## Attachment A:

## Stakeholder Comment Letters

Submitted for consideration for the At Berth Regulation Interim Evaluation Report

The Port OF HUENEME
Oxnard Harbor District

June 23, 2022

Angela Csondes
California Air Resources Board
1001 I Street
Sacramento, California 95812

Submitted Electronically

Comments for the 2022/23 Interim Evaluation as part of the California Air Resources Board 2020 At Berth Regulation

Dear Ms. Csondes:

On behalf of the Port of Hueneme (Port) we are submitting this comment letter to help inform CARB's Interim Evaluation as an essential part of the 2020 At Berth Regulation. The intent of this letter is to provide CARB staff with essential updates on the Port's efforts to comply with the rule while also expressing the Port's commitment to a zero-emission future. We feel it is essential for the successful implementation of these emissions reductions enabling regulations to take into account the real-world input of those entities charged with implementation, including potential challenges that could compromise compliance with the newly expanded regulation.

The Port would first like to state unequivocally that it is in full support of regulating the emissions from Ocean Going Vessels (OGV) and looks forward to continuing our partnership with CARB and our local air district to achieve further emission reductions through the At Berth Regulation. Thanks to the combination of the clean fuel rules and the current At Berth Regulation **the Port has seen a greater than 84% reduction in the emission of diesel particulate matter from OGV at berth in the Port since 2008**.

The Port plays a vital role in supporting our local communities, serving as one of the most important economic engines within Ventura County, supporting over 20,000 jobs in the county alone. While our overall cargo volumes and economic revenues have continued to grow, global supply chain issues have negatively impacted our automotive imports, resulting in an 12% decline in that roll-on roll-off (ro-ro) business recently. This decline is occurring as the Port, both the owner and operator of our terminals, is projected to invest over $22 million in shore power infrastructure and the procurement of an CARB approved emissions control system (CAECS).

**Challenge – Electrical Grid Capacity:** The aforementioned investments do not address the need for an estimated $100 million in upgrades to the Southern California Edison power supply to the Port which may be required to support shore power and future electrification.

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> **Recommendation:** Ensure that the Interim Evaluation addresses the grid capacity issues facing most California ports and terminals and which are beyond the control of the ports, including assessing the capacity improvements requisite to port build-outs, how these upgrades will be planned, engineered, and built, and critically, how they will be funded.

**Challenge – Ocean Carrier Retrofits:** The costs to ro-ro ocean carriers needs to be factored into the analysis. The estimated $3 million per vessel costs of making ships shore power compatible for ocean carrier fleets of 100 – 150 vessels add up quickly. Port staff have attended Auto Logistics conferences where the carriers are openly discussing reducing the number of Port calls to CA ports to comply with the regulations.

> **Recommendation:** Ensure the Interim Evaluation addresses the opportunity cost of consolidated and fewer port calls to the California ports and what those impacts are from an economic perspective including employment loss. We encourage collaboration with the ocean carriers to fully understand this impact and work to find innovative solutions or a phased approach to retrofits.

**Challenge – Technological Uncertainties:** Beyond the significant capital investment costs required to comply with the At Berth Regulation, there are two major technological uncertainties that threaten our ability to connect refrigerated cargo (reefer) and ro-ro vessels to shore power and CAECS when calling on the Port, starting January 1, 2025.

The lack of international electrical standards for shore power connections for ro-ro vessels are delaying both the completion of the shore-based components of shore power systems and vessel retrofits. Currently, there is uncertainty as to whether the IEC/ISO/IEEE High Voltage Shore Connection Standard 80005-01 for ro-ro vessels will be 6.6 kilovolts (kV) or 11 kV. This uncertainty is delaying the initiation of shore power retrofits of ro-ro vessels by vessel owners. Any delay in initiating retrofits can have significant ramifications to the Port's planned compliance strategies because vessel owners anticipate that retrofits of their fleets will take approximately three years due to the need to drydock vessels when performing retrofits.

Due to the lack of standardization for shore power systems for ro-ro vessels, it is projected that most ro-ro vessels calling on California ports will not be shore power ready in 2025. This will create a heightened demand for CAECS or bonnet systems likely through at least 2028. Currently, there are only three vendors offering bonnet systems, of which only one is CARB-approved. By January 1, 2025, California ports will need at least 15 new CAECS, including 11 to serve ro-ro vessels and 4-6 more to serve container vessels. Presently, there are only two systems in operation and another two in development, including one system specifically developed to serve tanker vessels. The limited number of CAECS suppliers and the lack of currently available systems calls into question the likelihood that sufficient systems will be funded, engineered, constructed and commissioned by 2025. Supply chain disruptions further complicate the issue and reduce the likelihood that sufficient CAECS will be available to meet the projected needs of California ports. Additionally, the enactment of At Anchor Control requirements will only further increase demand for a limited supply of CAECS and reduce the probability that all California ports and terminals will have access to bonnet systems.

