23 May 2022

TO: CHAIR: Tiffany Brown, VICE CHAIR: Trent Nagele, and Members of the Oregon Seismic Safety Policy Advisory Commission

CC: David Mulligan, Western Regional Office, Pipeline and Hazardous Materials Safety Administration (PHMSA)

Curtis Robinhold, Executive Director, Port of Portland

SUBJECT: CEI Hub Stalemate and Its Oddities

Earlier this year we passed SB 1567 widely regarded as a step forward in dealing with Oregon's poor civic infrastructure rating given by the American Society of Civil Engineers (ASCE): D+. To me the legislative priority is laudable and so too the ASCE grade clearly supported by rigorous research.

I do not regard it as a radical idea that regulated entities should be audited by an expert third party authority. In the effort to perhaps improve the leisurely two year wait for DEQ to even begin its review of CEI Operator self-assessment reports, I contacted the regional office of the US DOT Pipeline and Hazardous Materials Safety Administration (PHMSA) in Denver, CO regarding the safety assessment of above ground storage tanks (AST) of which there are about 400 within the CEI Hub. The response is interesting. Their safety jurisdiction actually encompasses "breakout tanks" (BOT) and there are about 20 of these within the 6-mile hub. Here is the recent response from the Western Regional Office:

> PHMSA makes records available to the public for all regulated pipeline facilities (including breakout tanks). This includes infrastructure, notifications, annual reports, inspection history, enforcement history. PHMSA does not regulate the Zenith Energy tanks in Oregon because they are not considered breakout tanks. We do regulate Zenith Energy pipeline facilities in other parts of the country that meet our regulatory authority.
> Email 18 May 2022 Ref: National Pipeline Mapping System

If you concur that safety is not an optional responsibility, you will find it strange that reporting the existence of such critical tanks to PHMSA is optional. But there is more.

PHMSA has the authority to levy safety standards on ASTs if they serve the BOT function. They do so by rule. Currently PHMSA adopts an industry standard as their US DOT tank safety standard. At present this is API Standard 650, "Welded Steel Tanks for Oil Storage," 11th edition, June 2007, effective February 1, 2012, (including addendum 1 (November 2008), addendum 2 (November 2009), addendum 3 (August 2011), and errata (October 2011)).

Being a post-career engineer with a history of product safety assignments (DOD and NASA projects, and a UK one) I can still read hundreds of pages of specifications and stay awake. The referenced American Petroleum Institute (Houston, TX) spec starts out ominously: "This Standard is designed to provide industry with tanks of adequate safety and reasonable economy for use in the storage of petroleum, petroleum products, and other liquid products."

In my line of work, funding resources for safe design are always debated, and the linking the API safety standard to "reasonable economy" just makes it problematic for the conscientious engineer to get things done right. If you want to argue the point, there is this: my Fortune 500 employer sought full compliance with NASA Space Shuttle safety criteria. The rocket company Thiokol did not comply. The result: Was no fault of mine but I had to watch the Challenger Crew fall out of the sky. Made a lasting impression about having stringent safety criteria and appropriate enforcement.

What kind of spec is API 650? If you rely on the current DOD standard for a complete and proper specification document, namely MIL-STD 961, API 650 looks like a multi-faceted compilation: micro-management guidebook, product fabrication data sheets and repeated liability exemptions from responsibility for anything an industry operator would do after reading the spec.

To be a little more precise, API 650 Table 1-1 lists the Appendix subject matter referenced by the body of the Standard spec. Half of the Appendices on the list are categorized as "Information," "Option", or "Recommendation" (14/26). Among the Appendices exempted from any compliance to the Standard:

Appendix C – Seismic Design of Storage Tanks
Appendix CE – Commentary on Appendix E.

