA))  
[TDG-TMD@TC.GC.CA](mailto:TDG-TMD@TC.GC.CA)

### CANUTEC

Information: 613-992-4624  
Emergency: 613-996-6666 Fax: 613-954-5101  
1-888-CAN-UTEC (226-8832)

### Atlantic Region

Dartmouth: 902-426-9461 Fax: 902-426-6921  
St. John's: 709-772-3994 Fax: 709-772-5127  
Moncton: 1 866-814-1477 Fax: 506-851-7042  
E-mail: [TDG-TMDAtlantic@tc.gc.ca](mailto:TDG-TMDAtlantic@tc.gc.ca)

### Quebec Region

514-283-5722 Fax: 514-283-8234  
E-mail: [TMD-TDG.Quebec@tc.gc.ca](mailto:TMD-TDG.Quebec@tc.gc.ca)

### Ontario Region

416-973-1868 Fax: 416-973-9907  
E-mail: [TDG-TMDOntario@tc.gc.ca](mailto:TDG-TMDOntario@tc.gc.ca)

### Prairie and Northern Region

Winnipeg: 204-983-5969 Fax: 204-983-8992  
Saskatoon: 306-975-5105 Fax: 306-975-4555  
E-mail: [TDG-TMDPNR@tc.gc.ca](mailto:TDG-TMDPNR@tc.gc.ca)

### Pacific Region

New Westminster: 604-666-2955 Fax: 604-666-7747  
Kelowna: 250-491-3712 Fax: 250-491-3710  
E-mail: [TDGpacific-TMDpacifique@tc.gc.ca](mailto:TDGpacific-TMDpacifique@tc.gc.ca)

## WRITERS/CONTRIBUTORS TO THIS ISSUE

- **Nicole Girard**  
Director General,  
TDG Directorate
- **Mylaine DesRosiers**  
Executive Director, Emergency Response Task Force Secretariat,  
TDG Directorate
- **Julie Laurendeau**  
Remedial Measures Specialist,  
Compliance and Response Branch, TDG Directorate
- **Chris Powers**  
Chair, Emergency Response Task Force, TDG Directorate
- **Rebecca Paul**  
Junior Analyst, Regulatory Affairs Branch,  
TDG Directorate
- **Benoit Philippe**  
Emergency Response Advisor,  
CANUTEC, TDG Directorate
- **Alison Butko**  
Emergency Response Advisor,  
CANUTEC, TDG Directorate
- **Dale Gratton**  
TDG Regional Manager,  
Ontario Region
- **Tagenine Alladin**  
Scientific Research Advisor, Safety Research & Analysis,  
TDG Directorate
- **Chris Kirney**  
Engineering Research Officer, Safety Research & Analysis,  
TDG Directorate
- **Neil Cristo and Milan Rose**  
TDG Inspectors,  
Prairie and Northern Region
- **Greg Sliva**  
TDG Inspector,  
Prairie and Northern Region
- **Priti Zachariah**  
Research/Analysis Officer, Safety Research & Analysis,  
TDG Directorate
- **Julie Prescott**  
Analyst, Special Regulatory Projects,  
TDG Directorate
- **John Harpin**  
Manager, Co-ordination and Information Center,  
Dangerous Goods, Rail Safety and Alberta 511
- **Darren Jette**  
Policy/Economic Officer, Compliance Measurement and Data Governance,  
TDG Directorate
- **Charlie Pitts**  
TDG Inspector, Compliance and Response Branch,  
TDG Directorate
- **Roberto Bruni**  
TDG Instructor /Inspector, Compliance and Response Branch,  
TDG Directorate
- **Alexandre Caron**  
TDG Instructor /Inspector, Compliance and Response Branch,  
TDG Directorate
- **Stéphane Garneau**  
Superintendent, Small Means of Containment and IBCs, Regulatory Affairs Branch,  
TDG Directorate
- **Shaun Singh**  
Means of Containment Specialist, Regulatory Affairs Branch,  
TDG Directorate

A HIT is a different type of tank car failure. Under the intense heat of a fire, non-pressure tank cars containing flammable liquids will tear, generally at the top, causing the product to suddenly vent at high speed, generating a fireball and an intense heat wave. Unlike BLEVEs, HITs rarely result in the projection of tank car fragments. HITs have been known to occur within 20 minutes to several hours after a derailment of tank cars carrying flammable liquids such as crude oil or ethanol. Unlike a BLEVE, where all the product is quickly released or consumed, a tank car with a HIT may still contain product that can burn or leak for 8 hours or more.

For rail incidents involving tank cars containing flammable liquids under fire conditions, the risk of HITs makes the response very complex and dangerous. HITs can occur without warning and produce a fireball, generate extremely intense heat and release toxic gases. Anyone too close could suffer serious or fatal burns. Responding safely to a flammable liquids rail incident requires specialized training, specialized equipment and a tactical approach. First Responders must first focus on securing the scene; any other action could put both the responders and the public at risk.

## SIGNS THAT THE INCIDENT WILL LIKELY GROW OR CASCADE RAPIDLY INCLUDE:

- Running or unconfined spill fires and releases. Spills may flow into storm drains and other underground structures, creating secondary spills and fires. Using large water streams for cooling may also spread the fire to unintentional areas.
- Direct flame contact on tank cars from either a pool of fire or torch fire.
- Heat induced blisters appearing on the tank car shell.
- Activation of pressure relief devices (PRD).
- Growth of fire area after First Responders arrive on-scene.



Picture of ruptured tank car taken at Lac-Mégantic in July 2013 by the Farmington (Maine) Fire Rescue Department.

## FIRE DEPARTMENT STRATEGY AT FLAMMABLE LIQUIDS DERAILMENTS

Since rail incidents may involve a combination of flammable liquids and other dangerous goods in large amounts, the situation will exceed the capacity of local fire services to take any offensive actions. In fact, taking offensive actions would place First Responders at great risk.

Responders should consider taking offensive actions only after the incident has reached a state of equilibrium, which may take 8 hours or more.

## EQUILIBRIUM

- **Fire confined to area**
- **No PRD activation**
- **Two-dimensional fires** (refers to a spill, pool, or open container of liquid that is burning only on the top surface)
- **Lower probability of more HITs or breaches**

## REMEMBER:

- 1-The priority is to secure the scene.
- 2-Refer to the **Emergency Response Guidebook** for suggested general and specific isolation distances for spill or fire situation to ensure the safety of responders and the public.
- 3-Call CANUTEC.  
Get immediate help, best advice and accurate information.
- 4-Non-intervention is the first best strategy until the situation stabilizes.  
In case of fire, if a flammable product is involved, let the liquid burn off rather than take any offensive action. Anything beyond non-intervention without appropriate guidance can easily make a bad situation worse.

**CANUTEC :**  
toll free 1-888-CAN-UTEC (226-8832),  
613-996-6666 or \*666 on a cell phone  
in Canada

## WORD FROM THE DIRECTOR GENERAL

By Nicole Girard

For some years now, the transportation of flammable liquids has increased – and crude oil is part of this reality.

In a previous edition of the Transportation of Dangerous Goods (TDG) Newsletter, we mentioned that the tragic event in Lac-Mégantic would continue to define our priorities in the long term. Today, we want to assure you that this is still the case.

Research is crucial to understanding the components and characteristics of crude oil and to putting appropriate safety measures in place. In the past few years, cooperation with our American partners, our Canadian stakeholders and our TDG specialists has allowed us to share the results of research on crude oil and to direct safety initiatives towards sustainable solutions. It is very important to develop and take concrete measures as soon as research results identify dangers requiring intervention.

Other recent activities include:

- Publishing the final report on the sampling and analysis of crude oil, which helps keep the public informed of the latest studies;
- Publishing a safety advisory on the dangers of crude oil and hydrogen sulphide on our web site to increase awareness among those who work with those products; and
- Introducing new regulatory measures, including requirements for emergency response assistance plans to provide quick and effective information to First Responders in the case of an incident.

These initiatives are an important step forward as we continue our work. Our objective is to keep our population, including employees, safe and well-informed!

## CRUDE OIL 101

By Rebecca Paul

### Overview

Crude oil is a term for “unprocessed oil” that comes from the ground. This important resource was formed from plants and animals over millions of years, in various places throughout the world. Canada has four main crude oil regions: British Columbia, Alberta, Saskatchewan and Manitoba.

Crude is usually a thick dark liquid with a “rotten-egg” smell, depending on where it was found and under what conditions it was formed underground. It can be processed to produce plastic, latex paints, fertilizers, pharmaceutical drugs, synthetic fibers, and even explosives.

## Different Types of Crude Oil

Different areas produce different types of crude oil, which can vary in colour, composition and consistency. The following is a short list of the most common by-products:

**Bitumen** is a thick molasses-type by-product of the crude oil refining process. It is found locally in the oil sands regions of Northern Alberta and is most commonly used in roof tiles and road paving.