**Recommendation:** Incorporate into the Interim Evaluation a CAECS Study that includes a robust analysis of the Statewide demand for CAECS required to meet the regulation culminating in a total estimated number of units needed as well as a realistic assessment of the ability of the CAECS vendors to manufacture the required numbers of systems prior to January 2025. If sufficient numbers cannot be constructed then prioritize the available systems for larger ports with larger vessels and larger numbers of calls. If CAECS cannot be acquired for all needed terminals the only compliance option for them cannot be shorepower, TIE/VIE or remediation fund, especially for smaller ports. In other words, phase compliance and/or provide more flexibility for smaller ports until the technology is proven and supply is sufficient.

**Challenge: The Financial Burden is Significantly Higher for Smaller Ports:** The financial implications of the At Berth Regulation extend far beyond the costs of infrastructure upgrades, vessel retrofits, and CAECS procurement. Due to the technological uncertainties identified, it appears increasingly likely that many ro-ro vessels will not have access to an CAECS, requiring ports, terminals, and vessel operators to contribute to the Remediation Fund as their only means of compliance. As a smaller port that operates its own terminals and has annual revenues of approximately $20-$25 million, the requirement to contribute $1,900 per hour to the remediation fund for every hour that a vessel is not connected to a CAECS has the potential to create a significant financial hardship. We expect 180 ro-ro vessels will call on the Port in 2025. Once all nine Terminal Incident Events are used, the Port would need to pay $32,300 for a typical 17-hour ro-ro vessel call for each of the remaining 171 calls. This would mean that the Port would potentially be required to spend over $5.5 million on the Remediation Fund in 2025 alone for only ro-ro compliance, not including reefer/container. This amount would exceed 20 percent of our annual revenue, creating a disproportionate impact on the Port relative to larger ports and multi-national terminal operators. The uncertain availability of CAECS combined with the severe financial penalties has the potential to bankrupt the Port, which would have devastating economic impacts on the regional economy and surrounding communities, and would create more supply chain disruptions and only contribute to clogged conditions at other California ports.

Both investments in compliance and penalties of non-compliance with the At Berth Regulation disproportionately impact small ports. **The Port of Hueneme's total budget is less than 3% of the annual budget of the Port of Los Angeles!** The hourly Remediation Fund cost of $1,900 equates to 0.004 % of the Port's $49 million total budget, this is four one hundredths of 1% of the Port's budget. While the fund cost equates to 0.0001% of the budget of the Port of Los Angeles, *which is one ten thousandth of 1% of POLA's budget*. Additionally, the Port of Los Angeles has approved a budget of $1.9 billion in fiscal year 2022/23 as compared to the Port of Hueneme's budget of $49 million, of which $19 million is available for capital expenditure spending. The approximately $10 million cost of an CAECS equates to more than 50% of the

Port of Hueneme's fiscal year 2022/23 revenue or its cap ex budget, while only 0.5% of the Port of Los Angeles' budget.

