Portland Propane Terminal (Part 2)

Risk Assessment

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Northwest Citizen Science Initiative

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(Part 2) Risk Assessment

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Northwest Citizen Science Initiative*

April 5, 2015

ABSTRACT

Pembina's proposed propane terminal would not be a simple addition to Portland's marine industrial scene. Its miniscule number of jobs and relatively small tax payments would not begin to compensate the loss of land values, loss of railway and river capacity, and regional job loss. Therefore it would not in itself represent any kind of economic nirvana.

The terminal would, however, forever change Portland's character, and would represent a radical move away from a focus on sustainable living in a city that values ecological citizenship and receives awards for its aspiration to be green.

Opening Portland's door to propane would replace Portland's ecological aspirations with a myopic focus on fossil fuels that in their spread of unsustainability would lock down our rivers and our transportation systems. It could spread tank farms across all of T-6 and West Hayden Island, and in the process destroy our recreational areas, and cover what remains in a pall of concrete dust and diesel fumes. They would likely be cut off in mid-stream, when railways and governments finally realize that there is no way to safely transport oil and gas in mass quantities by rail, and it will no longer be done. Better to realize now what we would lose, rather than later-on when it would be too late.

This second part of the previously published NWCSI White Paper, "Portland Propane Terminal" looks more deeply into these issues and topics introduced in part one of this on-going research study and analysis.

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Deer Park, Texas, situated on the Houston Ship Canal.
239 tanks, 536-million gallons.
Annually: 770 ships, 3,700 barges, 12,000 rail tank cars, 33,600 tank trucks, pipelines.
This broke first soil 44 years ago; 13% average annual growth rate since then.

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typically be followed by a vapor cloud explosion, fireball, thermal radiation, and blast wave.

Hot BLEVE: Prolonged heating (usually fire) bursts a propane tank, resulting in flash boiling and sudden ejection of contents as a vapor cloud, usually followed by a vapor cloud explosion, fireball, thermal radiation, blast wave, and tank fragments (shrapnel) propelled at high speeds (up to 400 mph) in all directions for miles.

- **Rail Safety Risks: (page 16)**

  Rail tank cars are far from safe despite claims by Pembina, the manufacturers, fossil fuel associations, and railway associations. Many design flaws have been identified in the DOT-111, and even in the highly vaunted DOT-112J "safe" pressurized container for propane. The safety of these tanker cars is discussed in the context of numerous accident reports, all cited and referenced for further review.

- **The Big Risks: Earthquakes & Terrorist Attacks: (page 26)**

  The Big Risks: Earthquakes & Terrorism. The big expected Cascadian Subduction Fault earthquake will affect all of Portland, as would a concerted terrorist attack on large propane storage facilities attractively placed 2 miles from high density housing areas and critical infrastructure in Portland and Vancouver. Both of these risks could cause a highly destructive effect on the large refrigerated propane storage tanks, with the potential for secondary effects in onsite pressurized storage. The main difference between these two big risks is that the proposed propane facility would add even more devastation to the already massive destruction of the predicted big magnitude 9.0+ earthquake (magnitude 9, also written as M9.0, is 1,000 times the energy of M7.0) across most of Portland and Vancouver. According to every agency of first responders to North Portland, Hayden Island, and Downtown Vancouver, emergency response teams are quite unprepared in training and equipment and plan for the potential magnitude of injury in either case. However, while we don't have a choice about earthquakes, we can choose not to subject ourselves to the potential disastrous effects of propane storage in, and transportation through and out of, Portland and Vancouver.

- **TNT-Propane Blast Equivalence: (page 36)**

  Propane trains and tanks have often been likened to bombs. The fact of such a comparison, known as the blast equivalence between trinitrotoluene (TNT) and propane, has long been established as a result of large-scale tests. TNT-propane blast equivalence is 20 kilotons of TNT (1 atom bomb) = 10M US gallons of liquid propane. Eventually the amount of stored liquid propane at T-6 is likely to reach 90-million gallons.

- **UK HSE Tolerability Criteria vs. US Tort law, Rest. (2d) §520: (page 41)**

  UK HSE Tolerability Criteria vs. US Tort law, Rest. (2d) §520.

Portland Propane Terminal Risk Assessment

A Critique of the Pembina QRA

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Abstract

The Pembina propane terminal quantitative risk assessment (QRA) was developed by DNV, a Norwegian petroleum industry research company that specializes in assembling selective reports suitable to its clients. We are going to be very direct. If Pembina's QRA were an accurate and objective representation of all costs and benefits of such proposed projects, then communities would be competing for oil and gas terminals for their ports. However, the many canceled or rejected projects in Long Beach, Longview, Searsport, Guilford, and many other communities, are a testament to the due diligence done by these cities' leaders to look beyond the illusion of "free" petrochemical wealth-for-the-taking. In rejecting fossil fuel terminals, these individuals have adopted a more sustainable vision of prosperity and safety of their communities.

The word "rail" appears in Pembina's QRA an impressive 289 times, yet the rail safety risk discussion excludes all rail transport except on-site at the propane terminal offloading station. On page 13 of the QRA: "Risk related to railcar transit outside the terminal, carrier transit, and the collisions to a carrier or the dock are not part of the current QRA scope. Note that these excluded hazards are evaluated in separate studies." Where are these separate studies, and would they extend the scope? Without these studies the QRA is incomplete, and its conclusions invalid.

The bottom line is that Pembina, a pipeline company, has stated that they are not responsible for the safety of the "rail pipeline." However, the risk to our communities is from the entire "transportation pipeline," not just the terminal. If they were to take full responsibility for the entire chain starting with fracking gas from the ground to arrival at its overseas destination, the business would not be profitable. Shirking responsibility for the transportation does not meet the required legal or expected moral level of stewardship. The US common carrier law was not created for foreign companies to take advantage of for the benefit of their shareholders. No responsibility taken should mean no-project.

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Pembina Quantitative Risk Aanalysis (QRA)

a) The significant risk of rail transportation outside the terminal is excluded, making the QRA invalid. Where are the promised separate studies? *Their absence makes the QRA invalid.*

b) The large risk of terrorist attacks on gas facilities near cities is excluded. Prominent security experts say this is the number 1 risk. *Therefore the QRA is invalid*.

c) The word "domino" appears exactly zero times in the QRA, and even though the word "escalation" occurs 15 times, we have to assume that the QRA does not mean "domino escalation" because "escalation" does not have the same specialized industry technical meaning, and cannot legitimately be used as a synonym for domino effects.

"Escalation" means simply an increase or intensification, with nothing causal implied.

"Domino escalation", on the other hand, expresses or indicates a causal process that, proceeds exponentially at a rate that depends on the dynamic amplification factor, until it becomes resource limited.

Thus we note that "domino escalation" is a well-defined and meaningful (if not complex) industry technical term, whereas "escalation" by itself is not. The petrochemical industry standard reference book[1] on Domino effects says "Nowadays, no risk assessment can be considered complete without including the analysis of domino effect" and goes on to conclude that any propane terminal safety analysis that does not take account of domino escalation effects is faulty. When asked a question about domino effects at the March 15, 2015 PSC meeting, Pembina expressed an unwillingness to include Domino effects because they are non-linear, and because the modeling of non-linear effects would make the risks difficult to calculate. We believe that the standard industry software for calculating domino effects (such as Domiffect) may give too pessimistic a view of accidents for Pembina to want to use it or share the results. Nevertheless, without these calculations, and application of standard industry knowledge of Domino effects, the QRA is incomplete, arguably faulty, and should be rejected!

[1] *Domino Effects in the Process Industries: Modeling, Prevention and Managing*. Ed. by Genserik Reniers, Valerio Cozzani. 2013. Elsevier B.V., Amsterdam. www.elsevier.com

d) Pembina is a pipeline company, yet has stated that they are not responsible for the safety of the "rail pipeline." This does not recognize that the risk to our communities is from the entire "transportation pipeline," not just the offloading gate at the Portland terminal. If they were to take full responsibility for the entire chain from gas in the ground to its overseas destination, the business would not be profitable. Whatever it takes; if lack of profitability means that bulk propane stays out of Portland, then Portland and all of the communities along the rail lines, and along the Columbia river would be safer, cleaner, greener, and ultimately better off. Shirking responsibility for the transportation does not meet the required legal or expected moral level of stewardship. The US common carrier law is not something for a foreign company to take advantage of, for the advantage of their shareholders. No responsibility taken should mean no project. Rail risk is excluded, therefore the QRA is invalid. Pembina's proposal is likewise invalidated by their position on offsite transportation liability.

e) The QRA presents Pembina's findings of risk for "normal operation" (their words). It is actually abnormal operation and problems that are more the risk issue, whether related to equipment failure, human error, or criminal acts. *Therefore the QRA is invalid.*

f) The Pembina blast zones so seriously understate the EPA threat zones that something is wrong with Pembina's calculations, not to mention they are out-of-sync-with-the-US-public philosophical approach. Pembina is too willing to place the US public at risk. Figs. 4-1, and 4-2 (QRA pp. 8-9) show Pembina's maps of the EPA's worst case release scenario, showing 1 psi overpressure, and 10,000 & 20,000 ppm propane vapor contours. These worst-case EPA scenarios are not a "game" to see how the blast look overlaid on houses and communities. Rather, the EPA's intent is to help companies determine how to place a gas tank far enough away from communities to prevent worst case scenarios from causing serious problems, no matter how small the theoretical frequency. Pembina officials have too often denigrated the EPA's requirement to show a worst-case containment loss by saying that it is virtually impossible, and "it ain't going to happen." Indeed, the penultimate sentence of the QRA says, "The two worst cases … are IMPOSSIBLE …" (their emphasis). We need to be deeply distrustful of anyone who claims to be scientific, yet is willing to shout the word "impossible" for a scenario that can be approximated by a number of scenarios that the QRA excludes. *For these reasons, the QRA is invalid and should be rejected*.

g) Pembina's statement in the QRA, "Since there are not requirements for individual and societal risk criteria in the US, the UK HSE risk tolerability criteria for individual and societal risk are presented for the project" is a false claim due to the existence in US Tort law of Rest. (2d) §520. Furthermore, the QRA does not take into account that Portland has its own views on tolerability of risk, views which were expressed to Pembina at the March 17, 2015 PSC meeting by Susan Anderson, Director of Portland's Bureau of Planning and Sustainability, yet are not recognized in Pembina's final QRA. The UK