**Condensate** is a liquid mixture that contains a lot of light end hydrocarbons. It is found in the ground with natural gas and can be used as feedstock for oil refining.

**Fuel oils** are crude by-products containing the heaviest fractions of hydrocarbons. They serve as components of gasoline and can be refined to produce home heating fuel oil and diesel.

**Gasoline** is a highly flammable, colourless liquid crude by-product used as fuel for internal combustion engines.

**Kerosene** is a thin light-coloured crude by-product often used in lamps, home heaters, jet engines and furnaces.

**Lubricating oil** is a light crude by-product used as motor oils, greases and light machine oils.

## Some Relevant Physical Properties of Crude Oil

Here are the properties industry often uses to assess crude oil and get maximum value from it:

### API Gravity:

American Petroleum Institute (API) Gravity is a measure of how light or heavy the crude oil is when compared to water. Industry uses this property to determine the value of the crude oil: in general, the higher the API value, the lighter the oil. Lighter oils are generally easier to produce and refine than heavier oils, which gives them a higher dollar value. In the case of an incident, lighter oils are more likely to travel outwards and spread.

### Viscosity:

Viscosity is a measure of how a substance flows. Crude oil with a light colour and thin consistency that flows easily is usually a substance with low viscosity. High viscosity substances pose problems in transport during loading and handling, as these heavy substances do not flow.

## Sulfur Content:

Sulfur content can indicate toxicity and corrosion for any type of crude oil. Industry calls crude oil with a sulfur content lower than 0.5% "sweet" and those with a sulfur content above 0.5% "sour".

## Hazards Linked to Crude Oil

### Flammability:

Flammability is a concern because mixing crude oil with the proper amount of air when an ignition source is nearby can lead to rapid combustion or a heat-induced tear. Flammability also relates to flash point (the lowest temperature at which ignition can occur): the lower the flash point, the easier it is to ignite a material, which raises the probability it would cause a fire.

### Volatility:

Volatility is a measure of vapour pressure and an important consideration for both producers and refiners in determining how to handle and refine the crude. A volatile substance can easily form a significant concentration of vapour, especially in an enclosed space, which can be problematic if these vapours are toxic. Some cases document vapour build-ups that can displace oxygen, which creates an inhalation hazard.

### Corrosivity:

Corrosivity can be measured by pH and with sulfur content. The sulfur content indicates that acidic products can form when the crude oil is being refined. These by-products are problematic because they can corrode the metal in the means of containment and handling equipment. It can also lead to the formation of toxic hydrogen sulfide gas.

### Toxicity:

A toxic substance is a substance capable of causing injury or death by chemical means. Several dangerous goods can negatively impact human health through ingestion, inhalation or skin contact when they are handled or in transport. Some constituents of petroleum crude oil can be toxic to the people and the wildlife. Short term exposure to crude oil and petroleum products can produce symptoms of dizziness, nausea, blurry vision and headaches that can often resemble the 'common flu' or appear as a bad case of

'alcohol poisoning'. Longer term exposures can lead to more severe impacts. As many of the crude compounds can be absorbed directly via skin contact or lungs, it is important to wear protective gear such as boots, gloves, respirators and suits to minimize petroleum product poisoning.

## Conclusion

As crude oil is extracted from the ground, its properties can vary widely and so can the associated risks. To obtain accurate information, it is important to contact the manufacturer. CANUTEC is available 24/7 to help with an emergency.

## PROPERTIES OF CRUDE OIL – WHAT FIRST RESPONDERS NEED TO KNOW

By Benoit Philippe

Petroleum crude oil is one of the most transported dangerous goods by road and rail in Canada. This is why First Responders across Canada should be aware of the differences in petroleum crude oil properties as they may affect their emergency response actions. Since the 2013 incident in Lac-Mégantic, Transport Canada has begun research projects to analyze samples of petroleum crude oil from across Canada to assess the differences in their properties, behaviours and hazards.

## Flammability and Toxicity of Petroleum Crude Oil

The two main hazards that pose threats to First Responders at petroleum crude oil incidents are flammability and toxicity. This is why First Responders should always wear bunker gear and self-contained breathing apparatus (SCBA) when attending a petroleum crude oil incident. The flammability range of petroleum crude oil vapours in air is 0.4% to 15%. With such a wide range of vapour pressures for petroleum crude oil, the product can quickly exceed its lower flammability limit, creating a flammable or explosive environment, both outdoors and in enclosed spaces. If a container is exposed to fire or excessive heat, the container could rupture violently by heat-induced tear if it is not properly cooled with water.

An important measure of flammability risk for First Responders is a product's flash point, which is the lowest temperature at which a liquid can form an ignitable mixture in air. For Canadian petroleum crude oils, the flash point varies from -30°C to 172°C. Testing showed that only heavy crude and bitumen have a flash point above 0°C. Therefore, even in winter conditions, volatile vapours released from a spill may create a flammable atmosphere. During a petroleum crude oil incident, responders should eliminate all ignition sources and use only non-sparking tools and intrinsically safe equipment (equipment incapable of igniting flammable gases or fuels). Heavy vapours could also accumulate in low areas, such as sewers, travel to an ignition source, and flash back.

Toxicity is caused by the presence of hydrogen sulfide (H<sub>2</sub>S) and other dangerous chemicals (such as benzene) in petroleum

crude oil, and from combustion products such as carbon monoxide and oxides of sulfur and nitrogen. Hydrogen sulfide is a colourless gas with a rotten egg odour that may rapidly deaden the sense of smell. Therefore, odour alone can't warn of the continuous presence of H<sub>2</sub>S. The highest concentration measured from the samples Transport Canada tested was of 65 000 parts per million (ppm). These concentrations of H<sub>2</sub>S in air are well above the Immediately Dangerous to Life or Health (IDLH) value of 100 ppm. Inhalation symptoms range from sneezing, headache and nausea to pulmonary edema. Inhaling air with H<sub>2</sub>S concentrations ranging from 700 – 1000 ppm can be deadly.

## Impacts on the Environment

Most Canadian petroleum crude oils are lighter than water, which means they will float on rivers and lakes. Dangerous goods that float on water are generally easier to contain and absorb compared to heavier products that sink. First Responders can contain lighter products with floating booms or absorbent materials. For oils that are heavier than water, responders often construct a sand dam and piping to create an overflow dam. Since the density of petroleum crude oil is close to that of water, a petroleum crude oil / water emulsion could also occur, which is very difficult to separate and contain.

## Pre-incident Planning Challenges

In a large-scale incident involving petroleum crude oil, firefighters will need:

- Foam, to control any fires and suppress vapours;
- High volumes of water, pumps, fire trucks and water trucks to prevent the fire from spreading to any adjacent buildings and to keep tanks cool;
- An evacuation plan for densely populated areas; and
- Air monitoring and spill control resources in case the incident gets worse.

**Remember:** When responding to an incident with petroleum crude oil, First Responders need the safety data sheet (SDS) for the specific product. They can contact CANUTEC at 1-888-CAN-UTEC (226-8832) for immediate assistance.

## HOW CAN THE EMERGENCY RESPONSE GUIDEBOOK HELP FIRST RESPONDERS DURING A PETROLEUM CRUDE OIL INCIDENT?

By Alison Butko

### Why Do First Responders Use the ERG?

The Emergency Response Guidebook (ERG) helps First Responders recognize the presence of dangerous goods and identify the products involved. It also provides useful emergency response information.

A large-scale petroleum crude incident involving a leak, spill or fire would likely require a specialized, multi-agency response team. However, it is crucial that on-scene responders coordinate first response activities to ensure a cohesive approach. The ERG provides a standardized starting point.

### How Do First Responders Choose the Correct Guide Page?

First Responders can either use the product UN number (the yellow-bordered pages) or its shipping name (the blue-bordered pages). Petroleum crude oil is associated to either Guide 128 (for UN1267 – Petroleum Crude Oil) or Guide 131 (for UN3494 – Petroleum Sour Crude Oil).

First Responders can use the ERG even if they do not have access to the shipping document and if there are no placards visible. The ERG2016 contains expanded rail tank car and highway tank (road trailer) identification charts, which include commonly transported commodities for each type of tank cars or highway tanks. These charts, when lacking specific information, will direct First Responders to Guide 128 or 131, based on the shape of rail cars and highway tanks that can transport petroleum crude oil.

### What Information Will I Find in the ERG?

You will find information on:

- Potential hazards (flammability and toxicity risks);
- Emergency Response measures (in case of fire or leak); and
- Public safety measures (evacuation distances).

Establishing a security perimeter at the site of a dangerous goods incident is essential to ensure public safety. The ERG suggests initial isolation distances and the evacuation distances as **immediate** measures, but these may not be suitable for all incidents. Each incident requires assessment to adjust these preliminary distances.