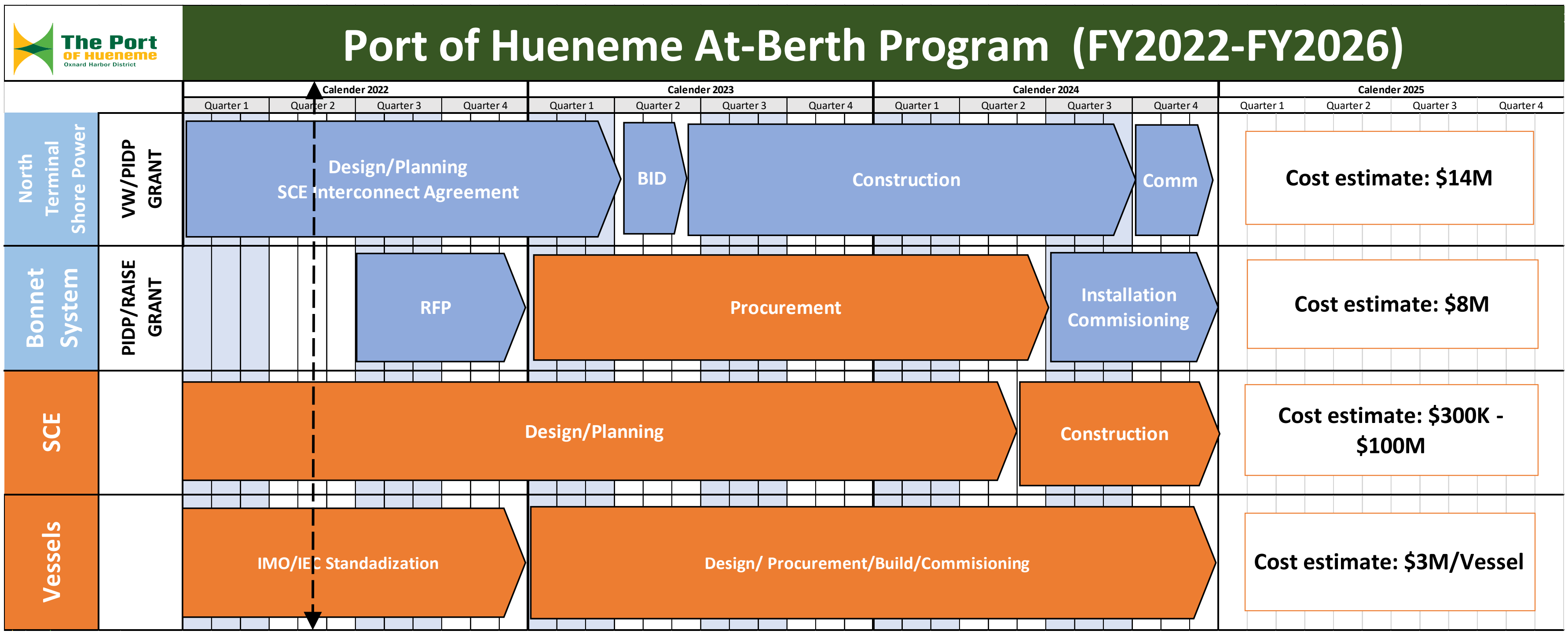
> **Recommendation:** CARB can play an important role in helping to reconcile the substantially higher financial burden on small ports by developing a sliding scale for the remediation fee with equitable amounts for smaller ports. In addition, allocating grant funding to help level the proportional investments in compliance with the At Berth Regulation between small and large ports would help level the playing field.

While there are significant challenges that we see on the horizon for obtaining the CAECS required for ro-ro vessels to comply with the At Berth Regulation, the Port is fully committed to being a leader in zero emissions goods movement. We embrace our role in protecting the local community and global climate through a long-term commitment to sustainability and decarbonization, while continuing to grow cargo operations critical to the local community and the regional economy. We are asking that CARB consider the challenges that we anticipate in complying with the 2020 At Berth Regulation starting in 2025 for ro-ro vessels due to the technological uncertainties and supply chain constraints that may limit the availability of CAECS at California ports. We look forward to working with CARB to develop an achievable road map to a zero emissions goods movement future that supports the important economic role of the Port.

Sincerely,

Giles Pettifor,
Environmental Manager

**Appendix A: Planned Investments in At Berth Regulation Compliance[1]**




[1] Note that the depicted SCE cost of $300,000 is beyond the initial cost of their on-Port infrastructure required for only the initial design work of the North Terminal shorepower project. The total cost of SCE work is yet to be determined as is whether or not the project can be supplied with existing electrical services. Finished costs of the project likely will be much higher and if the power need is unmet, then the high-voltage $100 million upgrade may be required with some combination of onsite generation and power storage.

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MAERSK

June 29, 2020

Ms. Nicole Light Densberger
California Air Resources Board
1001 I Street
Sacramento, California 95812

Submitted via email

Cc (email): Bonnie Soriano, Angela Csondes

Subject: **Maersk Input to the CARB Interim Report on Implementation of the 2020 Ocean-Going Vessels At-Berth Rule**

Dear Ms. Light Densberger and CARB OGV staff,

Thank you for this opportunity to provide additional Input to the CARB Interim Report on Implementation of the 2020 Ocean-Going Vessels At-Berth Rule. As you know, we met with CARB Enforcement and OGV Program Staff in March, April and again in May to review our progress and challenges, in preparing for the January 2023 implementation and provide an overview of our decarbonization strategy and progress. This letter will provide an update on the information presented on the shore power preparations. In addition, Maersk is a member of the Pacific Merchant Shipping Association (PMSA). We provided input to the PMSA letter that you will be receiving and support their comments and recommendations. In this letter we will emphasize some of the challenges they noted and provide examples that relate to some of their points.