HSE tolerability criteria were not designed for Portland, and have not been adopted by the US. For Pembina to tell us that this criteria is widely accepted in the marine industry, is irrelevant, and moreover, because it is not a quantitative statement, it has no place in a *quantitative* assessment such as Pembina's QRA. Nor has a marine industry statement any relevance in assessing a risk for individual Portland residents, who (apart from floating homes in the T-6 blast area) mostly live on land. (See the UK HSE Tolerability Criteria / US Rest. (2d) §520 section for a more detailed discussion). Since the UK HSE tolerability is a major tenet of the QRA, and for the above reasons, the QRA is invalid and should be rejected.

h) The QRA neglects to state the size (US gallons) of the new vertical pressure storage vessel design shown, yet still shows illustrations of the eight horizontal 125,000 gallon bullet transfer tanks. Nor does it justify the change or explain the discrepancy. By not stating the tank volume, and by not describing the tank configuration, we have no way to check their calculations. *These major omissions invalidate the QRA*.

i) Where is the Environmental Impact Report/Statement (EIS/EIR)? The Port of Long Beach (POLB) LNG import terminal EIS/EIR was almost 1,000 pages long. The omission and probable non-existence of these documents makes the whole project unacceptable, and therefore invalid.

j) The problem with the QRA's theoretical shrapnel physics is that actual experiments performed by the National Propane Gas Association found that hot BLEVE shrapnel extends out to 30x the fireball radius. This indicates that the 4x and 15x graphs and green curves in Fig. IV-4 of the QRA are invalid, and suggests the physics used in the construction of these curves is faulty, which also casts a cloud over other physics in the QRA. The unwillingness of Pembina to ignore the wealth of actual experimental results and accident data gained by fire researchers over the past fifty years creates much concern and suggests that all of the physics models used in the QRA low-balls negative results and high-balls positive results, in Pembina's favor, whether it be blast radii, shrapnel trajectories, etc. This should be sufficient to reject the entire QRA.

The Akana Independent Review:

k) The Planning Bureau's independent QRA consultant, Clackamas-based Akana "reviewed propane spills or releases over the last five years at nine comparable domestic propane terminals. There were no releases at seven of the terminals, and releases at the other two terminals did not seem to raise any cautionary red flags." Overall, Akana said the Norwegian company's report was fair, and in conclusion said, "The Pembina Portland Propane Terminal QRA is generally a thorough and realistic evaluation of the potential

risks and consequences that can be expected due to the operation of the proposed terminal." Was Akana very impressed by the volume of numbers and the essentially zero risk? That Akana said the QRA was "fair" (a highly ambiguous term), without making any mention of the missing promised appendices of risk factors (such as rail safety outside 50 feet of offloading rack at T-6), and the omission of certain other important risk factors (including terrorist attacks), makes their finding appear largely a non-event, and in our view should not be taken seriously by the PSC.

Word Frequencies Appearing in Pembina's Quantitative Risk Analysis (QRA)

The QRA key word frequencies appear to emphasize some issues of local concern that later are not sufficiently addressed, while other areas of local concern are not addressed at all. The following tabulation of terms indicates these disparities.
[*Note:* (x) *indicates terms that we consider appear too infrequently for this QRA to be valid*]:

Liability	0	(x)	
Promise	0	(x)	
Guarantee	0	(x)	
Responsible	0	(x)	
Responsibility	0	(x)	
Terrorist	0	(x)	
Criminal	0	(x)	
Domino	0	(x)	
Deflagration	0	(x)	
First Responders	0	(x)	
LEL	0	(x)	
Detonation	2	(x)	
Security	7	(x)	
Blast	8	(x)	
Emergency	10	(x)	
Escalation	15		
VCE	18		
Vapor cloud	27		
Jet fire	42		
Safety	43	(x)	
Flash Fire	51		
Pool fire	53		
Overpressure	59	(x)	
Accident	75	(x)	
BLEVE	79		
LFL	92		
Ignition	128		
Rupture	149		
Rail	289		
US	0	(x)	
USA	7	(x)	
UK	66		
Pembina	134		
IMPOSSIBLE	2		(Pembina's capitalization = shouting)
Cost	3		

Disclaimer: The above comments regarding the Pembina QRA comments are based on a cursory reading of the QRA, received just four days before the April 7th 2015 PSC meeting. Therefore beware of errors and omissions (QRA file: PembinaQRAReportFinal040215.pdf Retrieved April 3, 2015 DNV GL–Report No. PP124992, Rev.4)

Cold or Hot BLEVE & Domino Effects

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April 5, 2015

Abstract

BLEVE, a boiling liquid vapor explosion, is the name of a mechanism that can cause fire and destruction to spread throughout a propane pressure tank farm, or from one propane or Bakken oil tanker car to another, aided by the neat concertina arrangements these cars typically find themselves in following a derailment. BELEVEs can result either from prolonged or intense fire impinging on a tanker car, causing pressure build-up and wall weakening to the point where the tank bursts, or it can occur as a result of mechanical damage; a major cause being derailment. Pressurized storage of propane is particularly dangerous because the liquid is stored well above its boiling point.

BLEVEs also provide an effective mechanism for spreading and amplifying a fire, known as domino effect. Due to the fact that domino effects have been identified in a large proportion of fires and explosions involving propane, oil, or other flammable chemicals, industry authorities are stating that no risk assessment can be considered complete without including the analysis of domino effects. We would go further and suggest that industrial projects should not be allowed to go ahead unless the QRA contains a full treatment of all applicable domino effects.

One of the largest recent disasters involving domino amplification effects occurred in the Canadian town of Lac-Mégantic. An unattended runaway train carrying Bakken crude vaporized 47 people as they slept and wiped out half of the town of Lac-Mégantic, Canada, on July 6, 2013.

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Do You Like Your BLEVE Hot or Cold?

BLEVE is a boiling liquid expanding vapor explosion (popularly known as the Blast that Levels Everything Very Effectively). BLEVEs can occur in many different situations, but here we will mainly focus on propane and pressurized storage. Propane BLEVEs, one of the most dangerous kinds, now occur seemingly almost daily in propane and oil trains, particularly since the advent of propane-rich Bakken oil. Pembina's VP of engineering, Eric Dyck, in response to questions about BLEVEs in the popular DOT-112J propane pressure tank car, replied with, "*But that's impossible!*" and, "*Even if it were* [possible]*, it ain't going to happen!*" This appears disingenuous at worst, or sadly naive and unprofessional at best. Such comments are unfair to Portland residents, and Pembina shareholders, because DOT-112J propane rail transportation BLEVE accidents have occurred and are very well documented by professional investigators. We have read that rail engineers are in a quandary wondering what meaningful safety improvements can be made. Since any such improvements will take a long time to implement across the fleet, there is a strong likelihood of further propane accidents (not "if" but "when").

There are two kinds of BLEVEs, hot and cold. The North American rail industry uses the following definition, applicable to pressurized propane and LPG storage in DOT-112J propane pressure tank railcars, and propane bullet tanks[2]:.

> HOT BLEVE: Catastrophic failure of a tank induced by fire followed by explosive release of boiling liquid and expanding vapor.
>
> COLD BLEVE: Catastrophic failure of a tank with immediate release of contents. Failure occurs when the tank is weakened by severe mechanical damage caused by accident, sometimes aggravated by cold temperature, corrosion, existing defects or less desirable material properties such as brittle failures.

VP Eric Dyck of Pembina, on the other hand, maintains there is only one kind of BLEVE (which the rail industry refers to as a *hot* BLEVE). At two different meetings (HiNooN Oct 9, 2014, and PSC Mar 17, 2015), he said that the only way you can get a BLEVE is to have a pressurized tank subject to fire for an extended period of time. Therefore, when a Pembina company officer tells us that the only way a BLEVE can happen is if fire heats a tank past its bursting point, it is of very deep concern as it appears that Pembina officials do not know vital facts about propane rail transportation, else are engaged in a campaign of spin-doctoring.

Ambient-temperature pressurized storage of liquid propane is considered to be more dangerous than tank storage of other fuel gases, for the following reasons:

i) The propane is stored as a compressed liquid well above its boiling point.

[2] Gagnon, Jean-Pierre. Superintendent, Rail Tank Cars TDG Regulatory Affairs, Ottawa, Canada. "Tank Car Safety & Security Significant Improvements CAN/USA 1970s-2006." http://tinyurl.com/n7seke4 Retrieved April 4, 2015.

ii) A minor leak or rupture in a pressurized storage tank can lead to a fire that can cause the tank to self-BLEVE, or cause a BLEVE in an adjacent tank. These are known as *hot* BLEVEs.

iii) Hot BLEVEs project tank fragments, known as shrapnel, across large distances in all directions, at speeds up to 400 mph. These tank fragments have caused deaths and extensive property damage well beyond the extent of thermal radiation damage. The shrapnel can puncture other tanks, spreading the fire, eventually causing them to BLEVE (domino effect).

iv) The heavy propane vapor cloud resulting from a hot BLEVE will typically reach a flammable or detonable concentration, and given a source of ignition will result in an unconfined vapor cloud explosion (VCE) and blast that exceeds that from the original BLEVE burst.

v) Massive sudden rupture of a propane tank wall will cause the contents to flash boil, producing a cold BLEVE, instantly mixing with the air, resulting in a propane/air heavy vapor cloud that, if it finds a source of ignition can detonate in a vapor cloud explosion (VCE).

The most frequent causes of BLEVEs are as follows[3]

Cause	Type	%
Fire	Hot	26
Derailing	Cold (rupture), Hot(fire)	20
Overfilling	Cold	18
Runaway Chemical Reaction	Hot (exo.), Cold (endo)	12
Collision	Cold (rupture), Hot(fire)	10
Overpressure	Cold	6
Other	Cold or Hot	8

Domino Effects 101

Among the most destructive major accidents are those where a "domino effect" occurs, causing an escalation of the primary incident or accident. Domino effects are quite common, and so is a related effect that is known as "domino amplification" or "domino multiplication." All are run-away chain-reaction effects that, if not limited by some resource, tend to want to grow exponentially.

[3] Adapted from Casal, J., et al. "Modeling and Understanding BLEVEs." http://aevnmont.free.fr/SACH-BOOKS/Petrochemistry/Handbook%20of%20Hazardous%20Materials%20Spills%20Technology/Part%20V.%20Spill%20Modeling/22.%20Modeling%20and%20Understanding%20BLEVEs.pdf Retrieved April 3, 2015.

