WSPA
Jim Verburg
Senior Director, NW and SW Climate and Fuels

March 4, 2023

Sent via upload to: https://sppr.ecology.commentinput.com/?id=6Mx2s

Ms. Brittany Flittner
Department of Ecology
Spill Prevention, Preparedness, and Response Program
P.O. Box 47600
Olympia, WA 98504-7600

Re: WSPA Comments on CR-102 for WAC 173-180 and WAC 173-184 Amendments

Dear Ms. Flittner,

Western States Petroleum Association (WSPA) appreciates the opportunity to comment on the Washington State Department of Ecology (Ecology) proposed rulemaking (CR-102) for amendments to WAC 173-180 (oil spill prevention and oil transfer requirements for regulated oil handling facilities) and WAC 173-184 (oil transfer requirements for vessels delivering oil in bulk on or over waters of the state). WSPA is a trade association that represents companies which provide diverse sources of transportation energy throughout the west, including Washington. This includes the transporting and marketing of petroleum, petroleum products, natural gas, and other energy supplies.

Ecology has published draft rule language for WAC 173-180 and WAC 173-184. WSPA appreciates the stakeholder input process employed by Ecology during the CR-101 phase of the rulemaking for example the removal at our request of certain process safety management (PSM) elements from the spills analysis portion of the draft WAC 173-184 rules that were not fit for purpose.

This letter addresses WSPA's remaining concerns with the draft rule language. In general, we request that Ecology change its approach in several sections to ensure that the amended regulations are appropriately tailored to achieve Ecology's objective of reducing spill risk while avoiding unreasonable requirements that create a burden on the regulated entities that is disproportionate to the risk and impact Ecology seeks to address.[1]

General Comments

Need for Detailed Cost Analysis. It is concerning that no analysis was provided in the Preliminary Regulatory Analyses (dated January 2023 – Publication 23-08-001) regarding the direct costs of replacing or making significant changes to large secondary containment systems already in place at Tier 1 facilities pursuant to proposed WAC 173-180-320(1)(c). In addition, Ecology staff indicated during CR-101 consultation meetings and workshops that a detailed cost analysis of proposed WAC 173-180-330 control measures to be installed at existing Tier 1 facilities would not be performed by the agency. A range of potential costs of implementing the proposed rule for storage tanks and transfer piping (using "standardized cost estimates") are presented in Ecology's Preliminary Regulatory Analyses (PRA), dated January 2023.[2] As shown in Ecology's PRA, the costs to comply with the proposed rule changes could be significant which re-enforces that need for a detailed cost (and operability) analysis.

[1] *See, e.g., Nollan v. Cal. Coastal Comm'n*, 483 U.S 825 (1987); *Dolan v. City of Tigard*, 512 U.S. 374 (1994); *Chong Yim v. City of Seattle*, 194 Wn. 2d 651, 684, 451 P.3d 675 (2019); (Washington adopts federal standard for takings).
[2] Washington State Department of Ecology. "Preliminary Regulatory Analyses: Chapter 173-180 WAC and Chapter 173-184 WAC", Publication 23-08-001. January 2023.

In order to further inform Ecology further of the potential cost and operational limitations of this rulemaking, WSPA has retained an independent third-party contractor, Turner Mason, to conduct a cost and operability analysis focused on the proposed requirements of WAC 173-180-330 (Turner Mason Report). This independent, third-party assessment is provided in Attachment A to this comment letter.[3] The Turner Mason Report found that the costs for retrofits to existing tank systems can widely range with potential expenditures approaching $100 million for just WSPA-member company facilities. While the independent Turner Mason Report is a robust analysis, it is important to note that it does not consider all associated operational costs of retrofits. Other key findings from the Turner Mason cost and operability assessment include:

- A significant amount of the cost for seismic-related upgrades is associated with smaller sized tanks (despite smaller potential spill volumes).
- Bellows-style connections (with continued expansion, retraction, and vibration) are not expected to last as long as hard pipe (i.e., require replacement) with additional inspection and maintenance needed to manage these piping connections.

Note that the additional costs associated with piling foundations, piping retrofits, out-of-service tank usage during retrofits, and loss of capacity from short-cycling or reducing tank fill height operating levels were not considered in the Turner Mason Report due to the wide-range of tank and facility designs. These additional costs must be taken into account by Ecology.

Risk Analyses Should Precede Control Measures. As the proposed amendments are written, a facility would be required to complete spill risk analysis (under WAC 173-180-630(13)) pursuant to an expanded formal process. However, Ecology's amendments to the rules appear to require modifications to existing facilities to address seismic risk without reference to, and potentially in advance of, the risk analysis. WAC 173-180-330 and 173-180-340. Facilities must be able to assess current seismic status and the full scope of any equipment and operational changes through completion of a risk analysis in order to properly determine the effective and safe installation of any seismic-related tank, pipe, and/or containment system modifications/upgrades, or if the system currently meets seismic event criteria. As noted in the Turner Mason Report regarding operability:

- Flexible piping may not be as reliable as the existing hard piping and may be more prone to leakage.
- Control measures identified in the proposed WAC 173-180-330 and WAC 173-180-340 may not be appropriate for certain tanks and piping (i.e., one size does not fit all).

Given the importance of the risk analysis in informing operators as to the most appropriate and safe control measures, WSPA requests that the proposed rule language clearly addresses the role of the risk analysis process in determining the need for additional control measures. The oil spill risk assessment should be completed before seismic control modifications are prescribed to ensure that the regulatory burden is tailored to and not disproportionate to the risk and impact Ecology seeks to address.[4]

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[3] Turner Mason & Company. "Refining Industry Economic Impact Assessment Washington State Amendment to WAC Chapter 173-180, 184", February 16, 2023.
[4] *See Nollan v. Cal. Coastal Comm'n*, 483 U.S 825 (1987); *Dolan v. City of Tigard*, 512 U.S. 374 (1994); *Chong Yim v. City of Seattle*, 194 Wn. 2d 651, 684, 451 P.3d 675 (2019); (Washington adopts federal standard for takings).

Timeline Inadequate. The timeline to comply with the proposed changes to WAC 173-180 has not been completely and thoroughly addressed by Ecology. For example, containment and/or control system modifications pursuant to the proposed changes to WAC 173-180-320 and WAC 173-180-330 could take up to a decade or more to complete. Ecology needs to provide stakeholders with guidance on implementation of rule changes and provide a grace period so that facilities have a realistic timeline to complete these secondary containment changes or upgrades. For plans, tanks, piping due for inspections or updates soon after the rule effective date, no time is available for front-end risk analysis, engineering and project definition and project approval cycles. Furthermore, Ecology should provide facilities with sufficient time after rules go into effect to complete requirements related to secondary containment permeability measurements, seismic/hydrostatic calculations, and spill risk analysis in updating Spill Prevention Plans.

Specific Comments

WAC 173-180-221 Rate A Prebooming. In certain inlet/bay areas, the rapidly changing conditions, in conjunction with high currents often present in these environments have made prebooming difficult. Regulatory agency acceptance of alternatives to prebooming, places have routinely been considered acceptable in these situations to limit the additional operational logistical complexity and risk at facilities located in these outlying areas along tidally affected rivers. It appears that proposed regulatory language would require frequent tending by boat crews and undermine the use of alternatives. This increased frequency of on-water crew interaction at all hours, as required in proposed WAC 173-180-221 (5) would result in an increased risk of personal injury, thereby violating the safe aspect of the safe and effective requirements for prebooming. WSPA requests that include in the proposed regulatory language the historic flexibility to use alternatives to prebooming that account for rapidly changing conditions of inlet and bay areas.

WAC 173-180-320(1)(c) Secondary Containment Requirements. The addition of new WAC 173-180-320(1)(c) appears to serve the same purpose of existing WAC 173-180-320(1)(a). The addition of WAC 173-180-320(1)(c) makes WAC 173-180-320(1)(a) redundant and potentially confusing to regulated parties. WSPA suggests that new WAC 173-180-320(1)(c) be integrated into or replace WAC 173-180-320(1)(a).

WAC 173-180-320(9)(b) Secondary Containment Requirements. The proposed WAC 173-180-320(9)(b) states that *"secondary containment systems must be designed to withstand seismic forces."* However, the term *"seismic forces"* is not adequately defined in the rule, nor are the related terms "seismic events" and "seismic motion" defined. For example, it is not clear what Richter Scale earthquake or magnitude of Tsunami is considered significant by Ecology to require API 650 Annex E adoption. By their own terms, the standards in Annex E are only required for tank construction if specified by the purchaser. By contrast, the proposed regulations require adoption of Annex E without a clear definition of seismic event/forces). WSPA requests that the terms *"seismic forces", "seismic events" and "seismic motions"* be defined further in this subsection or in WAC 173-180-025 (Definitions).