Areas of challenge for implementation:

1. If this gathering of interim report input reveals high priority issues that would threaten the successful implementation of the rule as scheduled, we urge the Agency to request the Board to consider corrections this fall.

2. Updates to the overview slides discussed earlier this year are
    a. A high level of uncertainty and risk of COVID shut-downs continues in China. This has caused parts delays from Cavotec in China, delayed our AMP container

refurbishment program, and required us to do shore power installations in California and Panama. Dry dockings have also been impacted.

b. Travel constraints and a scarcity of qualified specialty engineers means we have had to equip only one vessel at a time this summer.

c. We have just learned of a delay in AMP equipment parts availability from a key European provider's plant and are investigating the cause.

d. On the positive side we are now scheduled to equip one of the three remaining Newberry class vessels in Long Beach next week, and a second in Balboa Panama in early August. We are working to schedule the final vessel now, hopefully also in Panama, in September. If this is completed as planned, we will have worked around the *Force Majeure* from Feb. 2020.

e. Another positive is that the virtual arrival system in LA/LB continues to be very effective in reducing the number of vessels at anchor to the lowest level in recent times.

f. Finally, we continue to progress on our decarbonization strategies and are working actively with the ports of Shanghai, Los Angeles and Long Beach as well as other parties (CMA CGM, COSCO, ONE, Amazon, C40, the Aspen Institute, et al) to establish this first Green Shipping Corridor between these major ports. The planned approach will be based on Well-to-wake CO2 equivalent metrics. We would encourage CARB to consider how this and other rules might be applied or adapted to encourage rapid deployment the new low carbon fuels and new technologies currently in development.

3. The "per-vessel" concept requires vessels to connect almost all calls starting January 1, 2023, however, there is only one CAECS available in LA (which cannot work the largest vessels), and nothing available in the other ports. Therefore, it is very important that the Agency establish an alternative to address such situations while still encouraging establishment of additional CAECS. Possible avenues to this could include:
   - Allow use of the remediation fund for vessels that are not equipped for shore power in ports without sufficient CAECS, possibly with additional restrictions or cost structures.
   - Provide additional or redistributed VIEs in these ports, potentially with phase-out by 2025 (so that there is no change in reductions).
   - Provide for a reevaluation of reduction potentials and VIE/TIE distributions when the rule has been in place for a specific period.
   - Allow vessel fleet operators the option to continue under the current successful averaging regime (rule and advisory) until 2025.

4. As far as we know, the remediation funds have not yet been established. We are concerned that this vital option may not be available in some ports. We would appreciate an update on progress in this work. If there is a risk of entering 2023

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without such an entity on any port a fallback alternative should be established prior to 1/1/2023.

5. The Agency has not yet provided guidance on reporting processes to enable regulated entities to begin IT system development to enable data collection, and reporting and receipt of payments within 30 days. These processes must be developed and tested prior to rule implementation, which is now only 6 months away. Our reporting forms should also be verified with CARB Enforcement to ensure that the forms meet their needs and cover all requirements. In the absence of standard reporting guidance, we request that there be a "no-fault" change-over period.

6. Reporting is required within 30 days, however VIEs and TIEs are granted annually. This incompatibility in time spans means vessel operators must make decisions with very significant annual cost and operational impacts without knowing the annual impact and without the ability to plan for the full year.
   - Recommendation: Allow adjustment of VIE and TIE visit allocations on an annual basis to enable cost controls and effective planning.
   - Recommendation: VIEs need to be flexible within a port complex like LA/LB since vessel services can move from terminal to terminal as business changes, may sometimes be shifted on a berth to better align for shore power, or even "double call" to avoid hundreds or thousands of truck trips.

     - A "double call" occurs when a vessel visits one terminal in a port complex and then makes a brief stop in another terminal in the same port (e.g., to load empty containers). An example is the Georg Maersk visit to Long Beach and LA last week. After completing normal cargo operations at the TTI terminal in Long Beach June 19-26, the vessel was moved to Pier 400 to take on empty containers, arriving at 07:06 June 26th and departing 05:27 June 27th for Asia. Moving the vessel instead of transferring the containers between terminals saved an estimated 3500 truck trips and helped reduce terminal congestion without requiring scarce truck drivers or additional road congestion and diesel truck emissions.