The key domino-effect concept is the "dynamic amplification factor" (DAF) which may be thought of as an "escalation-gain." Indeed, a very high DAF or gain is what makes propane extremely hazardous in this respect, giving propane the reputation that "there are no small propane fires." In a given flammability situation, if the DAF is less than one, a fire will burn out. If the DAF is much greater than one, then a single fire may create two fires, and each of those will create two more, and each of those will create two more yet, in an exponential acceleration that grows as fast as it can.

Domino effects have come to be recognized as being very important in all sorts of situations. Besides the domino-enhanced cascading of BLEVEs in pressurized propane tank farms (such as happened at Cosmo Oil in Tokyo Bay, which experienced seven BLEVEs, March 2011 –*see* White Paper, Part 1), some well-known examples of domino amplification are a small detonator exploding a house-sized stack of dynamite, the detonation of a nuclear fission bomb or nuclear fission/fusion bomb, and of course, actual domino competitions, where the energy released in the fall of one domino can build up to topple millions more. The chemical processing industry has lost count of the number of domino events they have experienced over the years. One of the best-known domino-enhanced accidents is the 1984 Mexico City LPG disaster, in which more than 500 people died.[4]

* * *

The process industries use the following terminologies: domino event / domino cascade / domino event tree / domino accident / simple and multi-level propagation / domino chain / dynamic amplification factor / inherent domino hazard / escalation vector.

The last term mentioned above, *escalation vector*, should be used to design the spacing of propane pressure tanks and bullet tanks to keep the dynamic amplification factor less than one. However, the industry does not do this; since most of these tanks are sold in close pairs, or even quads! We suspect the reason is that larger distances would be uneconomic, even if much lower risk.

[4] More information about this disaster: Arturson G. "The tragedy of San Juanico--the most severe LPG disaster in history." Burns Incl Therm Inj. 1987 Apr;13(2):87-102

The word "domino" appears exactly zero times in the Pembina QRA. Yet, the petrochemical industry standard reference book[5] on Domino effects says,

> "Nowadays, no risk assessment can be considered complete without including the analysis of domino effect."

This is a serious omission, as a further section from this book points out:

> "The 2011 Tohoku Tsunami in Japan that precipitated the unprecedented destruction and meltdown of three out of four nuclear reactor cores at Fukushima, has caused safety practitioners to focus more deeply on, and to model, manage, and manage the risks due to high-impact low-probability events such as domino scenarios."

At the March 15, 2015 PSC meeting, a Pembina official, when asked a question about domino effects, expressed unwillingness to include them in the risk analysis because they are non-linear, and because the modeling of non-linear effects would make the risks difficult to calculate. We believe that the standard industry software for calculating domino effects (e.g., Domiffect) may give too pessimistic a view of accidents for Pembina to want to use it or share the results.

In our view, no industrial project should be allowed to go ahead without a QRA which contains a full treatment of all applicable domino effects. Without domino calculations, and application of standard industry knowledge of Domino effects, the QRA is incomplete, arguably faulty, and should be rejected!

[5] *Domino Effects in the Process Industries: Modeling, Prevention and Managing*. Ed. by Genserik Reniers, Valerio Cozzani. 2013. Elsevier B.V., Amsterdam. www.elsevier.com
Chapter titles include: Features of Escalation Scenarios / Overpressure Effects / Heat Radiation Effects / Missile Projection Effects / Other Causes of Escalation.

Portland Propane Terminal Risk Assessment

Rail Safety Risks

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Abstract

Rail safety is at a crisis point. The daily news is replete with an increasing frequency of reports of oil and propane derailments, fireballs, and explosions. So much so that we fear for the things we hold dear: our families, our friends, our Portland scenery, our beloved and still sustainable Columbia Gorge (a major rail route), and so on. If Portland allows Pembina to build their propane terminal, our communities are future blast zones.

Local and state governments must consider the full transport scenario of propane to be all four phase:

1) *Brought by rail tank car unit trains from the oil fields to a transfer facility marine port*
2) *Off-loading and refrigerating it and storing it at a marine port terminal facility.*
3) *Off-loading it again onto refrigerated ships for overseas export.*
4) *Navigating propane ships down river and out to sea.*

All of these phases occur within and between the boundaries of Washington and Oregon. To consider only the propane marine port facility at Portland is to consider only one fourth of the transport, processing, and storage process.

Propane and crude oil traveling by rail through our cities puts them at risk. In the midst of all of the news of rail accidents we learned in a TSB report that the propane-carrying DOT-112J tank car has serious design flaws. Also that the DOT-112J's close cousin, the DOT111/CPC-1232 (used for oil, including the propane-rich Bakken oil, and non-pressurized liquids) has similar flaws and may soon be replaced by the DOT-117 (replaced on paper, at least, because we expect it will be decades before the million or more tank car fleet is replaced).

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Driven by these news reports to find out what is going on in the rail industry, we found out that while some individual (donated) tankers have been used for testing, there are no reports of dynamical train/rail system testing and modeling of all of the factors that may contribute to derailment and disaster. We ask why aren't the rail companies emulating the aircraft manufacturers by testing fully-loaded 100+-car unit trains to destruction, other than "live" on commercial routes, many of which run right through our communities?

Against claims of improved safety, we continue to see ever fresh pictures and video footage showing the same old scenarios: burning derailed tankers arranged concertina-wise, broken couplers, belly breaches, cold and hot BLEVEs, fireballs, and consequent environmental damage. Moreover, we read in the news that many rail companies have reached their limit on liability insurance, and want to have the right to refuse hazardous goods, despite their common carrier obligations.

In this Part Two to the Portland Propane Terminal white paper, Northwest Citizen Science Initiative (NWCSI) digs into this topic, takes a look at official accident investigations, discusses testing methodologies, adds some analysis of its own, and concludes that any QRA which does not include a satisfactory treatment of transportation risks and liabilities, should be summarily rejected. .

Introduction

Top among the big risks associated with a propane terminal in Portland is the risk of accident during rail transportation, including loading and unloading. Rail safety is a big deal for the "twin cities across the river," Portland and Vancouver. Especially so, with the Port of Portland (POP) and Pembina proposal to build a propane export terminal that would start with one 100-

THE BIG RISKS:

- ***Rail transportation accident risk***
- *The risk of the overdue M9+* Big One *earthquake*
- *The risk of terrorist attack; increased by proximity to high-density housing*
- *The risk of severe seismic liquefaction amplification effects throughout Portland Basin geological area*
- *The risk of inadequate geotechnical analysis of the proposed T-6 site*
- *The risk of living inside the EPA threat zone*
- *The risk of inundation due to dam breaks upstream on the Columbia*
- *A satisfactory scientific treatment and data disclosure of all blast effects and thermal threat zones, including shrapnel*
- *The risk of deciding not to model Domino effects*
- *The risk of Portland becoming another oil port like Texas City or Freeport*
- *The risk of insufficient disaster emergency and medical services*

tanker car unit train every other day. We estimate that the propane is in Pembina's big refrigerated tanks a mere 3- to 10% of the time. For the other 90–97% of the time, during rail transportation, the propane is at a much higher risk of accident, so much so, that any industrial project QRA that arrives at Portland's City Council omitting or inadequately analyzing the highest risks to our communities should, in our view, be summarily rejected, and the proposal canceled.

News Headlines: Derailment Accidents

After initial high-hopes for the DOT-111 CPC-1232 safety retrofit and amid headlines like "*Has Rail Industry Underestimated Risks of Tank Cars?*"[6] accident rates on the CPC-1232 are increasing. Part of the reason for this is undoubtedly that the numbers of tankers including CPC-1232s, active on the rails has been increasing. Retrofits will likely take years due to the vast size of the fleet (> 157,000). At the time that this tally was reported, the fleet size of the DOT-112 used for pressurized transport was 22,000. The relevance of DOT-111/CPC-1232 accident numbers to the current discussion is a shared safety design with the DOT-112J tanker, and the fact that Bakken crude oil is shipped with large propane content (and which used to be much higher). The bottom line is that even newer, supposedly safer tank cars have not reduced the risk of oil train collisions, rollovers, tank car ruptures, and spills. They have therefore failed to protect the public from the consequences of rail accidents. Indeed, the total amount of oil spilled in 2013, due to derailments, was greater in volume than all the rail spills occurring in the U.S. during the previous forty years.[7] Most of the spills involved oil, but more recently there have been an increasing number of accidents involving propane-rich Bakken oil, or the propane/butane/LPG gases.

R13E0142—Gainford, Alberta, Sept 19, 2013[8]

Nine-car DOT-112J Derailment, Propane Fire, Explosion.
TSB Verdict: DOT-112J Tanker Design Flawed

Several things happened in this accident that are not supposed to happen to DOT-112J pressure tank cars, particularly considering the low speeds involved:

[6] http://www.bnn.ca/News/2014/1/9/Rail-industry-has-underestimated-risks-of-tank-cars.aspx

[7] http://beniciaindependent.com/future-blast-zones-how-crude-by-rail-puts-u-s-communities-at-risk/ Retrieved April 4, 2015.

[8] http://www.tsb.gc.ca/eng/enquetes-investigations/rail/2013/r13e0142/r13e0142.asp Retrieved Apr 5, 2015
Also: http://www.tsb.gc.ca/eng/medias-media/communiques/rail/2015/r13e0142-20150224.asp)

The part of this train that derailed was the rear section. It consisted of four DOT-111/CPC-1232 crude oil tank cars, followed by nine DOT112J340W LPG tank cars, two of which were breached and burned. One of these two cars cold BLEVEd, producing a large fireball that extended across nearby HWY 16, scorching its surface, the other produced a jet fire that impinged on a third tanker. The third tanker which was heated by the jet fire, lost its contents through its pressure relief valve whereupon the lost gas ignited and burned for a considerable time.

The nine DOT-112J340W cars derailed concertina-style, with six of the cars coming nose-up to the side or belly of another car. Eight of the DOT-112J double-shelf couplers in this train uncoupled, which is not supposed to happen. In fact one of the couplers uncoupled by shearing off, becoming a sharp battering ram, breaching the unprotected underbelly of the next DOT-112J car with a jagged 2- or 3-foot hole, which is not supposed to happen. This caused immediate loss of its pressurized contents in a *cold* BLEVE, "which exploded in a fireball that stretched across Highway 16." The cars contained LPG, of which propane is usually the major component, which made this event very dangerous. Belly breaches like this are not supposed to happen because the new double shelf couplers in DOT-112J tanker cars are supposed to stay together.

