PHMSA Safety Regulations for Gas Transmission and Gathering Pipelines Docket number PHMSA-2011-0023

Tom Bender * Nehalem, Oregon * 27 June 2016

SUMMARY: Existing safety regulations and their interpretation and modification totally ignore the magnitudes of potential hazards and impacts on facilities and the public existing with the scale of today's LNG facilities and tankers, the global climate of terrorism potential, and history of actual accidents. Under these conditions, no approval for LNG transport/import-export facilities should occur until the above noted inadequacies have been resolved.

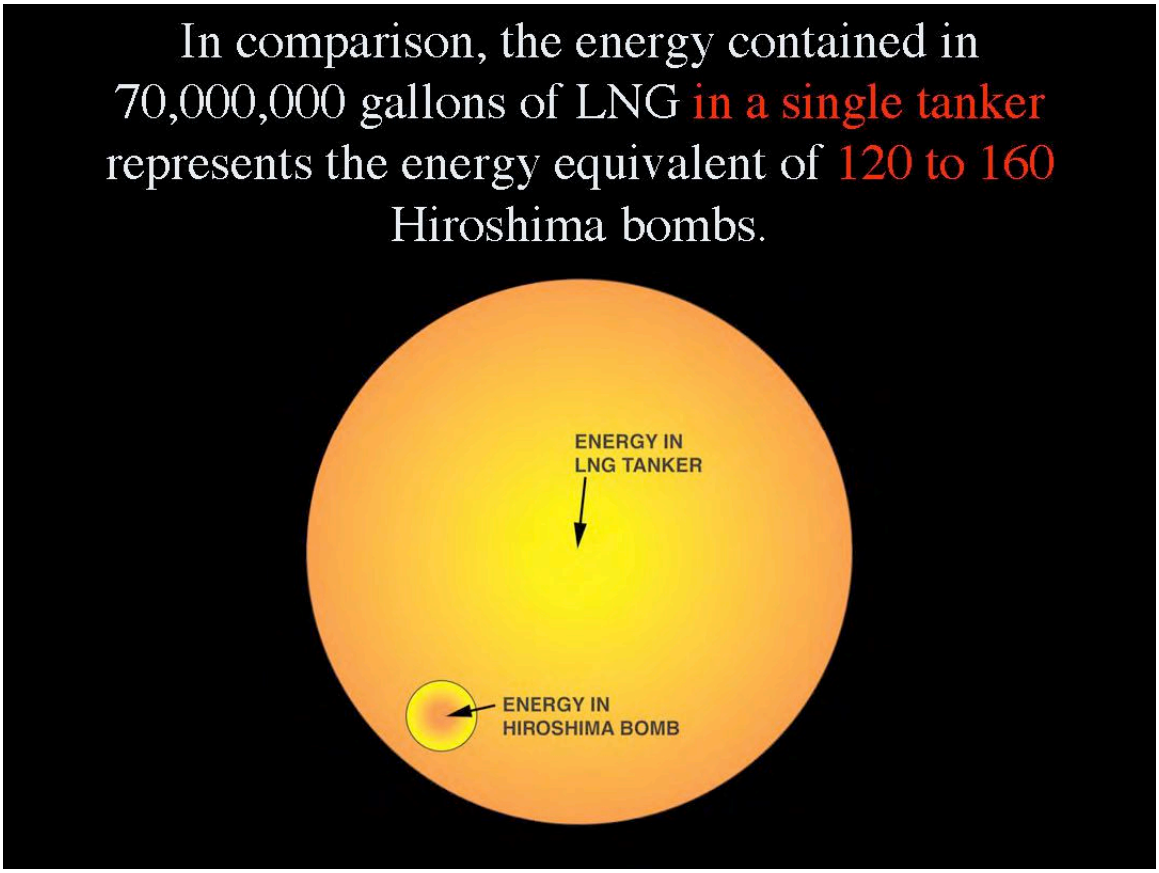
1. THE TRUE MAGNITUDES OF POTENTIAL HAZARDS HAVE BEEN IGNORED:

- "Determination of "Exclusion Zone" requirements for LNG facilities have shrunken from a "design accident" (release) being the catastrophic release of the entire contents of the largest storage vessel on the site to "holes in selected transfer lines". These totally ignore the immense magnitude of potential energy release possible with LNG facilities, water and pipeline transport." (Havens & Venart, 2015)

- Today's largest LNG tankers have a capacity of 70,000,000 gallons of LNG, *with the energy equivalent of 120 to 160 Hiroshima bombs.* Even if only 1% of that capacity ignited explosively, it would have greater impact than the Hiroshima atomic bomb. (Bender, 2014)

- This does not take into account LNG in storage tanks, pipelines, and other petroleum products involved in liquefaction of LNG for transport.

- "One of the U.S. government's responsible responses to the multiple terrorist attacks on 911 included preventing a scheduled LNG ship from entering the Everett, MA, terminal, holding it offshore for several days before directing it to proceed to Elba Island, GA to unload. This was due to concerns that LNG facilities in highly populated areas might be considered attractive targets for terrorist attack. This potential still exists, but is totally ignored by all safety regulations and agencies." (Havens & Venart, 2015)



(Bender, 2014)

2. PUBLIC SAFETY EXCLUSION ZONES ARE NOT BASED ON REALITIES OF HAZARDS:

- "FERC uses Thermal & Vapor Exclusion Zones, for public safety, which are based on a single spill from the largest transfer line for ten minutes.

- "According to Dr. James Fay, professor emeritus at MIT and an expert in LNG safety, "For all credible spills, including terrorist attacks on the storage tank and LNG tanker, the danger zone for humans extends almost four miles from the terminal site. " This does not include cascading and explosive events.

- "The methods used to determine vapor-cloud exclusion zones, particularly the use of "mitigation" methods such as gas-impervious concrete fences to prevent advance of vapor clouds beyond the applicant's property lines, could increase the potential for serious, even catastrophic, vapor cloud explosions. The JCE Terminal DEIS appears to ignore international experiences of catastrophic unconfined vapor cloud explosions (UVCE), at least four of which occurred in the last decade, destroying the facilities involved as a result of cascading events.

- "The JCE DEIS focuses principally on arguments directed to meeting the "letter" of the federal regulations governing a *single* index of public safety - *mathematical modeled* exclusion zones (safe separation distances) intended to keep the public out of harm's way. But this DEIS relies, for prediction of exclusion zone distances, on the use of mathematical models which have not been subjected to adequate (open for public

inspection) validation requirements either by comparison with experimental data or independent scientific peer review.

"Furthermore, the calculations of the exclusion distances for vapor dispersion and vapor-cloud-explosion hazards do not provide any evidence of applicability in near calm conditions coupled with reliance on impermeable (concrete) vapor fences designed to retard vapor cloud travel.

"Until there is produced by the applicant meaningful evidence of the accuracy and applicability-for-purpose of these modeling techniques, and that information is made available for public evaluation and oversight, it must be considered that the potential hazards of storage, handling, and shipping of such massive quantities of energy as are involved in this project could have been seriously underestimated.

- "With these hazard-worsening conditions and the presence of densely packed processing equipment and the vapor fences which become enveloped in the cloud, one could hardly design the releases to better maximize the potential for catastrophic explosion hazard." (Havens & Venart, 2015)

- *"Analysis of accidents indicates that vapor cloud explosions are MORE likely when the quantity in the cloud is MORE than 10,000 pounds." (edited)* (Havens & Venart, 2015) *(70,000,000 gallons rather exceeds this amount.)*

- "A high energy ignition source (such as a fuel-air bomb) also contributes to the probability of occurrence of a vapor cloud explosion.

- "There have been a large number of devastating hydrocarbon explosions, particularly BLEVEs, since 1994. Finally, we note that the design spills considered in the JCE DEIS exceed the 10,000 pound figure suggested by EPA as demarcating the size below which UVCEs are "improbable" (see emphasis added text in the EPA report quoted above) by at least a factor of 10, and in the case of LNG spills, by a factor of perhaps 300. (catastrophic release far greater)

- "The LNG spills are huge, and the vapor clouds formed have linear dimensions of hundreds of meters, with a corresponding potential for excessive flame acceleration.