Vulnerability

So this seems a little odd. US DOT agency PHMSA invokes an industry "Institute" Standard that then seems to exempt itself from any seismic design requirements that they know of. Not being a lawyer, I have a question: **Does API 650 do anything for CEI Hub safety?** Unless I missed something, there are no PHMSA BOT safety criteria that PHMSA could use for a safety compliance audit, nor are there any API seismic safety requirements DEQ can reasonably expect CEI AST operators to report compliance with.

More questions arise. Could PHMSA invoke ASCE 7 as OSSPAC has so consistently done over the years? Unfortunately, the OSSPAC mission is to inform the public while not chartered with a role of authority having jurisdiction (AHJ). So a superior ASCE Standard goes begging at US DOT, and OSSPAC has no authority to levy safety corrective action. Nor DEQ.

There is another matter to consider. If the CEI Hub ASTs were built perfectly 100 years ago, to a perfect API Welded Steel Tank Standard, where are the standards/requirements for a proper tank foundation needed for perfect tanks to achieve their perfect seismic safety? The referenced ASCE Grade report for Oregon states that the CEI Hub is built on hydraulic fill. What foundation do you put under a critical infrastructure storage tank? Found one ASCE paper that looks relevant: Performance of Oil Storage Tanks on Vibroflotation Improved Hydraulic Fill in the Port of Tampa, Florida. Not being a Civil Engineer I don't know how to add seismic energy to the referenced hydraulic fill model to see what we get in Portland for a state of the art hydraulic fill foundation, if we had one.

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Perhaps it's just me but I'm thinking the Surfside Champlain Towers South tragedy near Miami is relevant to this discussion. We have learned that concrete is porous to water intrusion, which then exposes reinforcement bar metals to rust formation. This process causes the rusted elements to expand into the concrete, weakening the concrete and reducing the shear strength of the rebar. If the west side Willamette hydraulic fill has a high water-table (the river never goes away, and the fill is 50 to 80 feet in depth) it doesn't take much imagination to wonder about foundation materials now in place.

We recently learned the Port of Portland tested PDX runway subsoils and found seismic vulnerability. [Federal dollars will help make Portland International Airport runway earthquake-ready.]
A brief call to the PSU prof leading the test confirmed there is no funding nor planning to test soils across the Willamette from the Port Terminals. Might be a good move to contact the Port Exec Director Curtis Robinhold about the extent to which the Port relies on the CEI Hub storage tank foundations, the ones of unknown design that rest on untested fill.

The reason it seems like there is a North Willamette stalemate over seismic safety standards and current seismic durability status are several:

1. The Zenith Energy site has been the focus of activist concern for years.

2. None of the Zenith ASTs nor their foundations are within the safety conformance authority of PHMSA or apparently any other responsible safety authority (local, state or federal) reporting to the public.

3. There is a BOT at Wilbridge, 600 yds south of the Zenith site, used for gasoline, diesel and jet fuel transfers, under the safety authority of PHMSA. Its Geotech and foundation status is currently unknown and if investigated could offer clues to nearby Zenith seismic vulnerability.

4. There are close to 400 other CEI Hub ASTs like those at Zenith Energy with unknown tank foundation status, nor are there any standards levied for the range of tank designs that have evolved over the last century, nor for their foundations universally sited on hydraulic fill.

This seems like a brick wall waiting for DEQ to hit in two years, under the terms of SB 1567. The scope and content of the stipulated Seismic Vulnerability Assessments (SVA) are undefined, and no quantitative criteria are cited leaving only qualitative imperatives like review and update mitigation plans.

Is the SVA a site assessment, a regional assessment, a pipeline assessment, a tank assessment, a tank foundation assessment? Note that a word search of SB 1567 fails to find the term "foundation."

A Safety Appendix is offered here as an example of how CEI Hub Safety can be quantified, allowing a numeric basis for identifying corrective actions that bring CEI Hub Safety up to an adequate level prior to a CSZ event.

Respectfully submitted, Tracy Farwell, 503-477-8811, https://better-energy-llc.com/
Not the best, just better

Safety Appendix

What constitutes adequate safety for Oregon's critical infrastructure has not been defined. To help deal with the safety authority and safety criteria stalemate, this Safety Appendix is offered in the hope that eventually at least a better response is elicited.