DOT112J propane tanker derailment, belly breach, cold BLEVE and fireball, near Gainford, Alberta, Oct 19, 2013. The Canadian TSB investigation report R13E0142 (Published Feb 24, 2015) cites critical design faults in DOT112J340W. The NWCSI

analysis of this accident also points to deficiencies in the unit train as a dynamical system, and a lack of evidence of live-train design testing. Trees and four-lane HWY16 in foreground gives a scale for the fireball. (Canadian TSB photo)

After perusing the reports of many rail accidents, we have concluded that the uncoupling-resistant double-shelf couplers appear to have increased the amount of jack-knifing in derailments, and this accident is no exception. The relatively tidy assemblages of jack-knifed tanker cars make a nice belly target for a following car whose coupler broke apart or sheared off, as happened at Gainford.

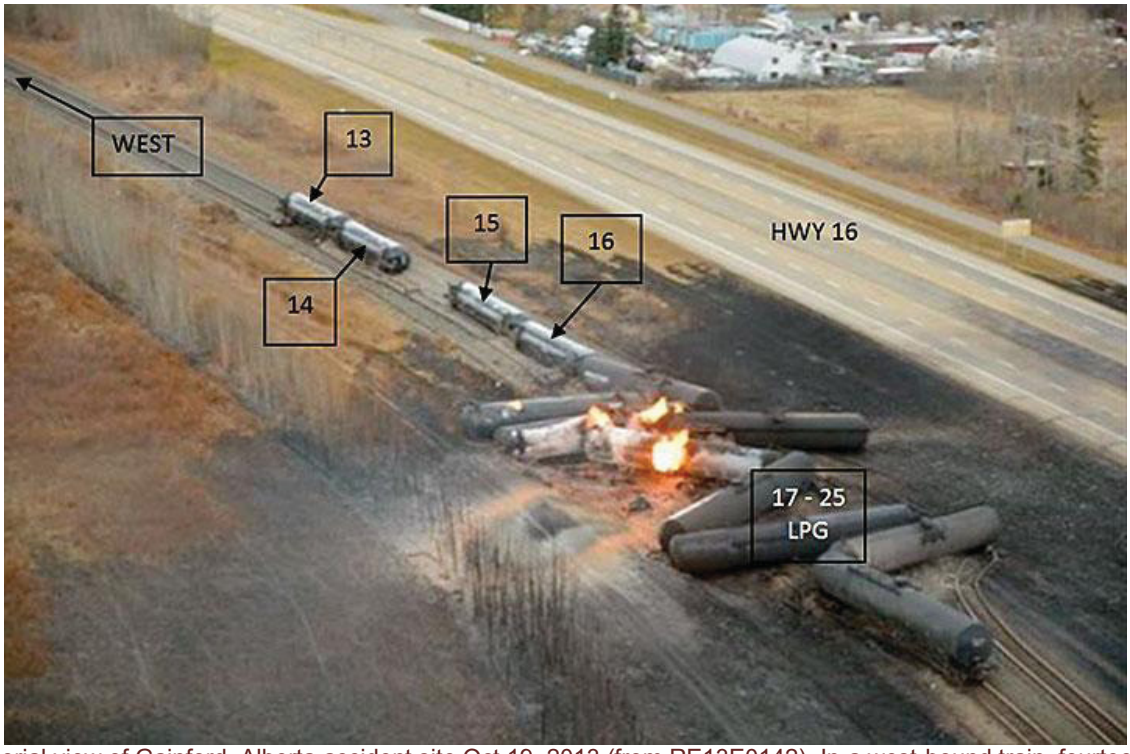
The other downside to the use of uncoupling-resistant couplers is that more tanks end up side-by-side, concertina-style (also known as accordion-style), causing a hugely increased risk of hot BLEVEs and domino-cascade-driven fires and explosions, which is also not supposed to happen in DOT-112J tanker cars. In such pile-ups the thermal coating, part of the "J" in DOT-112J, means very little due to the multiplied intensity, just like stacking logs on a fire. There may be other unintended consequences of the double-shelf redesign of tanker car couplers, but due to the lack of dynamical system testing of entire, loaded unit trains to destruction, we might not find out until it happens on a railway line near us.

Photo 1. Puncture in the underside of UTLX 955375

In the Gainford accident, tanks jack-knifed across the track concertina-style, tanks were breached, several couplers uncoupled; one coupler sheared off, tearing a jagged several foot hole in the belly (see Photo 1) of one of the jack-knifed tanks (known as a belly breach) which caused a cold BLEVE, which resulted in a huge fireball and blast (see photograph), which damaged a nearby house and the adjacent 4-lane highway. Several punctured tanks also burned for hours in this now infamous derailment. The derailment happened at a sedate speed of between 15 mph and 25 mph. In this case the tank head puncture resistance system (which is the other part of the "J" designation in DOT-112J tankers) was of little value. In our view, once the double-shelf couplers were introduced, the tank head puncture resistance system was somewhat redundant, in that it would have been more usefully applied to the belly of the tank (and also the sides) instead.

A photograph of the accident scene (see below, and more in Canadian TSB investigation report R13E0142) shows a large area affected by heat and burn damage, including fireball damage to surroundings including browning of the surface of adjacent HWY 16, caused by the large collision-induced BLEVE fireball that extended across the roadway. The ALOHA simulation software reports that the fireball diameter for a 30,000 gallon pressurized DOT112J

propane tanker car is 732 feet, which is consistent with the amount of damage in the site aftermath photograph. The small residual fire still burning when the photograph was taken, together with the large burnt area and the bare, burned-looking steel is but a tiny reminder of the ferocity of this accident. One home, immediately across HWY 16 from the accident suffered thermal damage from "the post-derailment fires and explosions". The TSB investigation points to serious deficiencies in the 112 tanker car design. The new coupler design, in our opinion, may exacerbate such accidents by keeping tanker cars in close proximity, allowing cars to land beside one-another, concertino-style, and still allow several jack-knifing scenarios where a coupler on one tank can act like a battering ram against another tank, leading to los of contents, *cold* BLEVEs, fires, and even *hot* BLEVEs in adjacent derailed cars not breached or punctured



Aerial view of Gainford, Alberta accident site Oct 19, 2013 (from RE13E0142). In a west-bound train, fourteen cars derailed at low speed in a siding, including 9 DOT-112J cars (numbers 17–25 in the photograph) which contained LPG, the major constituent of which is propane. One DOT-112 car was breached with a 2-3 foot hole in the underbelly by the coupler from another car. This caused it to rapidly release its load (of LPG) in a cold BLEVE, and ignite, with the fireball stretching across HWY 16. Despite double shelf couplers designed to keep the cars coupled during derailments, the DOT-112 cars uncoupled during the derailment and jackknifed across the track, concertina-style, making them vulnerable to secondary impacts from following cars. A second car was breached and apparently burned with a jet fire (still burning in the photograph). A third LPG tank car released product from the safety valve and ignited. About 600 feet of track was destroyed. The road surface and a nearby house were also damaged in the deflagration.

The investigation report says the following about this:

"These couplers are designed to restrict upward and downward movement so that they do not disengage when subjected to forces that can occur during train derailments. If the couplers are kept

> engaged, it is less likely that a coupler punctures another tank car. However, if cars are prevented from disengaging in a derailment, the torsional forces of a derailing car can be transferred to other cars, resulting in the derailment of the adjacent cars. When the forces caused by the derailing cars exceed the design specifications of the couplers, the couplers can disengage, or a coupler shank failure can occur."

If this had been a mile-long unit train, many more tankers might have ended up side-by-side, and through well-known domino effects this could well have escalated until there was a domino cascade of hot BLEVEs and tank fragment-induced additional cold BLEVEs, once the heating power of many burning tanks overwhelmed the safety valves in such a scaled-up scenario. It is fortunate that only nine LPG tanker cars were on this particular train, but I think it is significant that 1/3 of them burned. It took the Canadian TSB almost sixteen months to publish their investigation report, R13E0142, of this accident.

Double-shelf couplers are designed to prevent uncoupling through relative vertical movement between cars in a derailment, but in our analysis this may have added an additional lethal side-effect not mentioned in the Gainford TSB investigation report (R13E1042): Double-shelf couplers appear to encourage tank cars to concertina together into a pileup, making them more susceptible to BLEVEs and domino effects by causing intensification of fires.

R13D0054—Lac-Mégantic Tradgedy, July 6, 2013[9]

The train accident that tragically killed 47 people in the Canadian town of Lac-Mégantic, was another accident which might have been much less severe without double shelf couplers. According to photographic evidence and Canadian TSB Investigation Report R13D0054, approximately 40 DOT-111 tank cars largely remained coupled together in a massive concertina, spilling and/or burning a total of 1.7M US gallons of oil. If the cars had more readily uncoupled, they would have undoubtedly stopped in a more spread-out configuration which could have avoided the fire that followed, which was intensified by the proximity of most of the cars to each other. To give an idea of the slowness of safety changes in the railway industry, the TSB report says that as a result of a weak safety culture, although MMA rail had put a safety management system in place in 2002, it did not begin to implement it until 2010, and by the time of the Lac-Mégantic accident in 2013, it was still not functioning effectively.

Forty concertinaed DOT-111 Tank Cars. Lac-Mégantic R13D0054, July 6, 2013

[9] http://www.tsb.gc.ca/eng/enquetes-investigations/rail/2013/r13d0054/r13d0054.asp

Bakken Crude Derailment Involved Safer Tank Cars

Smoke and flames erupt from the scene of a train derailment Thursday, March 5, 2015, near Galena, IL. A BNSF Railway freight train loaded with Bakken crude oil derailed 21 tanker cars around 1:20 p.m. Two cars split open, burned, and set fire to three others cars, in a rural area where the Galena River meets the Mississippi. The tanker cars were the "newly improved" DOT-111/CPC-1232 type (AP Photo/Telegraph Herald, Jessica Reilly)

March 29, 2015 Galena, IL.[10] The two rail cars that split open and burst into flames during a western Illinois oil train derailment [March 5, 2015 near Galena, IL], were retrofitted with protective shields to meet a higher safety standard than federal law requires, railroad officials said. … No injuries were reported, but the accident marked the latest failure of the safer tank car model … the 1232, which was designed during safety upgrades voluntarily adopted by the industry … in hopes of keeping cars from rupturing during derailments. But 1232 standard cars involved in three other accidents have split open in the past year … [including] one last month in West Virginia in which a train carrying 3 million gallons of North Dakota crude derailed, shooting fireballs into the sky, leaking oil into a waterway and burning down a house. The home's owner was treated for smoke inhalation, but no one else was injured. …

[Galena officials announced] a voluntary evacuation of an area within 1 mile because of the presence of a propane tank near the derailment.