- "Secondary explosions that could boost the explosion processes cannot be discounted." (Havens & Venart, 2015)

3. PIPELINE TRANSPORT OF LNG IS MORE HAZARDOUS THAN ACKNOWLEDGED:

- Pipelines supplying many proposed LNG facilities would pass through landslide-sensitive geology. Earthquakes present another potential for severe pipeline failures. Oregon, for example, where at least four terminals have been proposed, is overdue for 3000-year subduction earthquake, with R 9.5 lateral movement. Terrorism potentials exist.

- Since 2000, there have been over 400 pipeline accidents in the U.S. (Wiki) From 1986 to 2013, there have been 8,000 incidents (300/year) with $7 billion damage, spilling three million gallons of petroleum products per year. (Center for Biological Diversity) Natural gas is one of the more explosive materials transported via pipelines.

4. WATER TRANSPORT OF LNG HAS UNACKNOWLEDGED HAZARDS:

- Water transport of LNG presents another significantly ignored hazard. The Columbia River Bar is one of the worst in the world, and "delay costs" would prompt bar crossings by LNG tankers in hazardous conditions.

- Location of terminals in populated locations, such as Boston, causes LNG transport tankers to be significant terrorist targets.

5. REGULATIONS HAVE BEEN BASED ON THEORETICAL, MATHEMATICAL STUDIES, NOT REAL TESTS OR EXPERIENCE FROM REAL ACCIDENTS. ACTUAL EXPERIENCE WITH ACCIDENTS INDICATES SIGNIFICANTLY GREATER HAZARDS THAN "REGULATORY THEORY":

Smoke pours from petroleum storage tanks following a 2009 explosion at the Caribbean Petroleum Corp. refinery in San Juan, Puerto Rico. The blast and fire damaged 17 of the 48 tanks at the site, and flames burned for nearly 60 hours. Photo courtesy of the U.S. Chemical Safety and Hazard Investigation Board.

- "DOT's Pipeline and Hazardous Materials Safety Administration (PHMSA) hosted an in-depth discussion of what went wrong during a March 2014 explosion at an LNG facility in Plymouth, Wash., that led to five injuries and $72 million in property damage.

- "During a congressional hearing in April 2015, Rep. Jackie Speier, a Democrat from San Francisco, pointed to the lethal and destructive natural gas pipeline accident in San Bruno, Calif.

- "Late last year, (2015) a leaking Aliso Canyon underground gas storage facility outside Los Angeles, operated by Southern California Gas Co., prompted handwringing that regulators were underprepared.

- "Natural gas and its liquid form are flammable and explosive in confined spaces, but researchers say it's not prone to exploding when released in large, open areas. That's not the case for other heavy hydrocarbons such as propane and ethane, storage of

which occurs at large LNG export facilities.

- "The concern among researchers and regulators grappling with how to regulate LNG safety is the potentially deadly mix of liquid fuels at an LNG site.

- "A recent presentation by Graham Atkinson, a principal scientist in the Major Hazards Unit of the Health and Safety Lab in Buxton, England, focused on what happens when heavy hydrocarbons explode: industrial accidents linked to liquefied petroleum gas (LPG), LNG, gasoline and other petrochemicals:

  "Researchers looked at 24 vapor cloud explosions but focused their attention on four major industrial accidents at gasoline storage sites in Buncefield, England, in 2005; Jaipur, India, in 2009; San Juan, Puerto Rico, in 2009; and at an LPG storage site at Venezuela's Amuay refinery in 2012. Those incidents took place within the last decade and were explosions of so-called unconfined vapor clouds that led to a series of cascading events that ultimately destroyed the facilities.

  "Atkinson said an accident can happen under two conditions. One is a small leak that, after as little as 15 minutes with no wind, can cause a massive explosion that resembles a bomb blast with no epicenter. Devastation is spread evenly across the range of the vapor cloud.

  "The other accident scenario is a large leak on a windy day, *when cloud dispersion from the wind cannot keep up with the volume of gas released.* That, too, creates a cloudsized explosion zone." (Mandel, 2016) (This potential obviously exists with catastrophic release of LNG from a tanker.)