WAC 173-180-330(2) Storage Tank Requirements. Ecology's proposed seismic requirements impose a potentially significant burden on existing operations without adequately recognizing that many storage tanks may already be designed to a standard that is sufficient to address seismic risk (API 650 Annex E). Additionally, any required modifications appear to be imposed independent from the risk assessment required by the rules that would inform the nature of the modifications that would meet Ecology's stated goal. Accordingly, to recognize that existing tanks may not require modifications because they were built to API 650 Annex E or meet the requirements of API 650 Annex E or other seismic risk and additional risk mitigation methods, WSPA suggests that the proposed subsection (2) language below amended as follows:

> *"(2) Storage tanks constructed before the effective date of this rule must either: demonstrate to Ecology that the storage tank is designed in accordance with and satisfies the performance goal of the seismic design requirements of API Standard 650 (2020), including Annex E and section E.7.3 Piping Flexibility; or, modify the existing tanks and piping system to ~~include protective measures that are designed, installed, and maintained to~~ reduce risk from seismic events. Acceptable system modification designs should be identified as part of the risk analysis required by WAC 173-180-630(13) and ~~and that~~ include one or more of the following:*
>
> *(a) Flexible mechanical device(s) between storage tank and piping or sufficient piping flexibility to protect the tank and pipe connection and prevent the release of product;*
> *(b) Foundation driven pilings;*
> *(c) Anchored storage tanks; or*
> *(d) Another seismic protection measure proposed by the facility and approved by ecology, as long as such protection measure equals or exceeds those required in this section. ~~This may include demonstrating the storage tank meets API Standard 650 (2020) seismic design requirements, including Annex E and section E.7.3 Piping Flexibility~~."*

WAC 173-180-330(6) Storage Tank Requirements. To include the industry standard for inspecting horizontal tanks, the following addition to this subsection is recommended:

> *"(6) Storage tanks must be maintained, repaired, and inspected in accordance with the requirements of API Standard 653 ((dated January 1991)) (2014 with Addendum 1 (2018) and 2 (2020)), or Steel Tank Institute SP001 5th edition September 2011, unless the operator proposes an equivalent inspection strategy which is approved by ecology. (((4) A record of all inspection results and corrective actions taken must be kept for the service life of the tank and must be available to ecology for inspection and copying upon request.))"*

WAC 173-180-630(10)(g) Class 1 Facility Prevention Plan Content Requirements. New WAC 173-180-630(10)(g) states that each plan must describe spill prevention technology currently installed and in use, including; *"Secondary containment, including capacity, permeability, and material design Permeability must meet requirements in WAC 173-180- 320(1)(e)."* The proposed language does not contain any specific numerical reference to permeability, criteria outlining acceptable limits or benchmarks, or consideration of variable permeability factors. As a result, the impetus is put on the owner/operator to demonstrate their ability to respond to a spill using all aspects such as existing physical conditions, response time, available equipment, transfer pumping, etc.

The proposed rule also does not identify what permeability value is acceptable or what value represents non-compliance with the rule or define what constitutes a ground penetration release from secondary containment if high permeability is a contributing factor. Further, the proposed regulations do not take into account that the high amount of precipitation in Washington limits the permeability in secondary containment areas due to oil products floating on stormwater inside of secondary containment systems which delays the oil spills from directly penetrating into soil containment systems. The delayed penetration into soils of petroleum spills due to the collection of storm water in secondary containment systems allows more time for spill clean-up and would negate the permeability (k) factor in many situations. WSPA suggests that Ecology reconsider how permeability is assessed in the proposed rule.

WSPA appreciates the opportunity to provide comments on this important proposed regulation. If you have any questions regarding this submittal, please contact me at (360) 296-0692 or via email at jverburg@wspa.org.

Sincerely,

James Verburg
Senior Director, NW and SW Climate and Fuels
WSPA

Attachment A: Turner Mason & Company. "Refining Industry Economic Impact Assessment Washington State Amendment to WAC Chapter 173-180, 184", February 16, 2023

ATTACHMENT A

ECONOMIC IMPACT ASSESSMENT OF WASHINGTON STATE PROPOSED AMENDMENT TO WAC CHAPTER 173-180, 184

Turner, Mason & Company – February 16, 2023

REFINING INDUSTRY

ECONOMIC IMPACT ASSESSMENT OF WASHINGTON STATE PROPOSED AMENDMENT TO WAC CHAPTER 173-180, 184

FEBRUARY 16, 2023

WSPA

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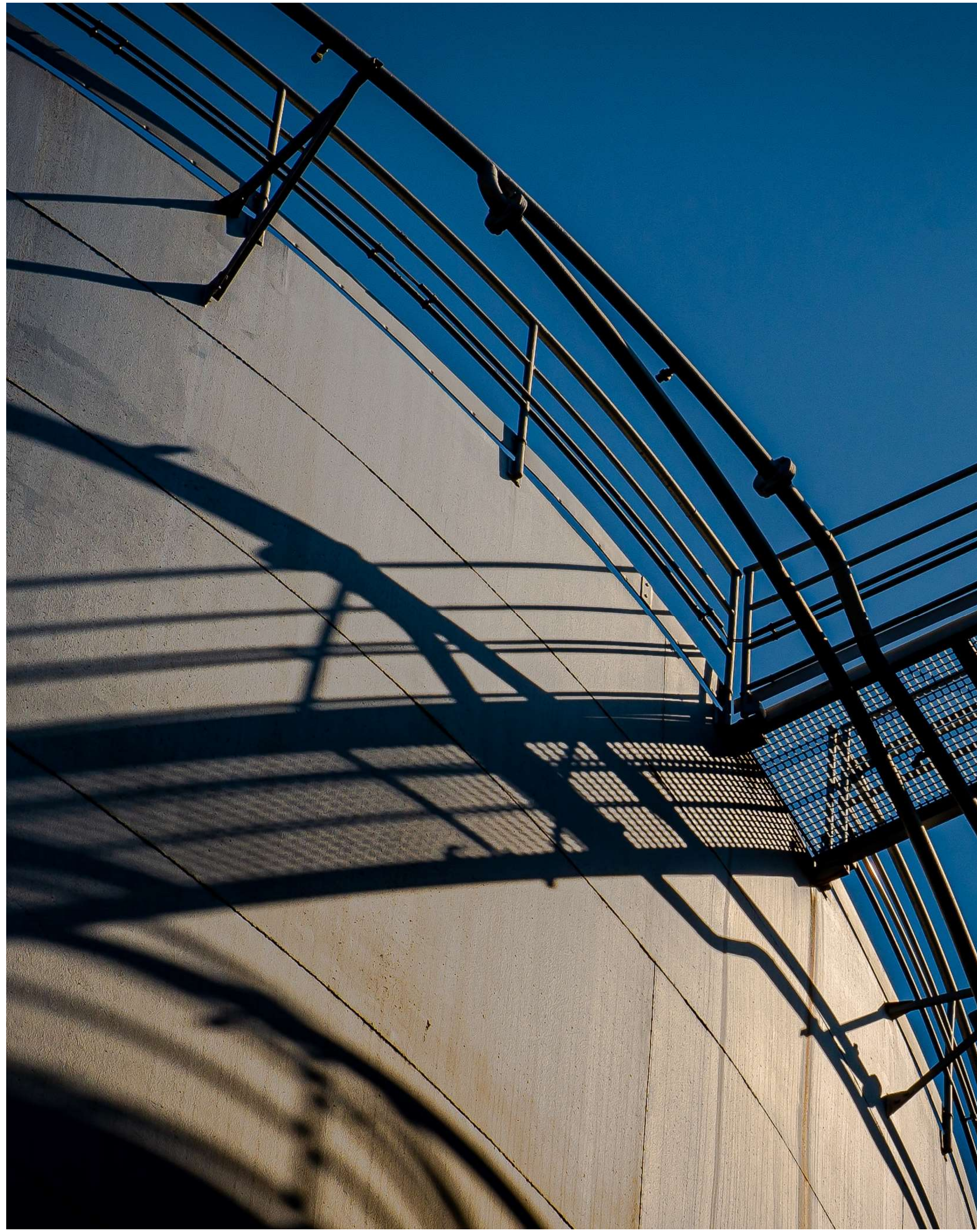

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SCOPE OF WORK:

Turner, Mason & Company (TM&C) was engaged to undertake an independent assessment of the measures which WSPA Washington refiner members currently have in place to satisfy API STD 650, Annex E and the proposed amendments to WAC Chapter 173-180 and 173-184, as well as an independent assessment of the measures which would need to be taken to reach full Annex E compliance. This assessment also factored in any incremental benefit / risk of the proposed amendments, including operability / feasibility.