### Are there Different Precautions in Guide 128 and Guide 131?

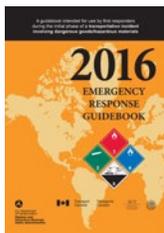
Despite similar recommendations in both guide pages, certain chemical properties require First Responders to use different precautions

for different types of crude oil. In the potential hazards section of a guide page, the **primary hazard** of the product is shown first.

**For example:** In the case of petroleum sour crude oil (Guide 131), the HEALTH hazard is shown **before** the FIRE OR EXPLOSION hazard. This lets First Responders know that vapours from the product could be toxic to them or to the surrounding public. Due to its toxicity by inhalation, the ERG highlights UN3494, Petroleum Sour Crude Oil in **green** in the yellow and blue pages, so First Responders know it is listed in Table 1 in the green-bordered pages. Table 1 lists initial isolation and protective action distances that First Responders should set in case of product release, to protect responders and the public from the effects of toxic inhalation. In case of a large spill of petroleum sour crude oil, the initial isolation distance should be 60 m, with downwind protection stretching as far as 700 m, compared with 50 m and 300 m for petroleum crude oil (Guide 128).

Both Guide 128 and 131 contain the statement “an emergency response assistance plan (ERAP) may be required for this product”, informing First Responders that specialized response teams and plans may be available to help local response efforts, particularly if the incident is large-scale and complex. First Responders can contact CANUTEC for more information during an incident.

## Will the ERG Provide all the Information First Responders Need for a Dangerous Goods Incident?



First Responders must remember that petroleum crude oil is not a pure substance, and its chemical properties will vary between shipments. The ERG does not distinguish between the various types of crude oil transported under UN1267. While the ERG is a valuable tool for First Responders in the initial response to a dangerous goods transportation incident, it does not replace specific information about the product involved. First Responders should get this information from a safety data sheet by contacting CANUTEC at 1-888-CAN-UTEC (226-8832).

## CRUDE OIL PERSONAL PROTECTIVE EQUIPMENT

By Dale Gratton

Anyone handling, offering for transport, transporting or responding to an emergency involving crude oil must protect themselves against potential hazards. Personal protective equipment (PPE) serves to shield or isolate people from the chemical and physical hazards they may encounter in their line of work. In general, there are four routes of exposure to the human body: injection, ingestion, inhalation and skin contact. For workplace activities that involve handling or transporting crude oil, we are mainly concerned with chemical exposure due to inhalation and skin contact, as well as the fire hazards most crude oils pose.

Crude oil itself is a naturally occurring, unrefined petroleum product, a complex mixture of hydrocarbons and other organic compounds such as nitrogen, oxygen, sulfur and some trace of metals. Different crude oils, extracted from different places, have different chemical compositions. These constituent chemicals dictate specific responses to the hazards they pose.

Many of the lighter hydrocarbon components of crude oil will readily enter the gas phase, making them dangerous to inhale. Some of these lighter components include pentane, hexane and benzene (a known carcinogen linked to leukemia and other cancers). Crude oil also usually contains varying amounts of hydrogen sulfide, an extremely toxic gas that can be released into the gas phase and quickly cause death on exposure. This is why air testing and monitoring should be the first step taken by those handling crude oil. These test results should then be compared with known exposure data. Some jurisdictions have set Occupational Exposure Limits (OELs) for crude oil inhalation exposure itself, while others rely on OELs of some of the more toxic constituents as guidance for selecting respiratory protection. Some OELs commonly referred to are in Table 1.

**Table 1 – Occupational Exposure Limits**

Chemical	Alberta	Ontario	OSHA PEL	ACGIH TLV
Crude Oil	300 ppm		500 ppm	
Benzene	0.5 ppm (8 hour), 2.5 ppm STEL	0.5 ppm TWA, 2.5 ppm STEL	1 ppm TWA, 5 ppm STEL	0.5 ppm TWA, 2.5 ppm STEL
Hydrogen Sulfide	10 ppm (8 hour), 15 ppm STEL (C)	10 ppm TWA, 15 ppm STEL (C)	20 ppm STEL (C)	1 ppm TWA, 5 ppm STEL

TWA – Time Weighted Average – average permissible exposure over an 8-hour period

STEL – Short-Term Exposure Limit – average permissible exposure over a 15-minute period

C specifies the ceiling value, as shown in the example STEL (C)

OSHA PEL – Occupational Safety & Health Administration Permissible Exposure Limits

ACGIH TLV – American Conference of Governmental Industrial Hygienists Threshold Limit Values

Depending on air monitoring and testing results, it may be necessary to look at respiratory protection such as air supplied respirators and self-contained breathing apparatus (SCBAs), or air-purifying respirators. For most situations involving crude oil, it is enough to use a cartridge air-purifying respirator suitable for organic vapours approved by the United States National Institute for Occupational Safety and Health (NIOSH). In more rare cases, particularly those involving high concentrations of chemical constituents such as benzene or hydrogen sulfide, an SCBA may be necessary. Anyone using respiratory protection should follow the Canadian Standards Association (CSA) Standard Z94.4 *Selection, use, and care of respirators*, and as part of a full respiratory protection program.

Crude oil can also have adverse health effects on contact with skin. Inflammation, redness, rashes, and even cancer can result from skin exposure to crude oil. This is why it is important to conduct a work assessment to determine the nature of the work being done and the potential for skin exposure. When choosing clothing for handling crude oil, it is important to consider the permeability, the rate of breakthrough of chemicals and the degradation of the fabric. There is often also a need to balance other safety issues, such as flame-resistance, breathability, and heat stress when selecting clothing for activities involving crude oil. Many workers choose flame retardant fabrics such as Nomex and Proban for flame-resistance and couple them with chemical impermeable accessories. Nomex coveralls by themselves, or combined with impermeable aprons, offer a good combination of protection from both hazards. In other circumstances (such as the presence of high hydrogen sulfide levels), workers may need to wear fully encapsulated chemical resistant suits. As for gloves, the most common types that offer good chemical resistance against crude oil hazards are nitrile, neoprene and viton gloves.

Working with crude oil also requires choosing:

- **Protective eyewear** that meet CSA Standard Z94.3 - *Selection, use and care of protective eyewear*. Most situations will either require safety glasses, splash goggles or a face shield that meets this standard. This protection may also come from the face shield portion of a full-face respirator or SCBA, which are also subject to the Z94.3 Standard.
- **Protective footwear** that meet the CSA Standard Z195 – *Protective footwear*.

All of the PPE required when handling, offering for transport, transporting or responding to an incident involving crude oil should be a part of a full PPE program. You can find more information on PPE programs, and health and safety in general, from the Canadian Centre for Occupational Health and Safety. <http://www.ccohs.ca/>

## TRANSPORTATION OF DANGEROUS GOODS RESEARCH: CRUDE OIL RESEARCH UPDATE

By Tagenine Alladin and Chris Kirney

Recent train derailments involving crude oil have often involved fire. Transport Canada's Transportation of Dangerous Goods (TDG) Directorate has always considered crude oil as flammable, and recognizes that some crude oils are more likely to catch and sustain fires than others. However, recent incidents have prompted TDG to conduct further research. For example, we are investigating:

- The role methane, ethane, propane, and butane gases play in the flammability and classification of crude oil; and
- The interaction between crude oil pool fires and crude oil containers

### Classification

Crude oil is a complex natural mixture of many substances and its makeup varies with geography and production processes. Under the TDG Regulations, most crude oil is transported as a Class 3, Flammable Liquids. The elevated presence of gases, more specifically flammable and toxic gases, in some crude oils may pose additional hazards during transport.

Since 2014, TDG has been working with Alberta Innovates – Technology Futures (AITF), a provincial research corporation, to further assess the composition and properties of crude oils transported by road and rail in Canada. The purpose of this is to:

- Verify the applicability of the current classification requirements for Class 3, Flammable Liquids, and Class 2, Gases as described in Part 2 of the TDG Regulations;
- Learn more about any other hazards crude oil poses during transportation; and
- Support TDG's regulatory and oversight policy decision-making.

From December 2014 to May 2015, we collected and analyzed 68 samples of crude oil destined for transport by rail or road in British Columbia, Alberta, Saskatchewan and Manitoba. These samples represent a wide range of crude oils from condensates to bitumen under controlled conditions. The samples were subjected to a variety of tests to determine properties such as flash point, boiling point, vapour pressure, compositional analysis and hydrogen sulphide (H<sub>2</sub>S) content in the vapour phase and flammable gas testing. To learn more about this work, you can consult the following web page:

<http://www.tc.gc.ca/eng/tdg/safety-menu-1242.html>. It is also possible to request a copy of the report by emailing [TDG-RD-TMD@tc.gc.ca](mailto:TDG-RD-TMD@tc.gc.ca).

TDG recently completed an inspection campaign targeting crude oil transloading facilities in the Prairie and Northern Region, from which we collected and analyzed 16 samples of crude oil. The data is currently being reviewed.