Recent derailments have increased public concern about the safety of shipping crude by train. According to the Association of American Railroads, oil shipments by rail jumped from

[10] http://missoulian.com/news/state-and-regional/bakken-crude-illinois-oil-train-derailment-involved-safer-tank-cars/article_037797c1-3466-54b2-9784-9d8943053cd9.html Retrieved Mar 20, 2015

9,500 carloads in 2008 to 500,000 in 2014, driven by a boom in the Bakken oil patch of North Dakota and Montana, where pipeline limitations force 70 percent of the crude to move by rail.

Comment: This accident is relevant because the DOT-111 tankers involved were CPC-1232.

Washington State to D.C., Fears of Oil Train Risks on Rise

March 28, 2015 The Dickinson Press:[11] BNSF began a move Wednesday to have all of its oil trains reduce speeds to 35 mph through all municipalities with 100,000 or more residents. The speed reduction is temporarily in place until its customers phase out DOT-111 tanks cars from service, BNSF spokesman Mike Trevino said Saturday. Phasing out of the older cars, which will be replaced by CPC-1232 railcars to meet federal safety standards, is expected to begin in May, and BNSF hopes to complete the process by the end of the year. When that happens, BNSF will reconsider the speeds. … The shipping companies, not BNSF, own the cars, so the railway company has to wait on its customers to make the transition to the newer cars. … North Dakota has also attempted to tame the flames. The state Industrial Commission unanimously approved a requirement for all oil producers to install and utilize oil-conditioning equipment to reduce the volatility of Bakken crude. The order would bring the vapor pressure of every barrel of oil produced in North Dakota under 13.7 pound per square inch before it is shipped. Crude producers must comply starting Wednesday.

Comment: What makes the Bakken crude so dangerous is that its vapor is mostly propane!

[11] http://missoulian.com/news/state-and-regional/from-washington-state-to-d-c-fears-of-oil-train/article_03377298-d44d-5f81-8582-b3f34c4f7080.html Retrieved Mar 30, 2015

Portland Propane Terminal Risk Assessment

The Big Risks: Earthquakes & Terrorist Attacks

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Northwest Citizen Science Initiative*

April 5, 2015

Abstract

Ever aware of risks to our wellbeing, we notice headlines like "Former White House counterterrorism adviser says LPG project too risky for Searsport" followed just 2½ months later (April 2nd 2013) by "Developers withdraw proposed Searsport tank application," a victory for the Thanks But No Tank *campaign. However, the reason stated for the withdrawal by the Searsport Planning Board was that the project spread into the town's commercial district in a way that is not permitted, among other ordinance and zoning problems. Whatever it takes…*

In this Supplement to the Portland Propane Terminal white paper, and on the 315th anniversary of the huge earthquake that hit the Pacific Northwest 315 years ago, Northwest Citizen Science Initiative (NWCSI) takes a look at the latest official statements of earthquake risk, the degree of preparedness of our emergency services and first responders, and the approach taken by other similar projects to the modern threat of terrorism in which facilities are targeted in relation to their potential for inflicting maximum damage to our populations and city-based infrastructure. We use as a guideline a study of the terrorist target potential of the canceled Long Beach LNG import terminal, which also planned to incorporate a large propane processing facility.

Pembina VP, Eric Dyck said at the March 15, 2015 PSC meeting that Pembina did not have to do so, but they would build the Portland Propane Terminal to withstand an M9.0 earthquake. When asked how he would do this he suggested it was not a problem and would be just a minor tweak of the design.

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*Northwest Citizen Science Initiative (NWCSI) is an association of civic leaders, scientists, engineers, and environmental researchers that promote thorough, valid, and reliable methods for the scientific study and enhancement of all of Nature's systems of livability and sustainability across the Pacific Northwest.

Introduction

Around 9:00 p.m. on Jan 26, 1700, what would one day be Portland and Vancouver experienced a great ground shaking known as the Great Cascadia Earthquake GCE). Geologists have estimated this "megaquake" to have been a magnitude 8.7 to 9.2. Geological evidence and coastal geomorphology shows that the GCE was not the first, and will not be the last earthquake in our area.

The Port of Portland (POP) proposed Propane Export Terminal project, and the (now canceled) Port of Long Beach (POLB) LNG Import Terminal project have many similarities; so much so, that the results of demographic modeling developed during the University of Southern California (USC) Long Beach terrorist study can be applied to Portland with few changes. This study was developed by Carl Southwell of the Price School of Public Policy at the University of Southern California, and submitted as part of the successful rebuttal of the POLB terminal. This study uses a very detailed decision tree approach of three different scenarios to capture differences in the chances of success for terrorists given changes in terminal location (proposed site vs. a remote location), defensive countermeasures, the season, and other factors. It factors in the cost of injuries and deaths, as well as loss of capital plant and a docked gas ship.[12]

The simulated attack on the proposed Portland Propane Terminal assumes a full breach of either facility tanks or propane gas carrier ship.

Expected losses from such an event include 5,000 fatalities, 25,000 injuries, and a total economic impact of about $83B ($83 billion). The total economic

THE BIG RISKS:

- *Rail transportation accident risk*
- ***The risk of the overdue M9+ Big One earthquake***
- ***The risk of terrorist attack; increased by proximity to high-density housing***
- ***The risk of severe seismic liquefaction amplification effects throughout Portland Basin geological area***
- ***The risk of inadequate geotechnical analysis of the proposed T-6 site***
- ***The risk of inundation due to dam breaks upstream on the Columbia***
- *A satisfactory scientific treatment and data disclosure of all blast effects and thermal threat zones, including shrapnel*
- *The risk of living inside the EPA threat zone*
- *The risk of deciding not to model Domino effects*
- *The risk of Portland becoming another oil port like Texas City or Freeport*
- *The risk of insufficient disaster emergency and medical services*

[12] C. Southwell, USC. "An Analysis of the Risks of a Terrorist Attack on LNG Receiving Facilities in the United States." Nov. 9, 2005.

impact was estimated by valuing each fatality at $5M ($5 million), each injury at $100,000, the Propane facility at $500M, a propane ship at $240M, local property damage at $4.36B, and ongoing economic impacts at $50B (primarily in terms of short- and medium-term reduced trade in the ports of Portland, OR, and Vancouver, WA.

Commercial Jetliner Used as Terrorist Missile

A large commercial jetliner used as a missile projected at the big tanks, or the gas carrier ship, is one possibility. To improve the probability of success, two planes might be used. Large jets would likely be acquired out of PDX, or possibly Pearson Field, WA. Probabilities of attack by terrorists can be assumed to correlate positively and strongly with the proposed location, an industrial location two miles from high-density housing and population. (On the other hand, a location ten miles or more from housing and populations would correlate negatively and strongly with attractiveness of the terminal to terrorists.)

We note that the proposed two large refrigerated double-wall steel tanks are not hardened against aerial attacks by aircraft.

Direct Terrorist Attack by Land, Water, or Drone

We note that the two large refrigerated double-wall steel tanks are not hardened against attacks by missiles, RPGs, drones, or truck-borne explosives, and nor are the pressure storage tanks nor rail tanker cars.

Renier and Cozzani point out that criminals who deliberately intend to cause damage require a very different approach to the QRA, compared to the assessment of accidental risk.[13] Moreover in discussing safety versus security, these authors assume that criminals or terrorists would carefully study the facility it to find the best way to carry out their plans, including how to cause maximum damage. Domino effects may come into this. Once their plans are in place, we believe that they would carry out their plan rapidly and simultaneously with everything that they've got, because typically there is only one chance. It is further assumed that the terminal personnel would be quickly disposed of in many of the possible attack scenarios, to prevent any attempts by them to save the facility, sabotage the terrorist efforts, or call for help.

As Renier and Cozzani point out, the ramifications of the port 9/11 era include a heightened security risk. However, safety and security require somewhat difference proactive approaches. For example an accidental fire can be put out by personnel, but in the case of a fire started by a terrorist there may not be anyone left who can put it out. This is where domino effects enter into

[13] *Domino Effects in the Process Industries: Modeling, Prevention and Managing*. Ed. by Genserik Reniers, Valerio Cozzani. 2013. Elsevier B.V., Amsterdam. www.elsevier.com pp. 5-7

the equation. So while the failure risk of a fire alarm and sprinkler system may be quantifiable under normal failure frequencies, this does not have much bearing on the deliberate disruption of such systems by criminals, who after disabling such systems may set very destructive fires and other destruction focused on leveraging domino effects to maximize damage.

Hobson's Choice: City-Sized Vapor Cloud Fire or Pool Fire and Million-Gallon BLEVE

We assume that a terrorist attack on the terminal is a) intentional, and b) catastrophic. In the latter assumption, and in several of the possible scenarios, we have to assume that it is also nearly instantaneous. There are two cases:

1) The large refrigerated tanks are breached, but do not burn, spreading a large heavy vapor cloud in a long plume, which depending on the wind direction, would cover much of Portland or Vancouver, be subject to local ignitions and flame pockets, and would negatively impact the health of hundreds of thousands of residents. Such a vapor cloud was previously modeled using a 115 foot hole in the tank wall, and discussed for a seismic scenario in the NWCSI white paper,[14] using the EPA/NOAA ALOHA software package.
2) The large refrigerated tanks are breached, and the contents immediately ignite, initiating a complex sequence of events, likely including two-phase flow and a large pool fire, which will very likely lead to a near simultaneous one-million gallon hot BLEVE of the bullet transfer tanks, together with multiple 30,000-gallon BLEVEs of the tanker cars in any waiting unit train, showering cascades of shrapnel at high speed in all directions as far as 6.7 miles. In a few short hours, these events can be expected to burn up, and/or explode, 100% of any remaining propane on site.

Southwell's conclusions were as follows ($ millions):

Expected cost of a terrorist attack was:
$27,625M (2 miles from high-density housing) to $3,390M (placed at the end of a 3-mile jetty).