APPROACH:

1. Analysis of API STD 650 Requirements
2. Survey of WSPA Washington refiner member companies
3. Networked with various Engineering Procurement and Construction (EPC) contractors, equipment vendors, and facility project teams
4. Perform API STD 650 design calculations on data provided by member facilities

EXECUTIVE SUMMARY:

TM&C expects the WAC 173-180 revisions, in their current form, to cost WSPA Washington refiner members up to an estimated $18MM combined to update existing tanks. This assumes that either tank anchoring or flexible piping would be enough to satisfy the requirements and that existing ringwalls are sufficient for seismic anchoring purposes. The total cost could be higher if additional tanks are included.

If companies were required to update existing tanks to meet Annex E, the total cost would be difficult to predict given the large amount of unknown factors. However, it could be as much as $178MM to modify the tank shells, floors, and foundations. Operational decisions could significantly reduce this amount.

SUMMARY:

- The existing tankage infrastructure is aged, with 89% of the tanks being built prior to the first implementation of WAC 173-180-330 in 1994.
- The larger-volume tanks tend to be permitted to self-anchor per Annex E.
- The cost-effectiveness between flexible piping and anchoring can vary from tank to tank.
- Some API STD 650 tanks could require significant modifications or even a rebuild to meet the more demanding loads accounted for in Annex E.

BACKGROUND

HISTORY OF API STD 650, ANNEX E

Welded Steel Tanks for Oil Storage

API STD 650

API STD 12C preceded API STD 650. The first version of API STD 12C was published in July 1936. The final version, the 15th Edition, was published in March 1958.

API STD 650 replaced API STD 12C in December 1961. The 13th Edition, the most recent version of the document, was published in March 2020.

Annex E

Annex E, which covers seismic considerations, was added to the standard in the 1979 publication (1977 Edition).

Annex E has gone under several significant revisions since its introduction. API STD 650 states that the specifications in Annex E are only required for tank construction if specified by the purchaser.

WAC CHAPTER 173-180 AND 173-184

Current Regulatory Text

173-180 Facility Oil Handling Standards

173-180-330 Storage Tank Requirements

Storage tanks constructed after the adoption date of this section must meet or exceed the 1993 version of the NFPA No. 30 requirements and one of the following . . .

(a) . . .

(b) API STD 650, Welded Steel Tanks for Oil Storage dated November 1988,

(c) . . ., or

(d) Otherwise approved by ecology . . .

173-184 Vessel Oil Transfer Advance Notice and Containment Requirements

No specific mention of API STD 650

WAC CHAPTER 173-180

Proposed Regulatory Text

173-180: Facility Oil Handling Standards

173-180-330: Storage Tank Requirements

Storage tanks constructed after ~~the adoption date of this section~~ May 1994 and before the effective date of this rule must meet or exceed the 1993 version of the NFPA No. 30 requirements and one of the following . . .

(a) . . .

(b) . . . API STD 650, Welded Steel Tanks for Oil Storage (1988) unless otherwise approved

(c) . . ., or

(d) Otherwise approved by ecology . . .

Commentary

While rule 173-180-330 was adopted in 2006, it superseded rule 173-180A-090 which became effective on June 4, 1994. Thus, this rewrite of 173-180-330 extends new rules to tanks built on June 1 – 3, 1994.

According to the data provided, we did not identify any tank construction dates which were commissioned during this three-day period.

WAC CHAPTER 173-180

Proposed Regulatory Text for Storage Tanks – 173-180-330

(2) Storage tanks **constructed before the effective date of this rule** must include protective measures that are designed, installed, and maintained to reduce risk from seismic events and that include **one or more** of the following:

(a) Flexible mechanical device(s) between storage tank and piping or sufficient piping flexibility to protect the tank and pipe connection and prevent the release of product;

(b) Foundation driven pilings;

(c) Anchored storage tanks; or

(d) Another seismic protection measure proposed by the facility and approved by ecology, as long as such protection measure equals or exceeds those required in this section. This may include demonstrating the storage tank meets API Standard 650 (2020) seismic design requirements, including Annex E and section E.7.3 Piping Flexibility.

WAC CHAPTER 173-180

Proposed Regulatory Text for Storage Tanks – 173-180-330

(3) Storage tanks **constructed after the effective date** of this rule **must meet the following requirements:**

(a) **Meet or exceed** the 2021 version of the NFPA No. 30 requirements **and one of the following** design and manufacturing standards:

(i) . . .

(ii) API Standard 650, Welded Steel Tanks for Oil Storage (2020);

(iii) . . .

(iv) . . .

(b) **Must be designed to meet** the following seismic design requirements:

(i) API Standard 650 (2020) seismic design requirements, including Annex E and section E.7.3 Piping Flexibility;

(ii) American Society of Civil Engineers (ASCE) 7-22 Risk Category III or IV, including Site Class A, B, C, D, E, or F based on on-site soil properties, and meet seismic design requirements under chapter 16 of the 2021 International Building Code (IBC) and WAC 51-50-1613 and 51-50-1615

WAC CHAPTER 173-180

Proposed Regulatory Text for Pipelines – 173-180-340

(3) All pipelines constructed **before the effective date of this rule** must include protective measures that are designed, installed, and maintained to reduce risk from seismic events and include **one or more** of the following, and are also installed under the provisions of chapter 57 of the 2021 International Fire Code (IFC), where applicable:

(a) Flexible mechanical device(s) between storage tank and piping or sufficient piping flexibility to protect the tank and pipe connection and prevent the release of product;

(b) Flexible mechanical device(s) or adequate pipeline flexibility between pipes;

(c) Pipeline supports that protect against seismic motion;

(d) Automatic emergency isolation shutoff valves that are triggered to close during seismic events; or

(e) Another seismic protection measure proposed by the facility and approved by ecology, as long as such protection measure equals or exceeds those required in this section.

WAC CHAPTER 173-180

Proposed Regulatory Text for Pipelines – 173-180-340

(5) Pipelines constructed **after the effective date** of this rule **must also**:

(b) Be **designed to API Standard 650 (2020), Annex E, section E.7.3 Piping Flexibility** when connected to storage tanks;

(c) Be installed under the provisions of chapter 57 of the 2021 IFC, where applicable, and **include one or more** of the following:

(i) Flexible mechanical device(s) or adequate pipeline flexibility between pipes;

(ii) Pipeline supports that protect against seismic motion;

(iii) Automatic emergency isolation shutoff valves that are triggered to close during seismic events; or

(iv) Another seismic protection measure proposed by the facility and approved by ecology, as long as such protection measure equals or exceeds those required in this section.

WAC CHAPTER 173-180

Storage Tank Definition – 173-180-025

API STD 650 defines a storage tank as containers that meet both of the following criteria:

- aboveground connected to **transfer pipelines** or any aboveground greater than 10,000 gal (238 bbl)
- used to store bulk quantities of oil (crude oil, gasoline, diesel, oil sludge, biological oils, etc.)

Specifically excluded by WAC 173-180-025:

- Tanks regulated by 90.76 RCW (underground storage tanks, now changing to say 70A.355 RCW), rolling stock, wastewater treatment equipment, process pressurized vessels or other tanks used in the process flow through portions of the facility

Member data which did not meet the above criteria was excluded from this study.

While the definition of "storage tank" did not change much, the definition of "transfer pipeline" did

Source(s): WAC 173-180-025

WAC CHAPTER 173-180

Transfer Pipeline Definition – 173-180-025

Definition

"Transfer pipeline" is a buried or aboveground pipeline used to carry oil to or from a tank, ~~vessel or~~ transmission pipeline, or ~~to a~~ vessel, ~~and the first valve inside secondary containment at the facility~~ provided that any discharge on the facility side of ~~that~~ the first valve inside secondary containment will not directly impact waters of the state…

"Tank vessel" means a ship that is constructed or adapted to carry, or that carries, oil in bulk as cargo or cargo residue…

Commentary

By changing the definition of a transfer pipeline from a "pipeline used to carry oil to or from a tank vessel" to a "pipeline used to carry oil to or from a tank," the meaning of the sentence is changed. However, the code states "a transfer pipeline does not include process ~~pipelines~~ piping" and the definition of "process piping" clearly states that it includes tankage interconnecting piping (tank to tank). Thus having process piping still does not make a tank a storage tank.