Among safety practitioners, it is common to declare a safe condition when risks are determined to be acceptable. Infrastructure risk analysis can be expressed in terms of probability of failure in response to the predicted CSZ event. This could be regarded as the next step toward quantified CEI Hub risk analysis after collecting immense amounts of data as provided from the Multnomah County study reported here. CEI Hub Seismic Risk Analysis: https://www.multco.us/sustainability/cei-hub-seismic-risk-analysis

The distinction between reliability and safety is often made in technical literature. In the case of the CEI Hub, tank reliability failure risks pose the safety risks so it is convenient to quantify safety in terms of tank and infrastructure reliability. What are the tank failure hazards that reduce tank reliability? Reliability experts are the ones to decide this but here is a typical list of hazards when exposed to a severe seismic event:

1. Tank wall base separation at foundation plate due to weak design requirements (no consideration of seismic environment), or from accumulated metallurgical corrosion
2. Foundation failure due to hydraulic fill settling during the event, releasing hazardous contents
3. Pipeline coupling separation due to displacement of pipeline supports or tank foundation movement
4. Impact on tank structure from pressure wave or debris stemming from nearby tank or pipeline explosion
5. Tank structure failure from tipping caused by hydraulic fill settlement
6. Etc.

We can postulate a CEI Safety Index made up of the cumulative CEI Hub Infrastructure Reliability.

CEI Safety Index = $\prod_{i=1}^{n} R_i$
which involves evaluating the reliability of each CEI Hub zone, then multiplying the reliability numbers together. This is conventionally described as the Series Reliability method. https://reliawiki.org/index.php/RBDs_and_Analytical_System_Reliability

Example
Assume these predicted reliability probabilities are determined after SVA as follows.

Kinder Morgan North:	R(KMN)	= 0.8
Linnton North	R(LN)	= 0.8
Linnton South	R(LS)	= 0.8
NW Natural	R(NWN)	= 0.8
Willbridge	R(WB)	= 0.8
Equillon	R(EQ)	= 0.8

Then the cumulative risk posed by each CEI Zone is represented by

CEI Safety Index = R(KMN) * R(LN) * P(LS) * P(NWN) * P(WB) * P(EQ) = 0.262

This is to be compared with the assumed reliabilities before the event, for example,

Kinder Morgan North:	R(KMN)	= 0.999
Linnton North	R(LN)	= 0.999
Linnton South	R(LS)	= 0.999
NW Natural	R(NWN)	= 0.999
Willbridge	R(WB)	= 0.999
Equillon	R(EQ)	= 0.999

Which gives a cumulative CEI Safety Index = 0.994.

Comparing the CEI Safety Index before and after the SVA offers a quantified measure of improvements needed for eventually adequate infrastructure safety.

Rules for quantifying vulnerability of each zone using the probability of Hub failure are important and should represent capacity of each tank in the zone, its pipeline couplings, its flammability, its API gravity, its structural status, its Geotech characteristics, its foundation status, its age and perhaps other factors. This report offers tank inspection practitioner insight from relying on guidance from API 653: https://www.commtank.com/tank-articles/preventing-storage-tank-replacement/

If the Safety Advisory Commission (not just a Policy Advisory Commission) sets a CEI Safety Index of 0.850 (for example) as adequate for Port needs and those of the public at large, conventional probability math would call for all of the zone reliability numbers to be improved. Examples of how to improve zone reliability numbers include retiring tanks where credible reliability cannot be decided (due to age or poor documentation or critical unknowns) or by retrofit hardening of hydraulic fill soils, or by rebuilding tanks on state-of-the-art foundations for water-saturated sandy soil.

Helpful link explaining statistical methods is provided here.
Series Reliability: https://reliawiki.org/index.php/RBDs_and_Analytical_System_Reliability