  "The researchers also looked at cases in which flash fires turned into explosions, finding that in some cases a confined space or a congested intersection of piping turned a fire into a blast. "In all but one of the incidents reviewed, when a very large cloud was formed, there was a severe explosion," Atkinson said. In low wind conditions, vapor clouds that accumulated from small, sustained leaks caused blast damage and fatalities nearly half a mile or more from the source. And if a large cloud of gasoline or LPG accumulates, a "severe explosion" is likely, Atkinson said." (Mandel, 2016)

- "In all four cases these clouds were ignited (presumably accidentally) and the explosions resulted in cascading events leading to catastrophic damages to the facilities (refineries/tank-farms) and injury/and/or deaths in the public sector. The following facts are a matter of record for all four:
  - The events occurred in very low wind (near calm or calm) weather conditions.
  - The maximum linear extents of the flammable clouds were at least 250 meters, ranging to at least 650 meters at Amuay.
  - UCVEs occurred in every case that registered above 2.0 on the Richter Scale.
  - The initiating explosions resulted in cascading events leading to total loss of the facilities. " (Havens & Venart, 2015)

- Based on energy facility security studies we did in Oregon Gov. Tom McCall's office during the 1974 Oil Crisis, we realized that highly complex technological cultures are highly vulnerable to unanticipated accidents or intentional harm. Consequently, I

predicted 9/11 fifteen years in advance, and steps needed to prevent. LNG transport and facilities are equally highly vulnerable and impactful targets. (Bender, 1986)

6. POTENTIAL FOR CATASTROPHIC UNCONFINED VAPOR CLOUD EXPLOSIONS (UVCES):

- Terrorist fuel-air bombing of tankers creates powerful shockwaves, potentially impacting storage tanks, incoming/outgoing pipelines, and other facilities. Accidental aircraft crashes may have potential for similar cascading events.

- "We believe the JCE DEIS fails to provide for protection of the public from credible fire and explosion hazards. The conversion of the Jordan Cove facility for export, including provision of gas treatment technology utilizing mixed hydrocarbon refrigerants for liquefaction and removal of heavy hydrocarbons from the natural gas feed to the plant, presents hazards to the project more serious (on a unit weight basis) than with LNG.

  "We believe these additional hazards have been discounted without sufficient scientific justification in spite of multiple international reports during the last decade of catastrophic accidents involving unconfined (hydrocarbon) vapor cloud explosions. It is clear that the increased hazards due to the presence of significant amounts of heavier-than-methane hydrocarbons, for which there is considerably more extensive research and accident experience than for LNG-ONLY projects, and which are “game-changing” in importance, have been seriously under-estimated in this DEIS.

  "We believe the hazards attending LNG export facilities could have the potential to rise, as a result of cascading events, to catastrophic levels that could cause the near-total and possibly total loss of the facility, including any LNG ship berthed there. Such an event could present serious hazards to the public well beyond the facility boundaries.

  "We also believe there remains significant potential for cascading fire and explosion events attending “LNG only” storage and handling that have not been sufficiently addressed, particularly regarding the worst-possible case events that should be considered on the shore side storage tanks and marine side (ship related), either by accident or terrorist activity." (Havens & Venart, 2015)

- Recent accident experience demonstrates that conditions are best for large vapor clouds to form *if there is a mechanism for rapid evaporation of the spilled liquid* and if there are near calm conditions which prevent rapid dispersion. Such obviously is the case with fuel-air bomb terrorist actions which have carefully been ignored.

- "The design spills considered for the Jordan Cove Export Terminal fit both criteria; the conditions considered are low-wind, near calm, and the materials are highly volatile; most volatile in the order of decreasing carbon content: methane, ethylene, propane, and pentane.

  "The simple fact is that while the vapor clouds considered in this DEIS are prevented by physical barriers (vapor fences) from posing a vapor cloud hazard extending much beyond the property line, the holdup of very large quantities of flammable hydrocarbons by the vapor fences causes the gases to accumulate, with spreading largely driven by gravity spreading, so as to completely fill the affected areas to depths of a few meters, with large portions of those gas clouds having concentrations between

the flammable limits.