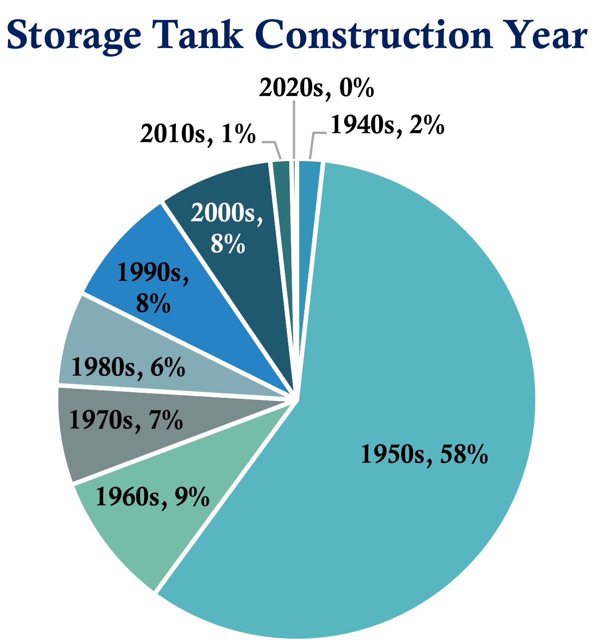
While the net result of these definition changes may not be significant, they should be taken under consideration

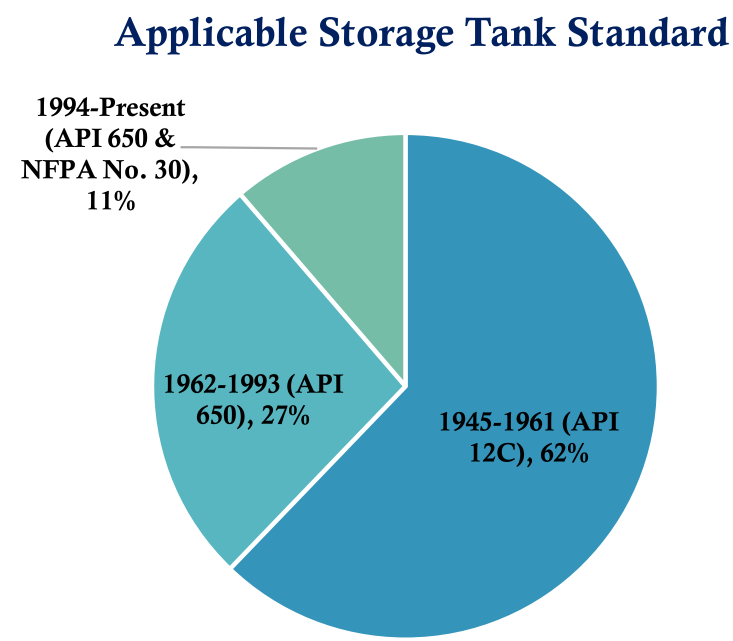
CURRENT STATUS OF MEMBER FACILITIES

MEMBER FACILITY STATISTICS

Storage Tank – Construction Year / Design Standard

Of the tank data which was submitted, 291 storage tanks would potentially be impacted by a change in the rules. Of those, 283 have a known year of construction.





62% of storage tanks were built on API 12C, and 89% were built prior to the implementation of WAC 173-180-330 in 1994

MEMBER FACILITY STATISTICS

Storage Tank – Construction Year / Design Standard

Of the 291 storage tanks, 25 were confirmed to have been built to Annex E.

Many facilities have already resorted to building tanks in recent years to Annex E, with some making Annex E the standard for new tanks

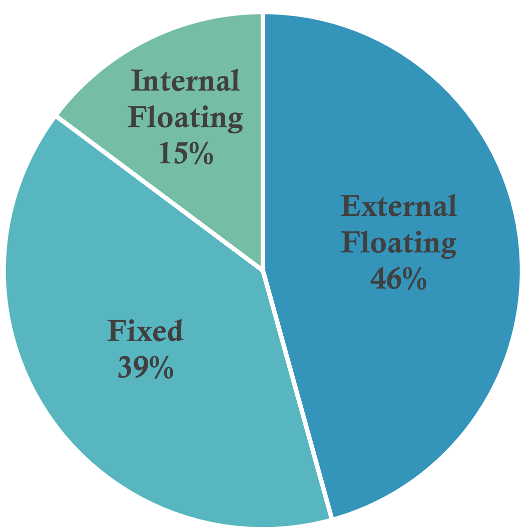
99 of the tanks listed in the data submitted lacked adequate information to determine whether or not this study was applicable. These tanks were excluded from the assessment.

MEMBER FACILITY STATISTICS

Storage Tank – Roof / Foundation Designs

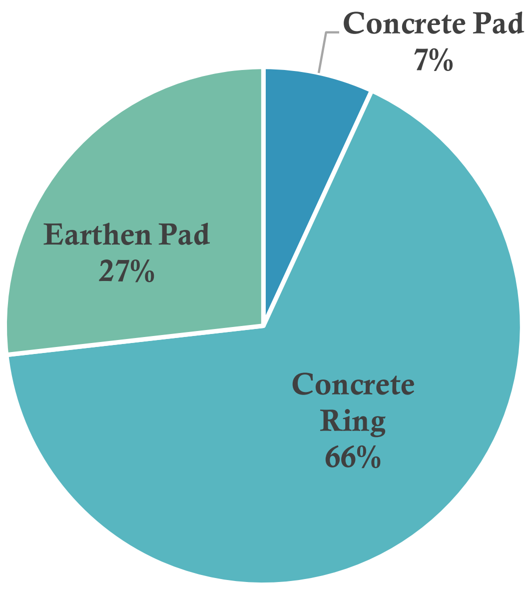
Roofs

An estimated 40% of the tanks have a fixed roof, 15% have internal floating, and 45% have an external floating roof.



Foundations

It's estimated that 73% of the member tanks covered under this regulation have a concrete pad or a concrete ringwall. About 18% of those tanks are mechanically-anchored, making 13% overall.



MEMBER FACILITY STATISTICS

Storage Tank – Anchorage Description

Tanks are either mechanically anchored or self-anchored. Mechanical anchors consist primarily of bolts or straps that attach the tank to concrete to hold it in place.

Self-anchored tanks have no anchor, but are instead held in-place by the weight of the tank and product.

Annex E explains how to calculate an Anchorage Ratio to determine whether or not a tank needs to be mechanically-anchored to comply with Annex E:

Table E.6—Anchorage Ratio Criteria

Anchorage Ratio J	Criteria
$J \leq 0.785$	No calculated uplift under the design seismic overturning moment. The tank is self-anchored.
$0.785 < J \leq 1.54$	Tank is uplifting, but the tank is stable for the design load providing the shell compression requirements are satisfied. Tank is self-anchored.
$J > 1.54$	Tank is not stable and cannot be self-anchored for the design load. Modify the annular ring if $L < 0.035D$ is not controlling or add mechanical anchorage.

MEMBER FACILITY TANK GROUPS

Grouping Methodology and Observations

In order to provide consistent costing, the tanks were grouped by volume with other like tanks. They were then further divided by foundation type, resulting in the formation of 14 tank groups.

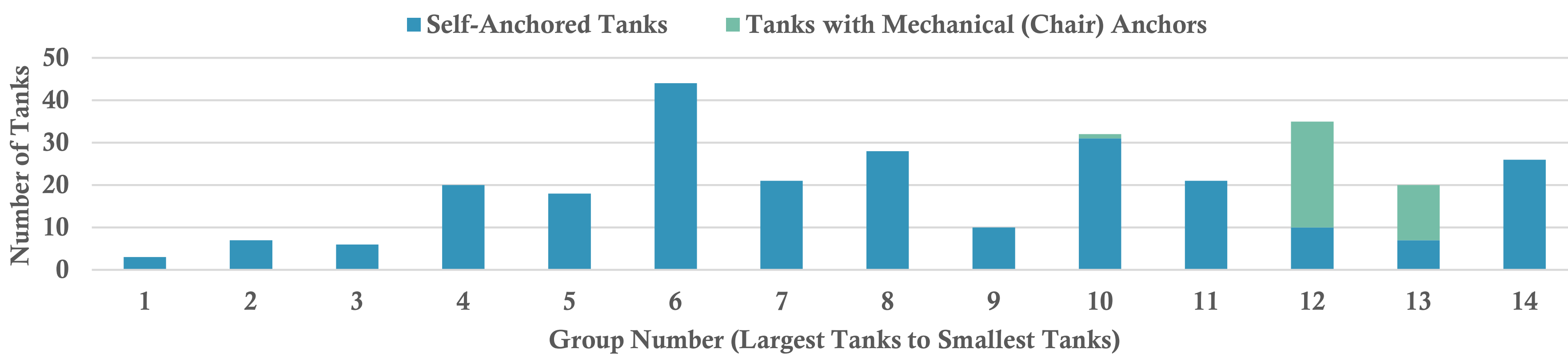
Tanks that did not have an assigned roof type, foundation type, or anchor method were categorized based on key data and the ratios of the known tanks.