In March 2016, TDG has begun a new phase of research with the United States Departments of Transportation and Energy. This work will include:

- Evaluating the accuracy and suitability of various crude oil sampling and testing methods; and
- Sampling and testing a variety of North American crude oils.

TDG is also working with the Canadian Crude Quality Technical Association on a project to develop a new fit-for-purpose test standard that both industry and TDG can use to assess the H<sub>2</sub>S vapour hazard of crude oil samples.

## Containment

When crude oil released from a tank car ignites, the resulting pool fire can be large and immerse other cars carrying crude. While sometimes pressure builds and the tank car shell tears (usually longitudinally along the upper part of the car) and releases a fireball, it sometimes does not. How and why this happens and how to prevent or minimize the severity of a release is being investigated.

Last year, the National Research Council of Canada reviewed the current research on containers like tank cars containing crude oil in pool fires. This year, they will conduct several fire tests to help better understand the characteristics of crude oil pool fires, such as:

- How the type of crude oil affects the fire;
- How the ground and ice affect the fire; and
- How hot do objects become in the fire.

In the future, we want to test crude oil containers with pressure relief devices in fires. We are coordinating our work with Sandia National Laboratories, who are conducting pool fire and fireball tests for the U.S. Departments of Transportation and Energy.

We are also working with Natural Resources Canada's CanmetENERGY and CanmetMATERIALS researchers to understand what happens to crude oil in tank cars when heated and under pressure. In some cases, some of the oil can become a solid that may stick to the side of the car; in other cases, it may become a gas (such as propane). These researchers are:

- Developing and testing a model to help predict what happens to the crude oil if we know its initial composition, the rate of heating, and any pressure releases.

- Reviewing what we know about tank car steel properties at higher or colder temperatures and if crude oil corrodes these steels in a significant way.

We want to tie all this research into a better model for accurately predicting how tank cars carrying crude oil will react in fires. We hope this will help us better understand and minimize the potential risks involved.

## CRUDE OIL, FROM THE GROUND TO ITS DESTINATION

By Neil Cristo and Milan Rose

How does an oil company find oil, pump it from the ground and transport it to the refinery? You may recall images of black crude oil gushing from the ground or oil wells in movies or television shows like *Dallas*, *Armageddon* or the *Beverly Hillbillies*, but modern oil production is quite different from the Hollywood version.

### Crude Oil Extraction

The most common method of crude oil extraction is drilling. Geologists will first identify a section of land they believe has oil flowing beneath it using methods such as satellite imagery, gravity meters, and magnetometers. Once an oil company finds a steady stream of oil underground, drilling can begin.

While drilling is not an overly complicated process, a standard method provides maximum efficiency. Here's how it works:

1. Drilling a casing into the ground in the exact location where the oil is located, until a steady flow of oil can be identified.
2. Lowering a perforating gun into the casing. Its explosive charges will create holes in the casing for the oil to flow through.
3. Running a tube into the hole, allowing the oil and gas to flow up the well.
4. Sealing the tubing by running a device called a packer along the outside of the tube.
5. Placing a structure called a Christmas tree, which allows oil workers to control the flow of oil from the well.

## Oil Sands

Oil can also be extracted from oil sands, also known as tar sands. Oil sands typically consist of sand or clay mixed with water and a very viscous (thick) form of crude oil known as bitumen. Since bitumen is so heavy, oil sand extraction methods are quite different from drilling. Industry extracts bitumen through strip mining or a variety of other techniques that make the oil less viscous. These methods can be far more expensive than traditional drilling, which is why these are used widely only in Canada and Venezuela.

## Transportation

### Pipelines

The U.S. ships 70% of its crude oil and petroleum products by pipeline, 23% by tankers over water, and only 4% by truck and 3% by rail. In Canada, almost all (97%) natural gas and petroleum products are transported by pipelines (**Canadian Energy Pipeline Association**). Canadians use millions of gallons of crude oil each day to support their activities. While many forms of transportation move this product to storage hubs and refineries, statistics show that pipelines remain the safest, most efficient and economical way to move this natural resource.

### Rail

Before 2012, rail moved less than 6,000 carloads of fuel and crude oil per year. Since then, the amount of crude oil carried by rail has grown (as did the amount transported by pipeline) as new sources of production in Canada became available. By 2014, there was a marked increase in transportation of Canadian crude oil (in gallon-miles) by rail. This growth is primarily linked to the need to connect new oil fields with refineries in certain regions where pipelines either are not present or lack sufficient capacity.

### Road

Before the economic downturn in oil commodities, crude oil exploration and production was on the rise throughout Canada. Transporting crude can be challenging due to the remote locations of new drilling sites and the lack of pipeline capacity to meet demand. Consequently, dedicated fleets of crude-hauling trucks deliver crude oil from the well heads to pipeline terminals, refineries and rail yards for transloading and eventual distribution throughout the country.

Finally, regardless of the transportation mode used, the crude oil will reach its final destination, which could be a gas station, a car or a home heating system.

## PETROLEUM CRUDE OIL TRANSLOADING FACILITIES ON THE CANADIAN PRAIRIES

By Greg Sliva

Increased oil activity over the last decade has made petroleum crude oil transloading facilities more common and important for the transportation of petroleum products on the Canadian prairies. With pipelines operating near capacity, the many benefits of moving Western Canadian crude by train include: speed, flexibility, potential cost savings in treatment and/or diluent costs, product integrity during transport, and low capital cost requirements. Portable or fixed transloading facilities set up along rail lines make it easy for shippers to transfer petroleum crude oil from highway tanks to rail cars, which then bring it to refineries across North America.

Since bitumen extracted from oil sands is too thick to flow in a pipeline by itself, it must be blended with lighter hydrocarbons called condensates. As a result, condensate also arrives at some transloading facilities. To meet pipeline specifications, approximately one barrel of condensate is often mixed with three barrels of bitumen. The light condensate can be separated from the mixture at a refinery and then recycled in the energy system.

Recently, lower oil prices have changed the environmental landscape for the energy industry but, as always, Transport Canada's primary concern is safety. Transport Canada's inspection program actively monitors transloading facilities for compliance with the Transportation of Dangerous Goods (TDG) Regulations and holds them accountable for any incidences of non-compliance.

Two container standards apply to the transportation of petroleum crude oil by either rail tank cars or highway tanks.

**1) Transport Canada Publication TP14877–*Containers for the Transport of Dangerous Goods by Rail, a Transport Canada Standard*** applies to:

- the design, manufacture, maintenance and qualification of tank cars and ton containers; and
- the selection and use of containers for the handling, offering for transport, or transporting of dangerous goods by rail.

This standard also sets out the various pre-unloading, unloading and post-unloading requirements for the railcar.

**2) CAN/CSA B621-09** – *Selection and use of Highway, TC Portable Tanks, and other large containers for the transportation of dangerous goods, Class 3, 4, 5, 6.1, 8, and 9.* Shippers of petroleum crude oil must select highway tanks in accordance with CSA B621. For example, they may choose TC-406 Crude, TC-406, TC-407 and TC-412 tanks (or their 300 series equivalents). This standard also sets out the various pre-unloading, unloading and post-unloading requirements for the highway tank.

The safe transportation of dangerous goods depends on shippers selecting and using proper containers, as set out in the TDG Regulations. The key to proper selection and use of any highway tank car and/or railcar is proper classification and proper understanding of the dangerous goods both leaving and/or entering the means of containment.

Classification of petroleum crude oils presents many challenges because they are complex mixtures of many different compounds (mainly organic), which come from a wide range of different geological sources. For example, when raw petroleum crude oil first comes out of the ground, it is usually a mix of different chemical phases (gases, liquids, emulsions and/or solids).

While almost all transported petroleum crude oil is considered dangerous goods, some heavy oil transported by rail isn't hazardous enough to be regulated. In fact, when a small amount spills on a cold day, the operators can just "roll it up" as part of their clean-up operation.

Hundreds of smaller oilfield batteries dot the rural landscape in oil producing regions of Canada, and ensure the oil is "treated" to mainly remove both water and/or some of the flammable and toxic gases that naturally occur in raw petroleum crude. This oil is often delivered from a smaller central oilfield battery via highway tanks and transloaded onto railcars. Trucks may travel up to 97 kilometers one way to a battery and make several shipments per day to fill railcars.

In other cases, petroleum crude oil is delivered via pipeline from large batteries or tanks which blend crudes to achieve the higher volume and more consistent product the refining market wants and needs. The blended petroleum crude product is then transloaded onto as many as 15-25 railcars at one time, depending on the size of the facility. Larger facilities can easily handle up to two unit trains, with each one being composed of approximately 120 rail tank cars.

Transport Canada's inspections of petroleum crude oil transloading facilities on the Canadian prairies are very important because they provide a wealth of compliance information about two modes of transportation (both road and rail) and provide a better understanding of how industry classifies and addresses the subsidiary hazards of petroleum crude.