Aerial defenses (not an option for Terminal 6, which is under the PDX glide path):
A $10,000M saving in the first scenario above, and $2,000M in the second.

[14] A. Roxburgh, R. Ebersole, T. Helzer. "Portland Propane Terminal." Northwest Citizen Science Initiative (NWCSI) March 15, 2015.

Primary Terrorist Target: Pressurized Storage Tanks

Onsite pressurized propane tanks, including any nearby fully loaded pressure tank rail cars are a primary target for terrorist explosive devices. The issue is made worse by their close proximity to the large refrigerated propane tanks (this is dictated by the small site). Such blasts would produce cold BLEVE/overpressure blast/shrapnel effects that would escalate to the other pressurized tanks through a process known as "domino amplification." The resulting showers of high-speed tank shards and shrapnel can slice and dice the double-insulated wall of a nearby big refrigerated tank. Since refrigerated tanks are not under pressure, this triggers a very different set of events, everything from pool fires, to jet fires, to ground-hugging heavy propane vapor clouds that borne by the breeze can find ignition sources and exhibit complex types of deflagrations, and flame pockets up to many miles away.

A collection of propane/LPG/LNG-terminal news items that discuss the ever-present terrorism threat are located at the end of this section.

Earthquake Risk

If a 33-million gallon refrigerated propane tank is seismically collapsed, there will likely also be many adverse health and even lethality from the asphyxiating effects of the heavy vapor. We are talking about a lot of propane vapor from 33 million gallons. Since propane in gaseous form occupies 270 times as much volume as the liquid, it can cover almost 43 square miles of ground to a depth of 20 feet with an explosive 5% vapor-air mixture. Larger or smaller tanks will scale the number of square miles up or down.

At the March 15, 2015 PSC work session meeting, Pembina VP of Engineering, Eric Dyck publicly committed Pembina to building a propane terminal facility in Portland that will endure a magnitude 9.0 earthquake at the T-6 site. When asked how they intended to do that, he claimed that it would be a small tweak of the design, and even though Pembina was only required to build for magnitude 7.0, they would build for magnitude 9.0. Considering that the energy of a magnitude 9.0 earthquake is 1,000 times that of a magnitude 7.0, we don't know how Pembina intends to do this, but before letting them build in Portland, consider their incomplete knowledge of the various kinds of BLEVE, and their lack of openness concerning the already tarnished safety reputation of the DOT-112J tanker car (the involvement of nine DOT-112J pressure tank cars in a fiery derailment near Gainford, Alberta, has been known by those in the rail business since October 2013; the TSB report R13E0142, published Feb 24, 2015, cited the DOT-112J as a flawed design). Yet at the March 17 PSC work session meeting (after TSB report R13E0142 was already published), Pembina VP Eric Dyck again said that the DOT-112 J is perfectly safe. magnitude 9.0 (also written M9.0) is about as far as earthquake measurements go. It is important to note that this would be Pembina's first marine propane terminal, and the first in a magnitude 9.0 seismic liquefaction threat zone.

We have noticed a small boom in the design of magnitude 9.0 earthquake-resistant buildings, mainly available from China. One problem is that due to a lack of recent magnitude 9.0 quakes, there is little or no real-world experience, and very little testing apart from small models on shake tables, and computer models. We notice that a typical claim is really M9 RESISTANT, not M9 PROOF! With that said, one of the major problems that causes seismically-induced tank rupture, is wave action or sloshing within the tank contents, with tanks succumbing to specific frequencies and durations of ground motion.

The following diagram visually describes earthquake magnitude. To suggest just how strong a magnitude 9.0 earthquake is, the red balloon would completely cover this page.

M_e Energy Magnitude	Relative Energy
1	1/1,000,000
2	1/32,000
3	1/1,000
4	1/32
5	1
6	32
7	1,000
8	320
9	1,000,000
9.3	2,818,283

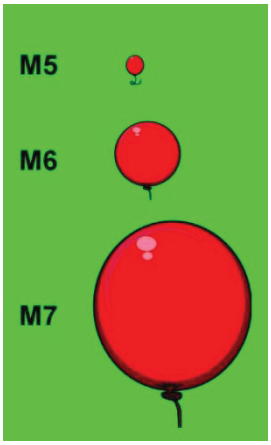

Figure showing a way to visualize earthquake magnitudes.
An M9 balloon would be big enough to cover this page.

News Headlines: Terrorism, Safety and Security

Former White House Counterterrorism Adviser Says LPG Project Too Risky for Searsport[15]

By Abigail Curtis, BDN Staff

Posted Jan. 14, 2013

SEARSPORT, Maine — A risk assessment study released this week by former White House counterterrorism adviser Richard A. Clarke recommends that the town of Searsport not proceed with a $40 million, 23 million gallon liquid propane gas terminal and storage tank project. Clarke is the former U.S. National

[15] http://bangordailynews.com/2013/02/08/news/midcoast/former-white-house-counterterrorism-adviser-to-testify-against-searsport-energy-project/

Coordinator for Security, Infrastructure Protection, and Counter-terrorism, and former chief counter-terrorism adviser on the National Security Council.
[his view is shared by 80.22% of voters in an on-line poll of 996 responders]

Among the 138-page independent report's findings:

- Regional public safety and security resources are not sufficient to address a significant land or maritime incident.
- Although agencies including the Searsport Police Department and the Searsport Fire Department signed "letters of compliance" in regards to their ability to respond to incidents, "no emergency management plans have been developed" to show how compliance will be established and maintained.
- There are no dedicated marine firefighters in the immediate area, or teams trained to respond to an incident involving a fire aboard an LPG carrier.
- If LPG facilities were regulated as strictly as liquid natural gas facilities, the one in Searsport would not meet the federally regulated criteria. "LPG and LNG pose serious risks," the report stated.
- Additionally, Clarke questioned whether Searsport is really the right place to locate a gas import facility.
- "If the price of gas continues to decline and if there are alternative, cost-effective measures to transport gas to the region, the Searsport facility may become a shuttered eyesore, unable to financially support the emergency response augmentation that building the facility requires," stated the report's executive summary.

Propane Risks Remain Unresolved at LA's Port[16]

Janet Gunter & Dr. Fred Millar
08 Feb 2013

… Retired US Coast Guardsman Stephen Flynn: "Like the coastlines of the Middle East, the US waterfront is littered with attractive targets." Refineries, power plants and chemical factories are ready-made weapons of mass destruction, located in some of the most densely populated areas… The waterside is too often an open flank."

Los Angeles Harbor area residents have been concerned for many years about the chemical release risks in their community, particularly those posed by the giant LPG storage tanks (specifically, butane and propane), which Plains All American Pipeline now operates under the name Rancho LPG LLC. The facility's

[16] http://www.citywatchla.com/in-case-you-missed-it-hidden/4494-propane-risks-remain-unresolved-at-la-s-port

huge tanks loom over homes, schools and businesses, with enormous storage volumes on site of butane and propane which railcars and trucks transport through neighborhoods and the Port of LA., bringing the disaster risks within a few feet of thousands of homes and businesses. And now the City is willing to put even more thousands of unsuspecting citizens at risk without notice. The very latest demonstration of political recklessness relating to public safety is LA City's compliance in a plan to develop the Ponte Vista housing project which will bring an additional 800-1,000 homes within ¾ of a mile of Rancho LPG. According to the EPA's own calculation method, Rancho LPG has a potential blast radius from a single tank of 3 miles. While the probability of a high consequence accidental release disaster is low, a well-planned terrorist attack on a storage tank or on a string of railcars could provide the terrorists their desired sensational media event.

The post-9/11 terrorism context in which two US wars and other military interventions has made the US a major focus of the ire of radical Jihadists worldwide. We badly need a thorough re-evaluation of locations and operations of major chemical storage tanks and the movement of hazardous cargoes in our densely populated local area, in perhaps the most important energy port in the US if not the world (thus a valuable target).

The latest Algiers natural gas plant takeover highlights the premiere opportunity that energy facilities offer in the way of terrorism. In particular, informed LA Harbor Area residents are deeply worried about the accidental release and terrorism risks posed by the Rancho Liquid Petroleum Gas storage facility currently operating adjacent to the inner harbor of the Port of LA.

Any notion that a public discussion of chemical accident or terrorism vulnerabilities in San Pedro Bay ports will be "teaching potential terrorists what to attack" is phony. The basic information on the major chemical release vulnerabilities are clear enough to any informed observer or internet user, and and even suggested by the NFPA hazard diamonds clearly visible on all the tanks.

Over the past several years, residents of the Harbor area have meticulously analyzed any and all public information made available through the Community Right to Know and the Freedom of Information Acts on Rancho's 40 year old facility. The stunning risk information highlights the failed oversight by government at all levels to properly safeguard citizens from the extraordinary risk exposure of Rancho LPG. even suggested by the NFPA hazard diamonds clearly visible on all the tanks.

… Even the new Canadian owners of the Rancho facility in their first public meeting with concerned citizens in 2008, publicly admitted that the helter-skelter siting of the major chemical facilities throughout the LA metropolitan area provided unnecessary disaster risks to the population, and that a sensible site for their own storage facility would be located outside a densely-populated area.

More Americans these days seem to favor protective, vigorous and technically informed government at all levels which bolsters productivity and employment while deploying informed oversight and eliminating unnecessary serious risks. A weak government and an uninformed public provide a recipe for possible disaster.

There is a profound phrase in the movie "Zero Dark Thirty" when the CIA is considering the uncertainty and risk involved in a Bin Laden raid. "How do you estimate the risk of doing nothing." Certainly, in the case of Rancho LPG…..we have been doing "nothing" for too long.

Fears of Terrorism Crush Plans For Liquefied-Gas Terminals[17]

Activists Claim an Explosion Could Create Deadly Fires; Dr. Fay Spreads Message
By **JOHN J. FIALKA** and **RUSSELL GOLD** Staff Reporters of THE WALL STREET JOURNAL
May 14, 2004

… Around the U.S. and in parts of Mexico, many coastal towns are rejecting similar plans that offer substantial economic benefits. In most cases the logic is simple: Residents fear the LNG tankers could become the target of terrorist attacks. In February, the state government in Mexico's Baja California bowed to pressure from local politicians and residents and appropriated land that Marathon Oil Corp. planned to use to build a terminal. The next month, residents of Harpswell, Maine, voted down a proposal for a terminal. A few days later, Calpine Corp. abandoned plans for a terminal in Eureka, Calif., after residents jammed a municipal auditorium to testify against it. Earlier this year, public fears were heightened by an explosion at an LNG liquefaction plant in Algeria that killed 27 people.