After group formation, the number of mechanically-anchored and self-anchored tanks were counted.

MEMBER FACILITY TANK GROUPS

Combined Tank Information								
Group	Shell Capacity (bbl)	Tank Height (ft)	Tank Diameter (ft)	Year Constructed	Roof Type	Foundation Type	Self-Anchored Tanks	Mechanically-Anchored
1	600,000-705,000	64	260-280	1970s	External Floating	Concrete Ring	2 (1)	0
2	295,000-350,000	48-60	190-210	1970s-Present	External Floating	Concrete Ring	6 (1)	0
3	200,000-250,000	42-53	166-200	1950s-1990s	External Floating	Concrete Ring	6	0
4	150,000-200,000	40-60	140-180	1950s-1990s	External Floating, Internal Floating, & Fixed	Concrete Ring	20	0
5	100,000-150,000	40-56	120-160	1950s-1990s	External Floating, Internal Floating, & Fixed	Concrete Ring	10 (8)	0
6	75,000-100,000	38-48	118-130	1950s-1990s	External Floating, Internal Floating, & Fixed	Concrete Ring	35 (9)	0
7	75,000-100,000	38-48	118-130	1950s-1990s	External Floating, Internal Floating, & Fixed	Earthen Pad	17 (4)	0
8	35,000-65,000	39-48	78-104	1940s-1960s	External Floating, Internal Floating, & Fixed	Concrete Ring	23 (5)	0
9	35,000-65,000	40	80-107	1940s-1950s	External Floating, Internal Floating, & Fixed	Earthen Pad	8 (2)	0
10	20,000-30,000	40-50	60-73	1950s-2000s	External Floating, Internal Floating, & Fixed	Concrete Ring	24 (7)	1
11	15,000-30,000	32-43	52-73	1940s-1990s	External Floating, Internal Floating, & Fixed	Earthen Pad	17 (4)	0
12	238-15,000	12-46	10-46	1950s-2010s	External Floating, Internal Floating, & Fixed	Concrete Ring	6 (4)	25
13	238-4,000	14-35	10-35	1950s-2000s	Fixed	Concrete Pad	6 (1)	13
14	238-4,000	14-35	10-35	1950s-2000s	Fixed	Earthen Pad	24 (2)	0

*Tanks in parenthesis don't have a known foundation type. They were categorized according to the ratios of the known tanks.



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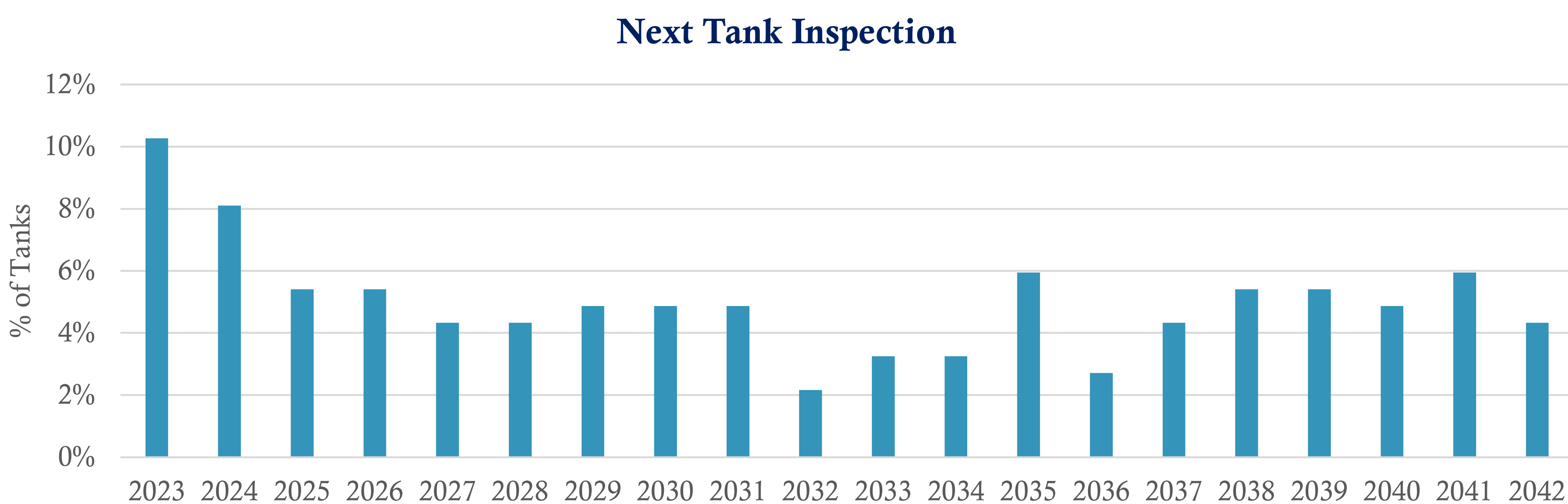
COMPLIANCE SCHEDULE

Future Tank Inspections

The tank inspection schedule is an important consideration in the timeline of any compliance implementation schedule.



55% of tanks are due for an inspection in the next 10 years, with 45% due in the following 10 years

COMPLIANCE SCHEDULE

WAC 173-180-080

Storage Tanks

Within 10 years from rule effective date or by the next scheduled internal API Standard 653 (2014 with Addendum 1 (2018) and 2 (2020)) inspection, whichever is later, any Class 1 facility storage tank constructed before the effective date of this rule must meet seismic protection measures in WAC 173-180-330.

Transfer Pipelines

Within 10 years from rule effective date or by the next scheduled API Standard 570 (2016 with Addendum 1 (2017) and 2 (2018), and Errata 1 (2018)) inspection, whichever is later, any Class 1 facility transfer pipeline constructed before the effective date of this rule must meet seismic protection measures in WAC 173-180-340.

WAC 173-180-080, allows tanks to reach compliance according to their inspection schedule. We do, however, recommend updating the wording to ensure that the 10-year period is from the effective date of the new changes to WAC 173-180-330 and WAC 173-180-340, rather than the effective date of WAC 173-180-080.

ECONOMIC IMPACT ASSESSMENT

ECONOMIC IMPACT ASSESSMENT

Calculation Methodology – API STD 650, Annex E

Tank data was received with varying levels of completeness. The data was compiled together, and any incomplete data was populated using engineering judgement based on similar tank data and industry best practices.

API STD 650 calculations, including Annex E calculations, were made on each tank. These calculations provided direction on whether the tanks needed to be mechanically-anchored and how many anchors to use, whether the tank design was sufficient for the hoop stresses, and the adequacy of the shell thickness.

Compliance costs were calculated for each individual tank based on the Annex E calculation results.

The cost analysis in this document excludes certain aspects mentioned in this document. The high case and low case are not meant to set the extreme limits of the total cost, but rather to identify the range of likely scenarios.

ECONOMIC IMPACT ASSESSMENT

Key Assumptions

The following are key assumptions that were made for this analysis:

- Unless otherwise stated, facilities were assumed to be in SUG I with Site Classification D
- Tank shells were calculated at a single thickness vertically. This impacts the weight of the tank, the ringwall moment, and other variables
- Assumptions were made on roof weights and centers of gravity
- Where data was missing, tanks were assigned a foundation type, roof type, material stored, and anchor type based on available data from other tanks
- An anchor bolt diameter of 1.5" was used for these calculations. Changing this number will affect the number of anchors to be installed
- Inspection costs, construction mobilization and demobilization, and equipment rental costs were excluded from this analysis
- Existing ringwalls were assumed to be sufficient for seismic anchoring purposes. If not, this could have a significant impact on the estimated cost

ECONOMIC IMPACT ASSESSMENT

Key Assumptions

Annex E states that "where the soil properties are not known in sufficient detail to determine the site class, **Site Class D shall be assumed** unless the authority having jurisdiction determines that Site Class E or F should apply at the site."

The Seismic Use Group (SUG) is based on tank's need, the risk of the tank to public health and the presence of secondary controls. Per Annex E, **"if it is not specified, the SUG shall be assigned to be SUG I."** The SUG can have a significant impact on the loads the tank must be designed to withstand.

Site Class	Description
A	Hard rock
B	Rock
C	Very dense soil and soft rock
D	Stiff soil
E	Soft soil or soft clay
F	Soils requiring site-specific evaluations

Table E.5—Importance Factor (I) and Seismic Use Group Classification

Seismic Use Group	I
I	1.0
II	1.25
III	1.5

ECONOMIC IMPACT ASSESSMENT

Tank Anchors, Unit Cost

API STD 650 5.12 covers tank anchors. A mechanically anchored tank must have at least 4 anchors with maximum spacing of 10 ft.