## Study Results

We surveyed members of the Crude Oil Logistics Committee (COLC) to gain first-hand information on their crude oil transportation processes. Survey responses and other research provided background information on crude oil operations in the study area (Table 1). In general, we found that typical service areas were within 160 km radius of rail stations. Not all facilities in western Canada engage with the rail network; many instead rely exclusively on pipeline networks.

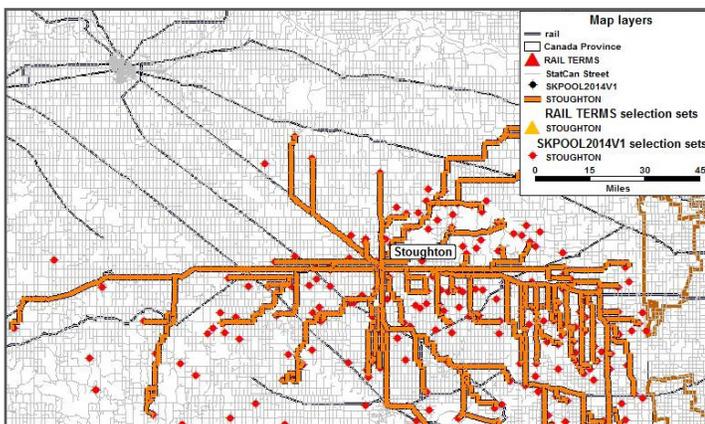
**Table 1. Background research on crude oil production and transportation in Western Canada**

Geographic Area	2014 daily crude oil production (BBLs per day)	Key production areas
Saskatchewan	3,239,253	Viking, Sparky, Bakken and Shaunavon
Alberta	2,690,000	Athabasca and Peace River, Swan Hills, Pekisko and Viking
Manitoba	47,000	Torquay and Amaranth oil formations; Daly Sinclair pools
British Columbia	21,000	Northeastern region of Maanish

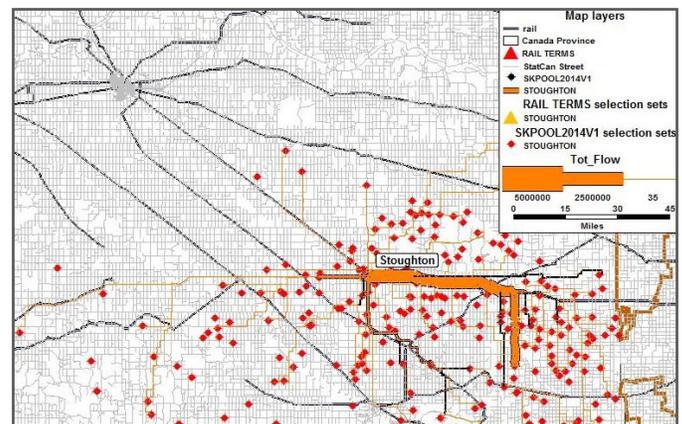
BBL: Oil barrel

## Route Maps and Crude Oil Commodity Flow

Finally, we produced maps showing the local service areas for 42 rail terminals. Each map indicates facilities where crude oil may be loaded on trucks and the routes they will likely use to get to the rail terminal (Fig. 2). The magnitude of road sections reflects the accumulated quantity of crude oil transported along the route (Fig. 3).



**Figure 2.** Crude oil transportation routes between facilities and rail terminal in Stoughton, SK.



**Figure 3.** Crude oil accumulated commodity flow between facilities and rail terminal in Stoughton, SK.

These results provide a preliminary survey into the logistical aspects of the crude oil supply chain in western Canada. This study is a foundational piece of the data-driven risk analysis process for dangerous goods transportation proposed by Safety Analytics.

# SHOULD PRODUCED WATER BE CLASSIFIED AS DANGEROUS GOODS?

By Julie Prescott

Oil and gas reservoirs have a natural layer of water called **formation water** below the hydrocarbons. For maximum oil recovery, producers often inject additional water into the reservoirs to help force the oil to the surface during crude oil extraction. Both formation and injected water, termed **produced water**, are eventually created along with the hydrocarbons as a *by-product of the extraction process*.

The extraction process for crude oil reservoirs can include three stages:

1. The crude oil flows naturally in primary recovery because the underground pressure present in the well pushes the oil up to the surface. When the crude oil needs a little help, producers pump it to the surface.
2. Over time, the underground pressure diminishes with the natural flow of the crude oil. In secondary recovery, producers augment the reservoir pressure to increase the flow of oil from the well. To do so, they inject water (or natural gas) into the well, driving the crude oil to the base of the well where it is pumped to the surface.
3. When extraction again becomes almost impossible, tertiary recovery begins. Producers inject more water, gas, steam and/or chemicals to improve the flow of crude oil. They only use this process when crude oil prices are high, as extraction becomes otherwise too expensive.

Industry treats produced water to remove as much oil and gas as possible. However, since the water may have been in contact with hydrocarbons for centuries, it has picked up some of their chemical characteristics. Its chemical composition varies widely depending on where and how it was formed. Major constituents are:

- Oil and grease, which can be found in different forms:
  - Free oil: larger droplets, readily removable using gravity methods;
  - Dispersed oil: smaller droplets, more difficult to remove; and
  - Dissolved oil: dissolved in the water stream, very hard to remove.

- Salt. Produced water is often saltier than seawater (which is why it is also called brine). Removing it is easy, but costly.
- Organic and inorganic toxic compounds introduced to improve the extraction process or leached from the rock formation.
- Naturally-occurring radioactive material (NORM), whose presence and concentration vary between wells.

Historically, produced water was disposed of in evaporation ponds, but this has become environmentally and socially unacceptable. Produced water is considered industrial waste and producers are expected to find beneficial re-uses for it. But before it can be transported to be reused, producers must determine whether or not produced water should be considered dangerous goods. Section 2.1 of the Transportation of Dangerous Goods (TDG) Regulations stipulates that any substance should be considered dangerous goods "when

- (a) It is listed by name in Schedule 1 and is in any form, state or concentration that meets the criteria of Part 2, Classification for inclusion in at least one of the 9 classes of dangerous goods; or
- (b) It is not listed by name in Schedule 1 but meets the criteria of Part 2, Classification for inclusion in at least one of the 9 classes of dangerous goods."

Since produced water is not listed by name in Schedule 1 of the TDG Regulations, producers should test it in accordance with the criteria found in Part 2 of the TDG Regulations. For obvious reasons, they can eliminate Classes 1, 2, 4, 5 and 7 as well as Division 6.2 from the process. Producers should test:

- (i) The produced water's boiling point and flash point against the criteria found in Section 2.19 of the TDG Regulations to see if it should be classified as Class 3, Flammable Liquids.
- (ii) The produced water's composition so they can check the LC<sub>50</sub> (lethal concentration) and LD<sub>50</sub> (lethal dose) values of its constituents against the criteria found in Section 2.29 of the TDG Regulations to see if it should be classified as Division 6.1, Toxic Substances.
- (iii) The skin corrosivity, and, if needed, corrosivity to metals, against the criteria found in Section 2.42 of the TDG Regulations to see if it should be classified as Class 8, Corrosives.

If the produced water meets none of the above criteria, the producer must determine if its constituents are marine pollutants as per subparagraph 2.43(b)(ii) of the TDG Regulations, and in large enough concentration, to see if they should classify the product as Class 9, Miscellaneous Products, Substances or Organisms under UN3082 Environmentally Hazardous Substance, Liquid, N.O.S..

More often than not, producers will find produced water to meet the criteria of Classes 3, 8 and/or 9. Once proper classification is established, it is the consignor's responsibility to follow the TDG Regulations to ensure the safe transport of the product from its origin to its destination.

# ALBERTA'S REGIONAL PERSPECTIVES ON CRUDE OIL

By John Harpin

Ever since they were first published in 1985, consignors have been challenged with the application of the Transportation of Dangerous Goods (TDG) Regulations when shipping petroleum crude oil. The Regulations worked well for consignors and carriers of refined, pure chemicals, or chemical mixtures with known chemical compositions and concentrations, because they did not have to perform rigorous classification procedures to ship the crude oil. Petroleum crude oil was designated as UN1267 and Packing Group II.

Some crude, made up of the lighter hydrocarbons such as those found in gasoline, can be extremely volatile and flammable. Crude oil may even contain dissolved gases such as propane and butane, making the resulting mixture even more difficult to classify, package or respond to in case of release. At the other end of the spectrum, the heavy oil found around Lloydminster and in the oil sands of Fort McMurray is generally more viscous and less flammable. It may sometimes not even meet the classification requirements of the TDG Regulations, unless it has been mixed with a diluent or heated above its flash point to allow it to flow more easily.

Before 1995, the predominant highway tank used for transporting crude oil in Alberta was a TC-306. Given the vast diversity of crude oil composition, classification changes and new tank standards have prompted industry to take a hard look at highway tank selection and use.