… Since 1970, Dr. Fay has warned about the danger that a collision might punch a hole in the hull of an LNG tanker, spilling part of its flammable cargo into Boston Harbor. His comments attracted relatively little attention. But after Sept. 11, Dr. Fay, a mechanical engineer, posited a more frightening scenario: a boat, manned by terrorists, detonating explosives against the hull of an LNG tanker. With this new approach, Dr. Fay has risen to guru status here among environmentalists and others opposed to LNG.

The main opposition group, Green Futures, has published a series of brochures based on Dr. Fay's findings that show how an attack against a tanker and the proposed terminal might trigger an enormous LNG spill.

Upon contact with the relatively warm water, the liquid would begin vaporizing back into a gas, and under some circumstances a spark could cause part of the gas to ignite. Green Futures argues that the resulting fire would incinerate as

[17] http://www.wsj.com/articles/SB108448658154011223

much as five square miles of Fall River and another four square miles of Somerset, Mass., just across the Taunton River from the terminal site. Buildings would catch fire, and humans exposed to the heat radiation could suffer severe skin burns, the group warns.

… Dr. Fay, who still teaches an occasional course at MIT, admits that some of the conclusions being reached by his disciples are exaggerated [*ajr: they say 55 Hiroshimas, whereas the reality is probably 1/10 of that, which is still substantial*]. "I think the Hiroshima comparison is unfair," he says, but he continues to assert that the heavily guarded LNG tankers are vulnerable to terrorist bomb boats as they move through the harbor. "It's easy to do. All you need is a 35-foot motorboat. You fill it up with two tons of ammonium nitrate, and you're in business."

At the end of January, Dr. Fay spoke at a public meeting in Fall River -- just as outside events were demonstrating the peril and potential of LNG. The meeting came four days after the LNG liquefaction plant in Algeria blew up, capturing the headlines and lending tension to the proceedings. But a preliminary investigation found the accident was started by a leaking pipe in a steam boiler.

Liquefied Natural Gas (LNG) Import Terminals: Siting, Safety and Regulation[18]

January 28, 2004 (Excerpt)

TERRORISM HAZARDS. LNG tankers and land-based facilities could be vulnerable to terrorism. Tankers might be physically attacked in a variety of ways to destroy their cargo — or commandeered for use as weapons against coastal targets. LNG terminal facilities might also be physically attacked with explosives or through other means. Some LNG facilities may also be indirectly disrupted by "cyberattacks" or attacks on regional electricity grids and communications networks which could in turn affect dependent LNG control and safety systems.

[18] http://www.au.af.mil/au/awc/awcgate/crs/rl32205.pdf

Portland Propane Terminal Risk Assessment

TNT-Propane Blast Equivalence

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April 5, 2015

Abstract

Propane trains and tanks have often been likened to bombs. Such a comparison, known as the blast equivalence between trinitrotoluene (TNT) and propane, has long been established using large-scale tests. The equivalence is defined as the amount of TNT (say 20 tons) used to create a reference blast, and an amount of propane and air required to create the same level of blast. The propane is assumed to be well mixed with air in the simple chemical proportions prescribed by the formula: $C_3H_8 + 5(O_2+3.76N_2)$. It is often said that 1 million gallons of propane = 1 atom bomb, or 20 kilotons of TNT. Nevertheless, while this is true on a purely chemical energy basis (20 kilotons of TNT contains 84 TJ, which is the energy content of 1M US gallons of liquid propane), this is not quite how it works in practice. Taking into account related to distance from the center of the explosion, a good rule of thumb number is 20 kilotons of TNT is blast equivalent to 20,000 tons or 10M US gallons of liquid propane.

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*Northwest Citizen Science Initiative (NWCSI) is an association of civic leaders, scientists, engineers, and environmental researchers that promote thorough, valid, and reliable methods for the scientific study and enhancement of all of Nature's systems of livability and sustainability across the Pacific Northwest.

TNT-Propane Blast Equivalence

Can we define blast equivalence between propane-and trinitrotoluene (TNT)? Experts say yes, and have completed large-scale experiment to prove it. The equivalence is determined by the mass of TNT required to create the equivalent blast effect of a mass of propane and air well mixed together, in simple chemical proportions, as prescribed by the formula: $C_3H_8 + 5(O_2+3.76N_2)$. It is often said that 1 million gallons of propane = 1 atom bomb, or 20 kilotons of TNT. Nevertheless, while this is true on a purely chemical energy basis (20 kilotons of TNT contains 84 TJ[19] which is the energy content of 1M US gallons of liquid propane), this is *not quite* how it works in practice.

In any chemical+oxidizer explosion (e.g., TNT, which contains its own oxidizer, or propane+air within the range of explosive mixtures) some of the energy will go into the overpressure blast (mechanical energy) and the rest to thermal energy. The amount of blast overpressure depends on how quickly the chemical reaction goes, and in this respect, propane and TNT are very different; one is a solid (molecules very close together), and the other is a gas (molecules very far apart). At the risk of oversimplifying, the sonic shock-front that propagates the explosion has much further to travel in the gas/air propane mixture versus the solid TNT. Therefore, we expect a purely energy-based comparison to over-estimate the equivalent TNT kilo-tonnage by some factor. By far the best way to make the comparison is to run a real-world test.

J. M. Dewey,[20] who analyzed data from Operation Distant Plain, a definitive set of large-scale tests to determine the actual propane-TNT blast equivalence, stated the following: "Knowing the energy yield of an explosive is not by itself sufficient to determine the properties of the resulting blast wave because not all the energy may be released in the compression wave. For example, in the case of a nuclear explosion approximately half of the available energy is released in the blast wave …. At the other extreme, a bursting balloon will release most of its energy into a compression wave. The rate at which the energy is released also has a significant effect on the properties of the resulting blast wave. Two explosives releasing the same amount of compressional energy, but at different rates, will produce blast waves with different properties. A rapid detonation will generate an initially intense blast wave with a strong primary shock …. As a result, less energy is available as the blast expands …. A less intense detonation, or a

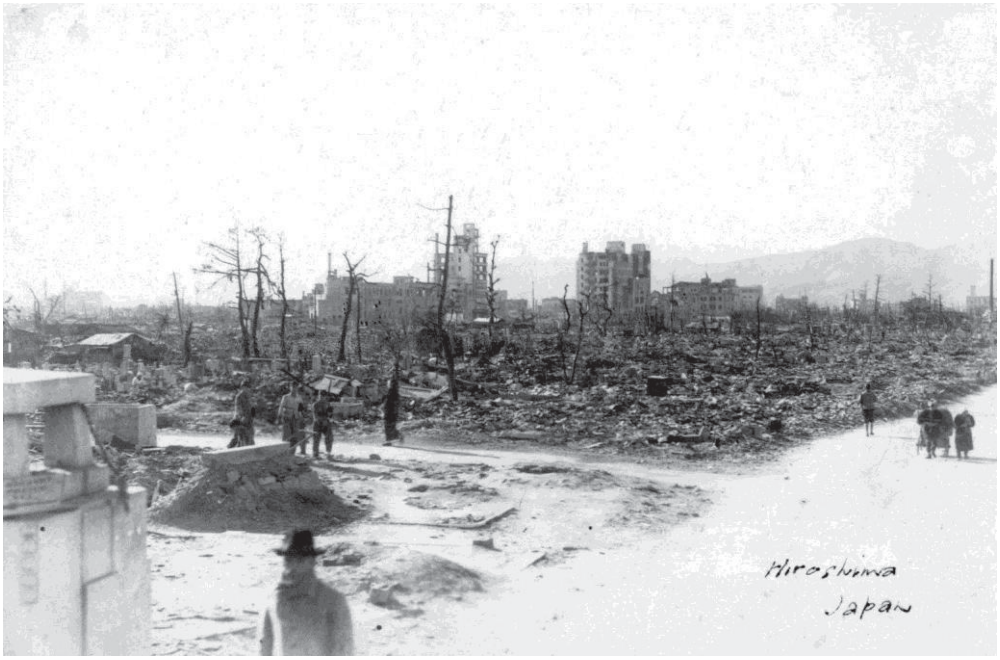
[19] The defined chemical energy content of 1 short ton of TNT is 4,184 MJ.

[20] Dewey, J M. "The TNT equivalence of an optimum propane-oxygen mixture" J. Phys D: Appl. Phys. 38 (2005) 4245-4251. http://www.blastanalysis.com/WordDocuments/Dewey%202005.pdf

deflagration, will produce a weaker initial shock … so that more energy is available in the blast at greater distances."

Based on measurements of the explosion of large charges (up to 19,281 kg) of propane and air, it has been found that 20 tons of liquid propane is closely equivalent to 20 tons of TNT. This equivalence, Dewey points out, will vary somewhat depending on the degree of fuel-air mixing (which in real-world situations is influenced by whether a propane vapor cloud originates from a BLEVE, or originates from a tank collapse) and on the shape of the vapor cloud.

Given that 3 million gallons of liquid propane has a mass of 5,695,447 kg, or 6,278 short tons, a unit train at 3 million gallons theoretically contains the blast capability of approximately 6.3 kilotons of TNT. Thus it would take approximately 3.3 unit propane trains to equal the 21 kiloton blast yield of the Trinity atom test. However, the likelihood of all of the propane in a unit train from forming a single vapor cloud is probably rather lower than some circumstance (e.g., earthquake or terrorist activity) which could collapse or breach the big refrigerated tanks. Between them, these two big tanks would hold 23.1M gallons or 48,430 kg of propane, making them blast-equivalent to 2.3 Trinity atom bombs. The big earthquake which could easily release this energy has been determined by geological experts to be almost certain within the life-span of the proposed terminal. To put this in perspective, Hiroshima was 15 kilotons (see photograph), and Nagasaki was 21 kilotons.



Hiroshima: Aftermath of 15 kiloton A-bomb blast and firestorm, 1945.
The degree of harm to Hiroshima's population was completely out of proportion to the improbability of this event: It resulted in 70,000 fatalities and 70,000 injuries (estimated), in a population of 142,700.