E.6.2.1 Self-anchored tanks are permitted if Anchorage Ratio J ≤ 1.54, providing shell compression requirements are met.

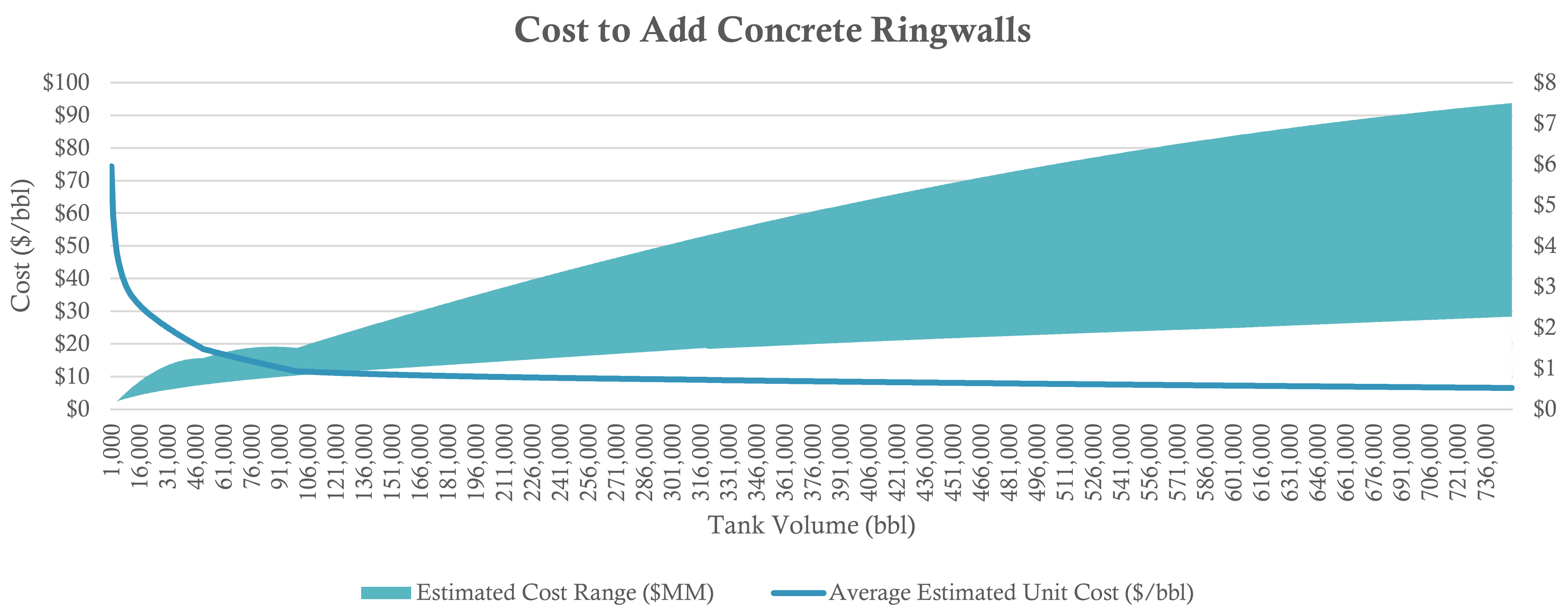
Anchor bolts must have a protruding slab or ring wall to anchor to. An existing slab or ring wall may not be sufficient.

Anchor Materials	Labor (Manhours)	Labor Cost ($/hr)	Engineering & Design ($)	Total Cost ($/Anchor)
$1,000	5	$122	$242	$1,851.50

ECONOMIC IMPACT ASSESSMENT

Concrete Ringwalls, Unit Cost

Concrete ringwall installation costs for existing tanks varied greatly. Costs are heavily dependent on whether segmented or monolithic (single pour) foundations are installed and whether or not the tank floor must be replaced.



ECONOMIC IMPACT ASSESSMENT

Flexible Piping, Unit Cost

API STD 650 Table E.8

	Condition	ASD Design Displacement (in.)
Mechanically-Anchored Tanks	Upward Vertical Displacement	1
	Downward Vertical Displacement	0.5
	Range of Horizontal Displacement	0.5
Self-Anchored Tanks	Upward Vertical Displacement	1 (Anchorage Ratio ≤ 0.785) – 4 (if > 0.785)
	Downward Vertical Displacement	0.5 (Ringwall/Mat) – 1 (Berm Foundation)
	Range of Horizontal Displacement	2

Some of the WSPA member facilities have analyzed their piping and found that some of the existing configurations meet the ASD Design Displacement requirements in this table, especially where there are longer runs of pipe. This is expected to satisfy the proposed requirement that piping have "sufficient piping flexibility to protect the tank and pipe connection and prevent the release of product." (WAC 173-180-330)

Flexibility requirements are much lower for mechanically-anchored tanks, though flexible piping may be more cost-effective than mechanically-anchoring

ECONOMIC IMPACT ASSESSMENT

Flexible Piping, Unit Cost

There are various methods to add piping flexibility. Some, such as thermal expansion loops, are often built into longer runs of pipe and add flexibility to the system. Sorter runs of pipe and stiffer configurations may need to use ball joints, expansion joints, or other means to achieve this flexibility.

Expansion joints and ball joints are much more likely to leak than expansion loops and therefore are less desirable and require more maintenance. WSPA members reported numerous failures of expansion joints.

The low case estimate assumes that the existing piping configurations are sufficient to satisfy requirements in all cases where the anchorage ratio ≤ 0.785 and all but 30% of cases where the anchorage ratio > 0.785.

The high case estimate assumes that single expansion joints are needed to satisfy requirements for mechanically-anchored and self-anchored tanks with an anchorage ratio ≤ 0.785. Universal expansion joints are assumed for all other connections.


Thermal Expansion Loop


Ball Joint


Single Expansion Joint

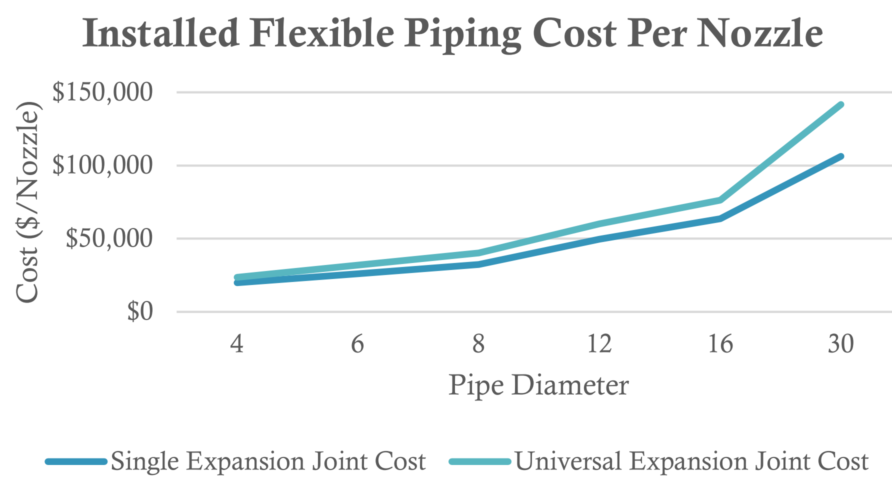

Tied Universal Expansion Joint

ECONOMIC IMPACT ASSESSMENT

Flexible Piping, Unit Cost

Flexible piping costs were derived from multiple quotes from various vendors. Expansion joints were SS bellows-style with CL 150 carbon steel flanges.

The estimate included 2 nozzles per tank, with nozzle sizes increasing with the tank volume.



Pipe Dia. (in.)	Single Expansion Joint Cost	Valves, Flanges, & Materials	Labor (Man-hours)	Labor Cost ($)	Pipe Clean-out & Hydro	Single Exp. Joint Eng. & Design	Single Expansion Joint Total Cost	Universal Expansion Joint Cost	Universal Exp. Joint Eng. & Design	Universal Exp. Joint Total Cost
4	$700	$6,792	11	$1,281	$10,000	$1,316	$20,089	$4,000	$1,811	$23,884
6	$900	$9,917	15	$1,769	$12,000	$1,888	$26,474	$6,000	$2,653	$32,339
8	$1,125	$13,052	18	$2,196	$14,000	$2,456	$32,829	$8,000	$3,487	$40,735
12	$3,000	$20,232	26	$3,203	$20,000	$3,965	$50,399	$11,951	$5,308	$60,693
16	$5,000	$25,125	36	$4,331	$25,000	$5,168	$64,624	$16,000	$6,818	$77,274
30	$10,000	$45,051	69	$8,467	$35,000	$9,528	$108,046	$40,838	$14,153	$143,509

ECONOMIC IMPACT ASSESSMENT

Option Comparison

Anchors & Ringwalls

Tanks were analyzed to determine the cost to install anchors on all existing tanks, and concrete ringwalls where necessary.