- Light crude oil, transported in a TC-306 or TC-306 Crude tank, can easily vapourize and vent into the atmosphere given the 3 psi maximum allowable working pressure.
- The 25-40 psi operating pressure of the TC-307 and TC-407 tanks allows a wide variety of crude oils to be moved without emitting volatile hydrocarbons or hydrogen sulphide ( $H_2S$ ) into the atmosphere.
- Although numbers of TC-307 and TC-407 tanks have gradually risen, the current selection and use standard still allows UN1267, Petroleum Crude Oil, Packing Group II, to be transported in a TC-306 or TC-406 tank, regardless of the inhalation toxicity hazard, as long as the tank markings and documents are appropriate.
- UN3494, Petroleum Sour Crude Oil, Flammable, Toxic, Packing Group II, requires the use of a TC-407 tank.

All crude oil contains some  $H_2S$  dissolved in the liquid, ranging from a few parts per million to a significant percentage. The classification UN3494 Petroleum Sour Crude Oil, Flammable, Toxic, Class 3(6.1) was created to identify the  $H_2S$  inhalation hazard presence in sour crude. This classification means that industry must consider the inhalation toxicity hazard of  $H_2S$  and not just the flammability of the crude oil when classifying, shipping, and, most importantly, when responding to any release.





The TDG Regulations include well-defined consignor and carrier responsibilities but work best when there is a consignor physically on-site to hand over the product to a carrier for transport. Much of Alberta's crude oil is directly loaded into highway tanks from well-head storage tanks located in rural or forestry areas with no consignor present. In the past, some consignors pre-printed documents, minus the quantities, for the carriers to complete at the site, but even this practice was replaced with carriers completing TDG shipping documents for consignors. Now, consignors generally rely on contracts that stipulate that the carriers will supply adequate documentation and placarding for all regulated shipments.

Section 3.6.1 (Consignor's Certification) of the TDG Regulations requires the consignor, or someone acting on the consignor's behalf, to identify themselves on the shipping document and to certify that the dangerous goods are being shipped in full compliance with the legislation. This means that the consignor must make sure that classification, documentation, dangerous goods safety marks, and compliance with tank standards are met before anything moves down the highway.

Over the years, especially after the tragic Lac-Mégantic train derailment, changes to the TDG Regulations have made it

mandatory for consignors to better classify their petroleum crude oils. Section 2.2.1 and Special Provision 92 of the TDG Regulations now require:

- Consignors to keep proof of classification by way of a lab report, test report, or an explanation of how the goods were classified.
- Oil producers to classify the crude according to specific locations of extraction, rather than using a generic classification to represent all their shipments. By doing this, they must take into account volatility, flammability, and toxicity variations.

First Responders should be aware of the issues surrounding crude oil classification, the possibility of improper classification, and the dangers associated with petroleum crude oil including, but not limited to, a change in flash point and the presence of vapours and/or H<sub>2</sub>S.

Insufficient pipeline capacity has recently increased rail transfers (transloading) of crude oil. As a result, this has duplicated the consignor responsibilities within the normal crude oil shipments from well-head to refinery/upgrader because it takes several truckloads of crude oil to fill a rail tank car. Unless all the oil is from the same well head, there is a possibility that the initial classification of the crude may no longer be valid when two or more loads are mixed together in the rail tank car or in a storage tank at the transloading facility. This activity requires the transloading company to take on the consignor responsibilities of classification, selection of the means of containment, dangerous goods safety marks, documentation, reporting, and Emergency Response Assistance Plans (ERAP) for all consolidated or blended shipments of crude oil by rail.

The shipping of petroleum crude oil by road in Alberta has changed a lot over the years. In many ways, it has been made safer through evolving regulations. For example, changes to placarding and documentation offer more accurate and immediate information to First Responders, allowing them to make better decisions.

Despite these improvements, industry advancements, technology, and economics continue to challenge legislators, regulators, and First Responders alike on how to best handle petroleum crude oil. The ever-shifting focus from road/pipeline transfers to the intricacies of road/rail movements of oil only highlights the fact that the challenges ahead will continue to evolve.

## INSPECTION PRIORITISATION AND CRUDE OIL

By Darren Jette

Industry compliance with the *Transportation of Dangerous Goods Act, 1992* and its Regulations helps promote public safety in the transportation of dangerous goods. While Transport Canada conducts thousands of general compliance inspections each year to foster industry compliance, we cannot conduct annual inspections of the tens of thousands of sites and facilities in Canada that handle, offer for transport, transport, or import dangerous goods, including crude oil facilities and transloading facilities. This is why the Transportation of Dangerous Goods (TDG) Directorate uses a risk-based approach to prioritise oversight activity, resulting in over 70% of inspections being at higher risk sites.

Each year, TDG reviews all the dangerous goods sites and facilities in its database and ranks them according to the risk they pose to the public, to the environment and to public infrastructure. TDG establishes this ranking by analysing a number of risk factors that help assess:

- The potential likelihood of an incident occurring; and
- The potential impact of an incident if it occurs.

Some site/facility related factors include:

- Its history and incident history;
- The classes of dangerous goods it handles;
- The mode(s) of transportation it uses; and
- The density of population surrounding it.

TDG also reviews its regional and national priorities quarterly, which means that emergency issues can affect its planned inspection activities.

One priority TDG has identified throughout this process is the need to inspect crude oil facilities and crude oil transloading facilities, where oil is transferred either from truck to train or from train to truck. This is why TDG has dedicated a portion of its resources specifically to inspecting these facilities and to studying the specific risks they may pose.

Managing risks and prioritising dangerous goods sites and facilities is a continuous process, because new risks may emerge, and current understanding of risks may change as TDG gathers and analyses new data. TDG strives to be responsive, adaptive and always improving how it prioritises its general compliance inspections to ensure that it inspects the sites and facilities that need it most.



# CRUDE OIL – ENFORCEMENT AT FACILITIES AND DURING TRANSPORT

By Charlie Pitts

A person that handles, offers for transport, transports, or imports dangerous goods, including petroleum crude oil, must comply with the *Transportation of Dangerous Goods Act, 1992*, and the *Transportation of Dangerous Goods Regulations*. Dangerous goods inspectors assess compliance during onsite inspections.

Transport Canada's Transportation of Dangerous Goods (TDG) Directorate can take enforcement actions that range from notices of infraction to prosecution in order to address the issues they discover while inspecting crude oil transportation sites. However, we can sometimes face challenges in our oversight of crude oil dangerous goods function.

## Enforcement Challenges

Identifying all transloading facilities is a difficult task, since they are not all fixed locations. Some are temporary installations known as portable transloading facilities. Since the movement of crude oil is greatly affected by the market price as well as supply and demand, operations at some facilities can begin or stop at a moment's notice.

Another enforcement challenge is that sampling and testing crude oil to ensure proper classification requires specialized training and equipment. Furthermore, the different viscosities of the crude oil products sometimes limit the quantity of samples inspectors can take or the way they can test the samples.

## Action Taken to Properly Classify Crude Oil

Correctly classifying crude oil is important, as it determines the proper means of containment (MOC) the shipper must use during transport. The TDG Directorate has conducted two crude oil sampling campaigns since December 2014. The goals were to:

- Make sure the crude oil we sampled had been properly classified; and
- Assess any potential dangers such as the level of hydrogen sulfide, an asphyxiating gas.

The TDG Directorate conducted the first sampling campaign from December of 2014 to May 2015 with help from Alberta Innovates - Technology Futures (AITF). During this campaign, we gathered 68 samples of crude oil for analysis and shared the results with each research participant in August of 2015. The results indicated that 56 out of the 68 samples required an MOC tested for Packing Group I, the highest hazard group.

TDG conducted the second campaign with AITF from October to December of 2015. TDG gathered 10 samples from transloading sites and conducted full compliance inspections. These sites were selected because they were transloading a less dense crude oil that could be sampled under pressure (less dense or light crude has been shown to contain more volatile hydrocarbons than heavier or denser crude oil). Transport Canada has informed these sites of their individual results, and they have corrected any identified non-compliance.

## Coming Soon: An Oilfield Compliance Strategy

The TDG Directorate is currently developing an Oilfield Compliance Strategy to set out guiding principles and mechanisms to ensure the safe transportation of oilfield production fluids throughout Canada. This strategy aims to help the TDG Directorate:

- Identify primary oilfield producers;
- Develop safety awareness within the industry; and
- Conduct inspections at field locations.

This strategy will help TDG identify the level of risk associated with the handling, offering for transport, and transporting of crude oil.

## CRUDE OIL – IMPACT ON SHIPPING DOCUMENT, SELECTION OF A MEANS OF CONTAINMENT AND DANGEROUS GOODS SAFETY MARKS

By Roberto Bruni

Transportation by road accounts for over 60% of dangerous goods being transported. Rail is another preferred mode of transport because it allows the delivery of dangerous goods to locations with no easy access by road or pipeline.