Moreover, every week Pembina would be handling or storing in Portland, the equivalent blast threat of one Trinity "gadget" (as the first nuclear bomb was called, before anyone was sure it would work). Because the big tanks would be emptied and refilled on a weekly basis, the average blast potential that would be omnipresent in Portland would be a Trinity-equivalent.

The following table presents TNT-propane blast equivalence results for vapor cloud explosions (VCE), and boiling liquid expanding vapor explosions (BLEVE) which are also a type of VCE, strictly speaking. The oil industry has, in recent years, played down the scientifically established propane/butane/LPG/LNG-to-TNT-to-Atom-Bomb blast equivalence, shown in this table:

Liquid Propane (US Gallons)	Kilotons of TNT	Trinity Equivalents	Size Relative to Mexico City	Fatalities/ Injuries
1.5M (Mexico City, 1984)	3.1	1.6	1x	~600/5,000
3M (Pembina Unit Train)	6.3	1/3	2x	?
Trinity Atom Test	21	1	6x	0
23.1M (Pembina Tank)	48.3	2.3	16x	?
90M (Pembina Future Tank)	188	9.0	60x	?

Mexico City, 1984: A Half-Unit Train Equivalent Blast

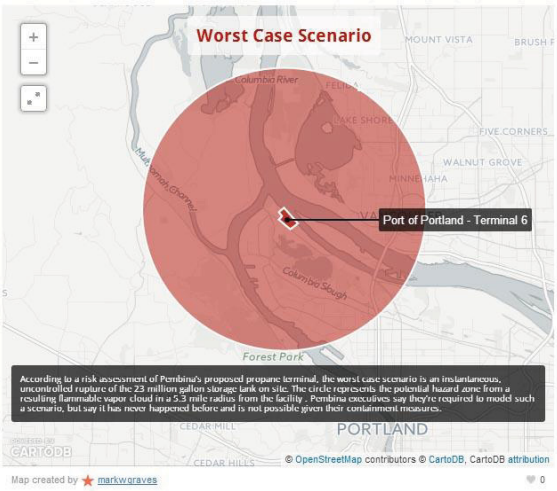
A propane vapor cloud explosion does not mind whether the vapor cloud originates from a BLEVE in a pressurized storage tank, from a collapsed refrigerated tank, or when the propane is accidentally pumped straight into the air. The Mexico City blast is a good example of the destructive power of a propane vapor cloud equivalent in mass to the liquid propane in just half of a unit train. Imagine the potential of eight to thirty times that amount, as detailed in the above table. Here's a compendium of Mexico City press reports:

> **Mexico City, Nov 19, 1984.** Tragic catastrophe at the Pemex liquefied petroleum gas (LPG) facility in nearby San Juanico. As the result of a break in a transfer pipe, propane was pumped directly into the air for an extended period of time under no wind conditions. This resulted in a massive series of explosions and a fire. The initial event led, in a Domino cascade, to multiple BLEVEs, and 3,000 tons of propane release. It caused the death of hundreds of people in a nearby shanty town.
>
> The disaster, one of the largest disasters in industrial history, began when an 8-inch pipe between a propane sphere and a series of cylinders ruptured. The operators could not identify the cause of the pressure drop. The release of LPG continued for about 5 to 10 minutes, and when the gas cloud, estimated at 650 feet x 500 feet x 7 feet high drifted to a flare stack, it ignited, causing a

violent ground shock. The explosions were recorded on a seismograph at the University of Mexico. Close to 600 people died. 5,000-plus suffered severe burns.[21]

The accident started in a large LPG (Liquid Petroleum Gas) storage and distribution centre in San Juan Ixhuatepec, 20 km north of Mexico City. The facilities, owned by the Pemex State Oil Company, consisted of a tank farm: six spherical storage tanks (four with a volume of 420,000 gallons; two with a volume of 630,000 gallons); and 48 horizontal pressurized bullet tanks of different sizes. At the time of the disaster the storage tanks contained 3M gallons of a mixture of propane and butane. The population of San Juan Ixhuatepec numbered about 100,000 people, including 60,000 living in the hills surrounding the village. The majority were poor country people living in one-story houses constructed of concrete pillars filled in with bricks and with roofs of iron sheets. Following the leak, a vapor cloud built up and was slowly blown by a north-east wind towards the ground-located flare pit at the western edge of the plant. The vapor cloud ignited around 5:40 a.m. This was followed by an extensive fire at the plant area. The first tank explosion occurred at 5:45 a.m., and was followed by a dozen explosions within the next hour, some of them of the BLEVE type, due to rupture of one or more storage tanks. Unburned and burning gas entered the houses south of the plant area and set fire to everything. Blast waves from the explosions not only destroyed a number of houses but also shifted several cylindrical tanks from their supports and added more gas to the fire. The smaller spheres and some of the cylinders exploded and fragments, and even whole cylinders weighing around 30 tons, were scattered over distances ranging from a few yards to up to ¾ mile.

We suspect that it is because of Mexico City that the EPA forces propane companies to plot a hazard map that shows the entire amount of propane instantaneously in the air as a vapor cloud mixed with air. We are not surprised that the oil companies try to play down its significance. Here is one of Pembina's worst case maps, for 23M US gallons of liquid propane in a vapor cloud:



[21] More information about this disaster: Arturson G. "The tragedy of San Juanico--the most severe LPG disaster in history." Burns Incl Therm Inj. 1987 Apr;13(2):87-102

Portland Propane Terminal Risk Assessment

UK HSE Tolerability Criteria vs. US Tort law, Rest. (2d) §520

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Abstract

The UK Health and Safety Executive discussion of abnormally dangerous or ultrahazardous activities does not offer clear guidelines or criteria as to how to determine if a particular activity or process is such. Moreover, it is written by British government health officials for Britain, and is unlikely to reflect what is tolerable to Portland. We note that like other parts of the Pembina QRA, this section seems to have been simply copied over, as a shortcut, from European practice by DNV, a Norwegian company.

We consider that the UK HSE criteria are uninformed of what is tolerable in Portland, with the result that it ends up being too backward-looking for Portland; too tolerant of the way things were done, and not supportive enough of future directions towards sustainability. In our view, any conclusions drawn from UK HSE of what is tolerable for Portland should therefore be removed from consideration for this project.

To its credit, HSE section 47 discusses that risks imposed on people should be justified nowadays by more than a little scrutiny of supposed benefits brought about by industrial activity versus the risks of such. However, in suggesting that this is particularly true for risks which could lead to catastrophic consequences, HSE does not present a clear-cut criterion for deciding the issue, and again was written for the UK.

By way of comparison (and as discussed in the NWCSI white paper), United States Tort law, Rest. (2d) §520, provides an actual framework for examining an activity or process to determine if it presents an unavoidable risk of serious harm to others, or their property, despite reasonable care exercised by the actor to prevent that harm. It enumerates the factors to be considered in determining if the risk is so unusual, either because of its magnitude or because of the circumstances surrounding it, that such an activity is "abnormally dangerous" or "ultrahazardous," and therefore subject to strict liability.

Two of the six Rest. (2d) §520 criteria recognize that in a city or town, or place of residence, the presence of factors such as residents not wanting to promote fossil fuels, or of wishing to promote sustainable living, may establish the right of the residents to reject this industrial proposal, which in our view, if not rejected would open the door to Portland quickly becoming the Houston of the NW.

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The Right of US Citizens to Reject Ultrahazardous Activities

The UK Health and Safety Executive discussion of abnormally dangerous or ultrahazardous activities does not offer clear guidelines or criteria as to how we should determine if a particular activity or process is such. Moreover, it is written by British government health officials for Britain, and may not (probably cannot) begin to reflect what is tolerable to Portland, a third of a world away from the UK. Like other parts of the QRA, this section seems to have been simply copied over, as a shortcut, from European practice by DNV, a Norwegian company.

Moreover, the UK HSE criteria is far too agnostic of the way things are done in Portland, with the result that it ends up being too backward-looking for Portland; too tolerant of the way things were done, and not supportive enough of future directions.

Section 47, however, does discuss that there is a growing perception that risks imposed on people should be justified by more than a little scrutiny of supposed benefits brought about by industrial activity versus the risks of such. However, in suggesting that this is particularly true for risks which could lead to catastrophic consequences, it does not present a clear-cut criterion for deciding the issue. By way of comparison (and as discussed in the NWCSI white paper[22]), US Tort law, Rest. (2d) §520, provides a framework for examining an activity or process to determine if it presents an unavoidable risk of serious harm to others, or their property, despite reasonable care exercised by the actor to prevent that harm. It enumerates the factors to be considered in determining if the risk is so unusual, either because of its magnitude or because of the circumstances surrounding it, that such an activity is "abnormally dangerous" or "ultrahazardous," and therefore subject to strict liability. It sets forth six factors which are to be considered in determining liability. These are:

"(a) existence of a high degree of risk of some harm to the person, land or chattels of others;
"(b) likelihood that the harm that results from it will be great;
"(c) inability to eliminate the risk by the exercise of reasonable care;
"(d) extent to which the activity is not a matter of common usage;
"(e) inappropriateness of the activity to the place where it is carried on; and
"(f) extent to which its value to the community is outweighed by its dangerous attributes."

Two of the six Rest. (2d) §520 criteria recognize that in a city or town, or place of residence, the presence of factors such as residents not wanting to promote fossil fuels, or of wishing to promote sustainable living, may establish the right of the residents to reject industrial proposals,

[22]Roxburgh, A., Ebersole R., Helzer T. "Portland Propane Terminal" 3rd rev. ed. Mar 15, 2015, p. 30.

such as the one Pembina has on the table which would open the door to Portland quickly becoming the Texas City or Houston of the NW.

In summary, in our view, UK HSE is not in keeping with the aspirations and hopes of Portlanders. On the other hand, the approach embedded in Tort law, Rest. (2d) §520, is in keeping with what Portland finds tolerable, while keeping the intolerable at bay, and should be applied in Portland and the US instead of UK HSE criteria. Therefore, on the basis of US Tort law, Rest. (2d) §520, and as we have discussed in the NWCSI white paper, a propane terminal at Terminal 6, due to its proximity to high-density housing, and where people live work and play, is inappropriate for Portland, carries far too much earthquake and Terrorist risk, and would be controlled by a company that is more likely less concerned about Portland, Portland's aspirations to be a green city, and would bring more serious liability and risk issues than Portland finds tolerable.

PSC Testimony submitted for April 7th Pembina E-Zone Amendment Hearing

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