The API STD 650 calculations were then performed to determine which tanks required anchoring, and the cost to only add anchors where determined by API STD 650.

Flexible Piping & Cost Efficiency

The cost to add flexible piping to all applicable tanks was reviewed and compared with the cost to add anchors. Results were split as to which option was more cost effective.

The estimate included 2 nozzles per tank, with nozzle sizes increasing with the tank volume.

COST ANALYSIS

Cost Case Summary

The cost data on the following page can be divided into four groupings:

1. Cost to add ringwall and anchors to all tanks that don't already have them, regardless of whether or not the anchorage ratio is acceptable for a self-anchoring tank. This scenario is likely in the event that the code calls for tanks to be anchored rather than just fitted with flexible piping. This is because there's a chance that many of the existing tanks don't have an appropriate annulus to allow for self-anchoring per Annex E. The high case uses the top of the range for the ringwall cost and the low case uses the bottom. The low case also only adds ringwalls and anchors where required and to 30% of the remaining tanks that can be self-anchored.

2. Cost to add ringwalls and anchors when prescribed by the anchorage ratio. This only covers tanks that don't already have them and assumes that the tank annulus won't have an impact. The high case uses the top of the range for the ringwall cost and the low case uses the bottom.

3. Cost to add flexible piping to tank nozzles. The difference between the high and low case is explained on page 31.

4. Cost-effective option: cost to add flexible piping or anchors, whichever is more cost-effective, when prescribed; flexible piping is not added to mechanically-anchored tanks. This case assumes that either mechanically-anchoring a tank or meeting pipe flexibility requirements will satisfy the regulation, and that both aren't required on the same tank.

The cases are not absolute highs and lows but are high and low approximations, relative to each other, of the expected cost given the stated set of assumptions

ESTIMATED COST TO COMPLY WITH PROPOSED RULE AS WRITTEN – HIGH CASE

Group	Add Ringwalls to All Tanks	Add Anchors to All Tanks	Add Concrete Ringwall if Prescribed	Add Chair Anchors if Prescribed	Add Flexible Piping to All Tanks	Cost-Effective Option
1	$0	$860,948	$0	$0	$387,746	$387,746
2	$0	$1,584,884	$0	$0	$930,042	$930,042
3	$0	$827,621	$0	$0	$775,493	$761,393
4	$0	$2,512,486	$0	$0	$2,098,321	$2,088,462
5	$0	$1,951,481	$0	$0	$1,855,549	$1,784,803
6	$0	$3,543,771	$0	$0	$3,252,644	$3,147,048
7	$31,860,439	$1,486,755	$0	$0	$1,378,820	$1,378,820
8	$0	$2,042,205	$0	$1,005,365	$2,154,677	$1,860,785
9	$12,547,972	$549,896	$0	$0	$704,018	$704,018
10	$0	$1,631,172	$0	$1,049,801	$2,011,015	$1,582,405
11	$20,001,541	$953,523	$9,423,414	$488,796	$1,252,648	$1,252,648
12	$0	$486,945	$0	$486,945	$1,482,100	$338,081
13	$0	$129,605	$0	$129,605	$849,083	$118,496
14	$8,070,963	$640,619	$6,947,879	$583,223	$1,234,355	$1,223,784
Total	**$72,480,914**	**$19,201,907**	**$16,371,292**	**$3,743,733**	**$20,366,510**	**$17,558,531**
Combined	**$91,682,821**		**$20,115,025**		**$20,366,510**	**$17,558,531**

ESTIMATED COST TO COMPLY WITH PROPOSED RULE AS WRITTEN – LOW CASE

Group	Add Ringwalls as Required & to 30% of Self-Anchored Tanks	Add Anchors as Required & to 30% of Self-Anchored Tanks	Add Concrete Ringwall as Required	Add Chair Anchors as Required	Add Flexible Piping to 30% of High Displacement Nozzles	Cost-Effective Option
1	$0	$258,284	$0	$0	$0	$0
2	$0	$475,465	$0	$0	$46,365	$46,365
3	$0	$248,286	$0	$0	$0	$0
4	$0	$753,746	$0	$0	$145,663	$145,663
5	$0	$585,444	$0	$0	$72,832	$72,832
6	$0	$1,063,131	$0	$0	$562,147	$562,147
7	$4,700,423	$446,026	$0	$0	$0	$0
8	$0	$1,316,417	$0	$1,005,365	$488,824	$488,824
9	$1,728,703	$164,969	$0	$0	$73,324	$73,324
10	$0	$1,224,212	$0	$1,049,801	$523,884	$523,884
11	$5,737,995	$628,214	$4,298,615	$488,796	$232,837	$232,837
12	$0	$486,945	$0	$486,945	$143,301	$143,301
13	$0	$129,605	$0	$129,605	$85,981	$82,760
14	$5,286,109	$600,441	$5,103,379	$583,223	$358,254	$358,254
Total	**$17,453,231**	**$8,381,185**	**$9,401,993**	**$3,743,733**	**$2,733,410**	**$2,730,189**
Combined	**$25,834,416**		**$13,145,726**		**$2,733,410**	**$2,730,189**

API STD 650, ANNEX E CONVERSION ANALYSIS

ANNEX E CONVERSION RISKS

Risks Associated with Annex E Conversion

Annex E contains some fundamental, ground-level requirements that many API STD 650 tanks will not meet without significant renovations, and in some cases full rebuilds. Examples of these requirements are:

- Shell Thickness: Annex E engineers to look at ground motions, vibrations, fluid motions, and other factors that are not factored into a standard API STD 650 tank. These calculations have the potential to require a thicker shell than would otherwise be needed. This requirement could quite possibly necessitate a full rebuild of a tank to be in compliance. If the site is classified with a high Importance Factor (higher than SUG I) or an unfavorable Site Classification these issues could be compounded.

- Annulus Requirements: In a typical tank floor, the sketch plates make up the center and can extend to the shell. The annulus lines the interior circumference of the floor, providing strength and resisting uplift at the shell. While we don't currently have much data about the floor structures that are in the existing tanks, Annex E has several requirements for tank floor construction. It requires a uniformly supported annulus under the shell. This annulus is a key part of the design and a requisite for self-anchored tanks. Mechanically-anchored tanks require their floor to be shimmed and grouted.

  There are methods to go in and change out the floor of a tank, but it is a costly endeavor. The shell can be lifted by hydraulic jack or crane.

ANNEX E CONVERSION RISKS

Risks Associated with Annex E Conversion

Cont.

- The structural support for the roof may need to be modified to handle the additional stresses.
- Penetrations, manholes, and openings in shell components may need to be reinforced.
- Equipment and accessories that are internal to the tanks would need to be guided or supported to resist lateral loads
- Equipment, piping, and walkways or other appurtenances attached to the tank or adjacent structures would need to be designed to accommodate the elastic displacements of the tank imposed by design seismic forces amplified by a factor of 3.0 plus the amplified displacement of the other structure.
- Additional foundation work could be needed, including the use of additional pilings.

Many of these risks are not built into the cases in this document

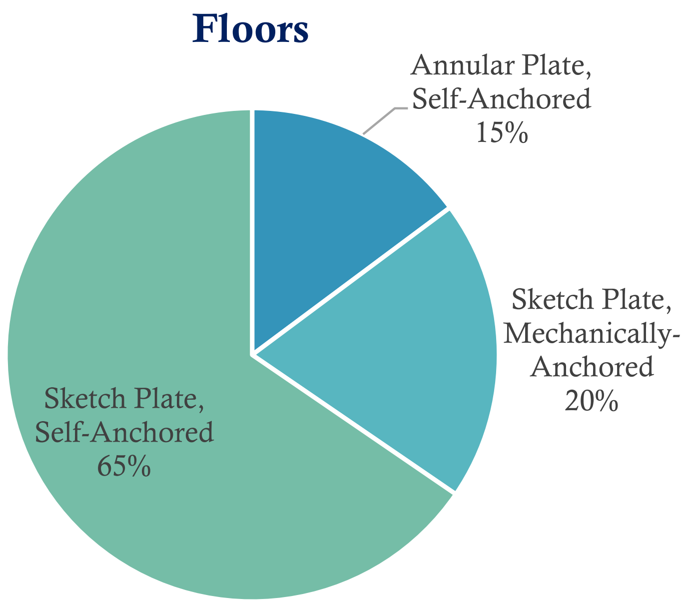
MEMBER FACILITY ANALYSIS

Annex E Conversion Issues

Annulus

While this particular piece of data was far from complete, 15% of the tanks that had a floor type identified were shown to have an annular plate.