Canada regulates the transportation of dangerous goods through the Transportation of Dangerous Goods (TDG) Regulations, which contain 16 Parts and 3 Schedules.

Dangerous goods must:

- Be classified, as set out in Part 2;
- Be transported with a shipping document, as set out in Part 3;
- Display all the appropriate dangerous goods safety marks, as set out in Part 4; and
- Be transported in an appropriate means of containment (MOC), as set out in Part 5.

The proper classification of dangerous goods is the most important step when deciding to transport. A mistake could result in selecting the wrong means of containment, using improper dangerous goods safety marks and producing an inaccurate shipping document. It could also affect public safety and First Responders' choice of response methods.

Schedule 1 of the TDG Regulations includes two shipping names for crude oil, based on classification testing results:

- UN1267, Petroleum Crude Oil (Class 3)
- UN3494, Petroleum Crude Oil, Flammable, Toxic (Class 3, Subsidiary Class 6.1).

## Selecting the Appropriate MOC

Once the classification is determined, it is very important to select the shipping name and packing group that **best describe the product**.

This will:

- Determine which MOC to use if the dangerous goods are being transported by highway tank or tank car; and
- Ensure that the MOC is compatible with the dangerous goods being transported and that there will be no release of dangerous goods under normal conditions of transport.

For example, a corrosive liquid should not be transported in a plastic drum. The dangerous goods could damage the drum and cause an accidental release.

## Highway Tank

In order to select the appropriate highway tank for the transportation of UN1267 and UN3494, the "CSA<sup>1</sup> B621-09 – Selection and use of highway tanks, TC portable tanks, and other large containers for the transportation of dangerous goods, Classes 3, 4, 5, 6.1, 8, and 9" standard must be used, as per the Table of Standards found in Section 1.3.1 of the TDG Regulations.

The table below indicates the type of highway tank to use when transporting UN1267 and UN3494 by road.

UN#	Class	PG	TC306 MC306	TC406 Crude	TC406	TC407	TC412	TC331
UN1267	3	I				• <sup>1</sup>	• <sup>1</sup>	• <sup>1</sup>
		II	• <sup>2</sup>	•	•	•	•	•
		III	• <sup>2</sup>	•	•	•	•	•
UN3494	3 (6.1)	I				• <sup>3</sup>	• <sup>3</sup>	• <sup>3</sup>
		II				• <sup>1</sup>	• <sup>1</sup>	• <sup>1</sup>
		III			•	•	•	•

1. Maximum allowable working pressure (MAWP) of at least 172 kPa (25 psi).
2. Meets the requirements of clause A.8 of standard CSA B620-09.
3. MAWP of at least 276 kPa (40 psi). Tanks must not have bottom discharge outlets and must be insulated.

## Rail Tank Car

When transporting UN1267 or UN3494 by rail, the "TP14877 – Containers for Transport of Dangerous Goods by Rail, a Transport Canada Standard" must be used to select the appropriate tank car. The table below indicates the type of tank car that must be used when transporting UN1267 or UN3494.

UN#	Class	PG	105	111	112	115	120	AAR211
UN1267	3	I	•	•	•	•	•	
		II	•	•	•	•	•	
		III	•	•	•	•	•	•
UN3494	3 (6.1)	I(*)	•	•	•	•	•	
		II	•	•	•	•	•	
		III	•	•	•	•	•	

(\*): Clause 10.5.1.2 of the TP14877 Standard may apply and as a result, the selection of MOC may change.

<sup>1</sup> CSA: Canadian Standard Association

In May 2015, the TDG Regulations were amended to incorporate the new tank car design TC-117 for the transport of flammable liquids.

## Dangerous Goods Safety Marks

Once the appropriate MOC has been selected, Part 4 of the TDG Regulations sets out the requirements for dangerous goods safety marks to be displayed.

As a general rule, the primary class placard for each dangerous goods contained in a large means of containment must be displayed, on each side and on each end. Therefore, if transporting UN1267 Petroleum Crude Oil or UN3494 Petroleum Sour Crude Oil, Flammable, Toxic, in a highway tank or a tank car, you must display a Class 3 placard.

You must also display a UN number within a white rectangle on the primary class placard (Class 3) or on an orange panel placed next to the primary class placard, since in this case, the dangerous good is a liquid in direct contact with the large means of containment.

You do not need to display the subsidiary class placard for UN1267 since this product doesn't have any subsidiary class and it does not meet Section 4.15.1 - Subsidiary Class Placards on a Large Means of Containment requirements of the TDG Regulations. However, for UN3494 (which does have a subsidiary class), you must display a subsidiary class placard if you determine that the product meet all the requirements of Section 4.15.1 of the TDG Regulations.

### Table of the Dangerous Goods Safety Marks to display on a Highway Tank or a Tank Car

Requirements	UN1267, PETROLEUM CRUDE OIL	UN3494, PETROLEUM SOUR CRUDE OIL, FLAMMABLE, TOXIC
Primary class placards and UN number	Class 3 placards and UN1267 	Class 3 placards and UN3494 
Subsidiary class placards	None	Class 6.1 placards if requirements of Section 4.15.1 are met. 

## Shipping Document

In order to transport dangerous goods, the consignor (shipper) must prepare a shipping document in accordance with Sections 3.5 and 3.6 of the TDG Regulations.

The shipping document requirements for UN1267 or UN3494 are the same. However, if UN1267 contains hydrogen sulphide in sufficient concentration that vapours released from the crude oil can present an inhalation hazard, you must include the words "toxic by inhalation" or "toxic — inhalation hazard" on the shipping document, immediately after the description required under Paragraph 3.5(1)(c) of Part 3 (Documentation).

It is essential to meet the requirements of the TDG Regulations to ensure public safety. Transport Canada is always working to increase the safe transportation of dangerous goods.

For the latest news or for more information about the transportation of dangerous goods, please visit our web site at <http://www.tc.gc.ca/eng/tdg/safety-menu.htm>.

# CRUDE OIL – REQUIRED TRAINING

By Alexandre Caron

Complying with the *Transportation of Dangerous Goods Act, 1992* and its Regulations includes ensuring that everyone who handles, offers for transport or transports dangerous goods receives proper training, as detailed in Part 6 of the Transportation of Dangerous Goods (TDG) Regulations. Employers are responsible for the adequate training of their employees to ensure their safety, the safety of the public, and environmental protection.

The results of the current crude oil research:

- Highlighted the importance of ensuring the safe handling of crude oil. In August 2015, Transport Canada published a Safety Advisory to raise awareness toward crude oil's complex mixture, mostly hydrocarbons, which can vary greatly and pose different hazards.
- Determined that the presence of H<sub>2</sub>S concentration in the vapour phase of crude oil was higher than expected, therefore increasing the danger to those handling crude oil.

## Adequate Training

This term describes the sound knowledge people gain on aspects such as classification, dangerous goods safety marks, emergency response assistance plans and shipping documents relating directly to their duties and to the dangerous goods they are expected to handle. While training methods are not described in the regulations, proper training content and duration will increase the knowledge and skills of employees performing a **specific job** when handling dangerous goods. Adequate training may include a combination of formal in-class training, on-the-job training, and work experience. It is up to the employer to decide the type of training required for each employee.

Hazards can exist due to the nature of a task, the location where it is being performed, and the equipment or material involved. This is why the responsibility rests on the employer to provide adequate training to employees, to ensure they have the knowledge and skills needed to handle dangerous goods. It should be noted that employees who are not trained

can still handle, offer for transport, and transport dangerous goods as long as they are under the direct supervision of a trained person.

## Employer's Responsibilities

Along with ensuring that employees are adequately trained, the employer is responsible for issuing training certificates. A training certificate must indicate:

- The aspects of handling, offering for transport or transporting of dangerous goods the employee is trained to perform;
- The employer's name and business address;
- The employee's name;
- The training certificate's expiry date; and
- Both the employer's and employee's signature

The employer must also:

- Keep a record of an employee's training or a statement of experience, as well as a copy of the training certificate, for up to two years after the certificate's expiry date;
- Produce evidence of training (such as a copy of the training certificate or record of training) to an inspector within 15 days of receiving a written request.

**Note:** Self-employed persons must issue themselves a training certificate once they judge they are adequately trained.

## Employee's Responsibilities

Although the TDG Regulations do not directly address the employee's responsibilities with respect to Part 6, Training, it is important to note that:

- Because employees often directly handle or transport dangerous goods, it is important they make sure to receive sufficient training before they handle and / or transport dangerous goods.
- Employees are responsible for immediately providing evidence of their training certificate upon request from a designated TDG Inspector. Since the regulations do not specify the format, an electronic copy of their training certificate would be acceptable, as long as it is presented immediately when requested.