"Secondary impacts of such explosions would cause rapid evaporation of LNG and potential large vapor cloud explosions." (Havens & Venart, 2015)

7. NO SAFETY REGULATIONS ARE ADEQUATE WHEN REAL-LIFE HISTORY SHOWS THEM IGNORED BY PUBLIC AGENCIES, OR "TWEAKED" TO FALSIFY REAL RISKS:

- In reviews/approvals of four proposed LNG terminals in Oregon, *not a single state or federal agency acknowledged ANY potential terrorism target issues,or safety issues from locating terminal facilities across from runways of public airports in locations with 100mph winds and 100" of rain.*

- "FERC finalized Jordan Cove's EIS in Sept '15, making NO MENTION of Havens and Venart's comments of export risks far exceeding import risks, of ignored cascading hazards." (Mandel, 2016)

- "Initially, "design accident" (release) was taken as the catastrophic release of the entire contents of the largest storage vessel on the site.

  "It later was changed to the "guillotine" severance of the largest transfer line in the facility, with the release duration assumed to be ten minutes, or a shorter time if the applicant could demonstrate the ability to limit the spill duration (such as by incorporation of emergency shutdown procedures).

  "There followed the adoption of a provision by which an alternative release rate and total amount (termed an "accidental leakage rate (ACR) spill" can be submitted by the applicant for approval. Such ACR spills are typically spills from smaller lines (such as branch or instrument lines) rather than the largest lines carrying the hazardous material.

  "The regulation provisions now allow consideration of even smaller releases from "holes" in the selected lines.

  "In our opinion these developments can only be understood as resulting from pressures on the applicants to seek approval of smaller and smaller required exclusion distance determinations. But the requirements placed on the applicant to demonstrate the probability or lack thereof of the different kinds of releases assumed for designation as an ACR are not sufficiently quantified – the process appears to be largely a "good-faith" decision reached jointly by the applicant and the DOT/FERC staffs. In our judgment this is not good science or engineering; it is indicative of regulation that facilitates facility approval – potentially at the expense of public safety." (Havens & Venart, 2015)

8. EVEN GREATER HAZARDS EXIST WITH LNG THAT OVERRIDE ANY POTENTIAL REGULATORY APPROVAL PARAMETERS:

- It is my perception that routine transfer of LNG is not supportable under ANY safety regulations:

  - Global warming impacts of ANY extending use of fossil fuels, such as new LNG facilities, will create inundation, storm damage, and other impacts far exceeding any benefits.

- The processes involved with LNG of pumping, liquefaction, transport by ship halfway around the world, re-evaporation, conversion to electricity, and its transport consume 75% to 80% of the energy in the fuel. Such waste of an irreplaceable resource is unacceptable. Use in area of production, without liquefaction, is far less wasteful.

- Theoretical analysis without any "real" testing is unsupportable as basis for regulations with the magnitude of potential hazards involved.

- Cascading hazard events of the magnitudes involved cannot be predicted.

CONCLUSIONS: No approval for LNG transport/import-export facilities should occur until the above noted inadequacies have been resolved.

*** "**Assessing Explosion Hazards Of Large Hydrocarbon Clouds Formed In Calm Conditions: Are We Doing It Wrong?" Jerry Havens, Department of Chemical Engineering, University of Arkansas, USA. 55th UKELG Meeting on "Dispersion and Consequences of LNG Releases" April 26, 2016 -HSE Laboratory, Buxton Derbyshire.

* "United States LNG Terminal Safe-Siting Policy Is Faulty" Jordan Cove Export Terminal Draft Environmental Impact Statement Docket No. CP13-483 Jerry Havens and James Venart, January 14, 2015.

* "Natural Gas: Explosive LNG Issues Grab PHMSA's Attention", Jenny Mandel, E&E reporter, EnergyWire: Tuesday, June 7, 2016.

* "Statement In Opposition To Approval of the Jordan Cove LNG Terminal Proposal", Tom Bender, 11 December 2014.

* "The End of Nuclear War", Tom Bender. December, 1986.