65% of the floors were indicated to have sketch plates while being self-anchored. While sketch plates and annular plates can be part of the same floor, if these tanks are missing an adequate annulus they would either need the floors to be rebuilt or would need to be mechanically-anchored as part of the process of coming into compliance with Annex E.



MEMBER FACILITY ANALYSIS

Annex E Conversion Issues

Shell Thickness

Shell thickness is heavily dependent on assumptions made in the calculations, and thus can vary.

Some of the tank data that was supplied did not include a shell thickness. Thus TM&C used standard API STD 650 calculations to determine an appropriate thickness. That thickness was then compared to the seismic requirements of Annex E, and in most cases was sufficient.

Causes of Deficiencies

Reducing the tanks that were calculated under SUG II (66 out of 291 tanks) to be SUG I would reduce the tanks that fail to 1%.

MEMBER FACILITY ANALYSIS

Annex E Conversion Issues

Annex E Deficiencies

The API STD 650 calculations prescribed that anchors be installed on 30% of the existing tanks. A few tanks that are already anchored required additional anchors.

5% of tanks also have hoop stress concerns that would need to be addressed. This could require a significant rebuild of the tanks to reach Annex E compliance.

5% of the tanks did not pass the wall thickness checks. This again would require major renovations or a change in tank operations.

Causes of Deficiencies

While many of these deficiencies are caused by the increased rigor of Annex E, it's likely that some of the assumptions that have been made in the calculations have contributed to them.

COST ANALYSIS

Cost Case Summary – High Case

The cost data on the following page can be divided into four groupings:

1. The Annex E conversion high case was done under the assumption that all of the tanks that showed an insufficient shell thickness would need to have the shell replaced. This involved many of the largest tanks in the facilities.

2. Cost to add ringwall and anchors to all tanks that don't already have them, regardless of whether or not the anchorage ratio is acceptable for a self-anchoring tank. Data on tank floors was limited, but shows that a large majority of the self-anchored tanks were likely constructed without an annular ring. In addition, with a lack of data on floor thickness, etc., we were unable to make an assumption about the number of tanks that would need a new floor. By adding a ringwall to all tanks that do not have one, the tanks can be anchored to avoid the issue. The high case uses the top of the range for the ringwall cost.

3. Cost to add anchor bolts to all tanks to avoid issues with the tank annulus, as explained in #2 above.

4. Flexible piping was added to all of the tanks.

Please note that the costs in these four groups are additive, and that the estimate does not include any cost for structural support modifications, modifications to internal components, manway or penetration reinforcement, foundation modification or pilings, or other unforeseen costs.

The cases are not absolute highs and lows but are high and low approximations, relative to each other, of the expected cost given the stated set of assumptions

ESTIMATED COSTS OF ANNEX E CONVERSION – HIGH CASE

Group	Replace Shell for Increased Thickness	Add Ringwalls to All Tanks	Add Anchors to All Tanks	Add Flexible Piping to All Tanks
1	$20,788,331	$0	$860,948	$387,746
2	$23,828,849	$0	$1,584,884	$930,042
3	$9,533,387	$0	$827,621	$775,493
4	$2,680,551	$0	$2,512,486	$2,098,321
5	$4,117,990	$0	$1,951,481	$1,855,549
6	$3,286,062	$0	$3,543,771	$3,252,644
7	$0	$31,860,439	$1,486,755	$1,378,820
8	$697,267	$0	$2,042,205	$2,154,677
9	$0	$12,547,972	$549,896	$704,018
10	$555,329	$0	$1,631,172	$2,011,015
11	$0	$20,001,541	$953,523	$1,252,648
12	$0	$0	$486,945	$1,482,100
13	$62,941	$0	$129,605	$849,083
14	$0	$8,070,963	$640,619	$1,234,355
Total	**$65,550,706**	**$72,480,914**	**$19,201,907**	**$20,366,510**
Combined	**$177,600,037**			

COST ANALYSIS

Cost Case Summary – Low Case

The cost data on the following page can be divided into four groupings:

1. Rather than replacing an insufficient tank shell, the operator would likely select to operate the tank at a lower operating level or to change the service of the tank. The economic impact related to this operational change is out of the scope of this study, but should be accounted for.

2. Cost to add ringwall to all tanks where required and 30% of the remaining self-anchored tanks that don't already have them. Data on tank floors was limited, but shows that a large majority of the self-anchored tanks were likely constructed without an annular ring. In addition, with a lack of data on floor thickness, etc., we were unable to make an assumption about the number of tanks that would need a new floor. By adding a ringwall to all tanks that do not have one, the tanks can be anchored to avoid the issue. The low case also uses the bottom of the range for the ringwall cost.

3. Cost to add anchor bolts to all tanks where required and 30% of the remaining self-anchored tanks. This is to avoid issues with the tank annulus, as explained in #2 above.

4. Cost to add flexible piping to 30% of the nozzles where the anchorage ratio > 0.785. Everywhere else it was assumed that the existing piping would be sufficient to satisfy the ASD Design Displacement requirements.

Please note that the costs in these four groups are additive, and that the estimate does not include any cost for structural support modifications, modifications to internal components, manway or penetration reinforcement, foundation modification or pilings, or other unforeseen costs.

The cases are not absolute highs and lows but are high and low approximations, relative to each other, of the expected cost given the stated set of assumptions

ESTIMATED COSTS OF ANNEX E CONVERSION - LOW CASE

Group	Reduce Operating Level (Does Not Include Economic Impact)	Add Ringwalls as Required & to 30% of Self-Anchored Tanks	Add Anchors as Required & to 30% of Self-Anchored Tanks	Add Flexible Piping to 30% of High Displacement Nozzles
1	$0	$0	$258,284	$0
2	$0	$0	$475,465	$46,365
3	$0	$0	$248,286	$0
4	$0	$0	$753,746	$145,663
5	$0	$0	$585,444	$72,832
6	$0	$0	$1,063,131	$562,147
7	$0	$4,700,423	$446,026	$0
8	$0	$0	$1,316,417	$488,824
9	$0	$1,728,703	$164,969	$73,324
10	$0	$0	$1,224,212	$523,884
11	$0	$5,737,995	$628,214	$232,837
12	$0	$0	$486,945	$143,301
13	$0	$0	$129,605	$85,981
14	$0	$5,286,109	$600,441	$358,254
Total	**$0**	**$17,453,231**	**$8,381,185**	**$2,733,410**
Combined	**$28,567,827**			

OPERATIONAL CONSIDERATIONS

The existing proposal to allow tank-owners to address the larger seismic concerns with anchors and flexible piping, and to do so on a schedule that coincides with tank turnarounds, makes the operational impact manageable. However, there are still considerations that should be taken into account.

Some of the flexible piping options are not as reliable as the existing hard piping, as it is more prone to leakage. While there are various technologies that have different strengths, we looked at bellows-style connections in this study. One concern with this technology is that with continued expansion, retraction, and vibration, these piping connections would not be expected to last as long as hard pipe. Companies will likely expend energy managing these piping connections to ensure they don't leak or have other issues.

There are additional operational issues surrounding the possibility of requiring the adoption of Annex E in existing tanks. The potential significant costs will take resources that could be used to employ operational or maintenance improvements elsewhere. Rather than repair the tanks, they may be forced to reduce operating levels in the tanks or change tank service in order to meet Annex E requirements. This would have a financial cost to the facilities that is outside the scope of this study.

ECONOMIC IMPACT SUMMARY

As written, the proposed changes to WAC 173-180 and 173-184 give affected companies the ability to address the existing seismic concerns in various ways. While all options have potential to be costly, the ability to install flexible piping gives companies an alternative to anchoring. It is estimated that the cost to the member companies will be about $18MM, with the assumptions laid out in this document. If the WAC were to require the implementation of anchoring a tank and installing flexible piping simultaneously, this cost would more than double.

The potential of requiring the adoption of Annex E in existing tanks could leave the industry with a significant hurdle. While the high case cost of $178MM is a substantial investment, there are many factors that could drive the cost up, including unforeseen repairs, significant foundation work (pilings, existing ringwall strength, etc.), and additional tanks that were not included in the original data. In addition, other factors and practices could bring costs down. These may include changing assumptions (such as reducing the SUG where appropriate) and adjusting operational tank levels where possible, among others.

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