## Training Certificate Validity

Most crude oil is transported across Canada by road and railway. Training certificates for these modes of transportation expire 36 months after the issuance date. However, employees may need additional training if regulatory changes that apply to their duties occur before their training certificate expires.

Since handling and transporting crude oil can be dangerous for all workers involved, from engineers to transport drivers, regular and adequate training should be part of a learning

curriculum for each of these category of workers. Preventing incidents and protecting workers, the public and the environment depend on recognizing the potential hazards in the workplace, especially when it involves such dangerous goods as crude oil.

## NEW TC-117 TANK CAR FOR FLAMMABLE LIQUIDS

By Shaun Singh and Stéphane Garneau

On May 1, 2015, the Transportation of Dangerous Goods (TDG) Regulations were amended to incorporate the new tank car TC-117, the next generation of general service tank car that will replace the TC/DOT-111 in the transport of flammable liquids.

The TC-117 was developed by Transport Canada in collaboration with the U.S. Department of Transportation (DOT) and in consultation with industry stakeholders. It offers enhancements over the TC/DOT-111 to reduce risks created by a spectacular surge in the transport of crude oil by rail in North America. These improvements also address Transportation Safety Board (TSB) and U.S. National Transportation Safety Board (NTSB) recommendations related to perceived deficiencies of TC/DOT-111 tank cars in recent flammable liquids incidents, chiefly ethanol and crude oil, including the tragedy in Lac-Mégantic in 2013.

As tank cars of crude oil are increasingly transported in unit trains (trains made of cars transporting crude oil to a single destination), or very large cuts of tank cars carrying crude oil in a consist or mixed train, we observed a worrisome trend in recent derailments. The number of tank cars carrying flammable liquids breached in the incident itself is often much smaller than the number of cars breached by thermal tears in the ensuing fire. This is a consequence of a pile-up of cars that all contain flammable liquids. The burning liquids heat up the contents of the surrounding tank cars, the pressure relief devices activate and provide more fuel to the fire until some tank cars start rupturing by thermal tears, in which the top of the cars rupture in a plastic way that creates a fairly large longitudinal opening. Thermal tearing is not the worst mode of rupture, as it projects a jet of burning liquid in the least dangerous direction – upwards – but no solid parts of the tank car. In contrast, explosions or Boiling Liquid Expanding Vapour Explosions (BLEVE) project tank car parts, burning liquids and gases in a radial fashion.

The TSB, the NTSB, the DOT Federal Railroad Administration (FRA) and Transport Canada have not identified any case of explosion or BLEVE of tank cars transporting crude oil; thermal tears were the only kind of rupture from an incident found after all mechanical damage to the tanks settled. That being said, preventing these thermal ruptures is of the utmost importance to reduce the duration and impact of derailments involving a large number of tank cars containing flammable liquids.

This is why the TC-117 tank car has a thermal protection system that ensures survivability of the tank car for at least 100 minutes within a pool fire and at least 30 minutes from a torch fire. The thermal protection usually takes the form of a 13 to 16 mm (0.5in. to 0.65in.) thick, heat-resistant, insulating blanket covered by a weather-tight steel jacket. The top fittings, including the pressure relief device, which plays a crucial role in the survivability of the tank car, must be within a protective housing that provides a level of protection consistent with the Association of American Railroads (AAR) circular CPC-1232<sup>2</sup>.

Bottom outlets must be designed to prevent accidental opening during a derailment. The TSB and NTSB found the big 10 cm (4in.) bottom-operated straight-through ball valves, which have become standard equipment for bottom outlets on flammable liquid tank cars, to have a tendency to open when derailment forces impact on the valve's handle. Design fixes were made and are mandatory on TC-117 tank cars.

To improve puncture resistance, the TC-117 tank car must be constructed of AAR TC-128 Grade B material in the normalized condition. (For carbon steel, this material specification and the requirement for normalized heat treatment are recognized as providing better toughness and ductility.) The minimum thickness of the shell and heads may be no less than 14.3 mm (9/16 in.), which is 3.2 mm (1/8 in.) thicker than the minimum for TC/DOT-111. The tank is further protected by the mandatory jacket of at least 3 mm (11 gauge) steel sheet that is part of the thermal protection system. The tank ends must also use a head-puncture resistance system, which may be achieved by using full-height head shields of 12.7 mm (1/2 in.) thickness made of steel with a tensile strength of at least 380 MPa (55 ksi). Tank car designs may use alternative materials of construction, but must satisfy head- and side-impact performance standards and would be designated as TC-117P.

TC/DOT-111 tank cars manufactured before October 1, 2015 may be retrofitted for continued use in flammable liquid service. Designated as TC-117R, these cars must be retrofitted with the jacket, thermal protection system, tank head puncture resistance system and bottom outlet as specified for the TC-117. The steel specifications and thicknesses permitted at the time of construction are acceptable for the TC-117R specification.

<sup>2</sup> Requirements for Cars Built for the Transportation of Packing Group I and II Materials with the Proper Shipping Names "Petroleum Crude Oil", "Alcohols, n.o.s." and "Ethanol and Gasoline Mixture", AAR Casualty Prevention Circular No. 1232, August 31, 2011

The TC-117R must incorporate top-fittings protection to a standard specifically engineered for legacy tank cars. This entails the installation of a protective housing around the service equipment fitted on the manway plate. This top-fittings protection standard became mandatory for the TC-117R on June 6, 2016, following the issuance of Protective Direction 37 by the Minister of Transport. These requirements are consistent with those implemented in the United States under the Fixing America's Surface Transportation (FAST) Act signed into law by the US President on December 4, 2015.

The TC-117 is harmonized with the new U.S. requirements under 49 CFR for the DOT-117, meaning that the DOT-117, DOT-117P and DOT-117R are equivalent to the TC-117, TC-117P and TC-117R, respectively.

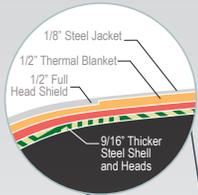
As of October 1, 2015, the TC-117 has become the sole general service tank car permitted for new tank cars built for flammable liquids service, while existing TC/DOT-111 tank cars will be progressively phased-out. The phase-out schedule is based on the type of flammable liquid and the safety features already present on the un-modified tank car. In general, if the tank car is equipped with a jacket and if the tank car is in compliance with respect to the CPC-1232 industry standard, the compliance date is pushed later.

Cut-off Date	Flammable Liquid / Packing Group	TC/DOT-111 removed from Service
May 1, 2017	Crude Oil PG I, II and III	non-CPC-1232, non-jacketed
March 1, 2018	Crude Oil PG I, II and III	non-CPC-1232, jacketed
April 1, 2020	Crude Oil PG I, II, III	CPC-1232, non-jacketed
May 1, 2023	Ethanol PG II	non-CPC-1232, non-jacketed non-CPC-1232, jacketed
July 1, 2023	Ethanol PG II	CPC-1232, non-jacketed
May 1, 2025	Crude Oil and Ethanol PG I, II, III	CPC-1232, jacketed*
May 1, 2025	All other Flammable Liquids, PG I, II, III	non-CPC-1232, non-jacketed non-CPC-1232, jacketed CPC-1232, non-jacketed CPC-1232, jacketed*

\*: most jacketed CPC-1232 tank cars will meet the requirements of the TC-117R specification with very minor changes, if any.

# ENHANCED SAFETY FEATURES

The updated standard includes several enhanced safety features to protect communities along Canada's railways.



The TC-117 tank car is required to be constructed as a thermally protected, jacketed tank car with steel that is 9/16<sup>th</sup> of an inch thick and full head shields. A jacket will be added as an outer cover on the exterior of the shell to keep insulation in place and provide additional strength and reinforcement. These features provide improved puncture resistance, structural strength and fracture resistance.

Mandatory top fitting protection will cover the valves on top of the tank car, guarding against damage in the event of an incident.

Full head shields will help protect the ends of the tank car from being punctured by equipment or collisions with adjacent rail cars in the event of excessive end impact or derailment. Previous standards of the class 111 tank cars did not require head shields in most cases.



Thermal protection increases the survivability of tank cars in the event of a fire. The thermal protection required for the TC-117 must be able to withstand exposure to a 100-minute pool fire and a 30-minute jet fuel fire without rupturing.

An enhanced bottom outlet valve must remain closed and not leak during an incident.

1/2" Thick Full Height Head Shield

**Note:** After May 2017, there will no longer be reciprocity for 49 CFR selection requirements for crude oil and ethanol tank car shipments originating in the United States, whether destined for Canada or transiting through Canada. For all other flammable liquids, the reciprocity will end on May 1, 2025.

For more information, contact TDG Engineering Services at [tdgmoc-tmdcontenants@tc.gc.ca](mailto:tdgmoc-tmdcontenants@tc.gc.ca).

Did you know that Transport Canada issued three protective directions this year?  
To consult the list of issued protective directions, please consult our website:  
<http://www.tc.gc.ca/eng/tdg/safety-menu-1272.html>.