       George Maersk successfully connected to shore power for both sections of the double call, however reported that "shore power was interrupted 4.5 hours on 22 June due to external reasons. (4.5 hours is 2.8% of the 160.2 hour vessel call). If shore power equipment had failed at any time due to vessel causes, or if the vessel used was an extra loader and not shore power capable, two VIEs would appear to be necessary to comply and avoid the many truck trips. This appears to be an unintended consequence. One solution to this issue would be to provide an option for the carrier to document a "lower environmental impact" decision to Enforcement and have it quickly accepted for compliance purposes.

This example also illustrates the need to have the option to treat LA and Long Beach as one port for the purpose of VIEs and Remediation Funds. If this is not clarified before then we will apply for this in the VIE period before Dec. 1st.

Again, thank you for this opportunity to provide input to the interim report.

Sincerely,

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June 30, 2022

Nicole Light Densberger, Marine Strategies Section
Elizabeth Melgoza, Marine Strategies Section
California Air Resources Board
1001 "I" Street
Sacramento, CA 95814
Via Electronic submittal

**RE: CARB's OGV At Berth Interim Evaluation Report**

Dear Ms. Densberger and Ms. Melgoza,

We would like to thank the California Air Resources Board for soliciting stakeholder input on the CARB's OGV At Berth Interim Evaluation Report.

Pacific Environment is a global environmental organization that protects communities and wildlife of the Pacific Rim. We support community leaders to fight climate change, protect the oceans, build just societies, and move away from fossil fuels toward a green economy. Pacific Environment is a headquartered in California and has earned rare permanent consultative status at the International Maritime Organization (IMO), the United Nations' entity that sets international shipping law. We are co-founders and leaders of a burgeoning new global coalition of environmental, environmental justice, and ocean organizations working to rapidly accelerate the shipping industry's zero-emission transition on a 1.5C-aligned timeline.

**COVID impacts**

Diesel exhausts from ships carrying goods at ports are known to cause severe illnesses from aggravated asthma, lung cancer, heart disease and neurological disorders, and premature deaths. According to a recent study from the Harvard T.H. Chan School of Public Health, communities that have long exposure to fine participle air pollution such as PM 2.5 are linked to substantially higher death rates from the coronavirus. [1]

CARB's own emissions analysis report found that fossil fuel pollution from 2021 cargo ship congestion at San Pedro ports has caused an increase in NOx emissions equivalent to 5.8 million passenger cars in South Coast, and an increase in particulate matter (PM) emissions equivalent to *100,000 big rig trucks (or "Class 8 diesel trucks") *per day*. **This highlights the need to take**

[1] Air pollution and COVID-19 mortality in the United States: Strengths and limitations of an ecological regression analysis**.** https://projects.iq.harvard.edu/covid-pm

**all regulatory actions possible to regulate this industry, protect public health and combat climate change.**

**Feasibility of control requirements for bulk and general cargo vessels**

We urge CARB to add bulk carrier vessels and general cargo vessels into existing At-Berth emissions regulations. While bulk carrier vessels account for only 9% and 7% of DPM and NOx Ocean Going Vessels (OGVs) emissions in California, respectively, these vessels comprise the majority of ship calls to smaller ports, which are often located adjacent to communities that already bear the brunt of air pollution.

The Ports of Stockton and Richmond, for example, see much of their annual throughput in dry and liquid bulk, which is transported by bulk carrier ships. At the Port of Stockton, over 50% of shipping throughput in 2020 comprised of dry and liquid bulk cargo. Portside communities in Stockton and Richmond, furthermore, reside in CalEnviroScreen $92^{nd}$ and $98^{th}$ percentiles for air pollution burden in the state, respectively. It is critical for CARB to recognize that, by excluding bulk carrier vessels from At-Berth requirements, the state is failing to address the major DPM, NOx, and PM pollution concerns of some of California's most pollution-burdened communities.

There are a number of zero emission bulk and general cargo vessels on the water or currently being developed.

| | | | |
|---|---|---|---|
| 2017 | Newbuild | TBN | Bulk carriers |
| 2020 | Retrofit | Paolo Topic | Bulk carriers |
| 2017 | Newbuild | Invotis IX | Bulk carriers |
| 2022 | Newbuild | Misje Verde | Bulk carriers |
| 2022 | Newbuild | Misje Viola | Bulk carriers |
| 2022 | Newbuild | Misje Vita | Bulk carriers |
| 2022 | Newbuild | unknown | Bulk carriers |
| 2022 | Newbuild | Aasfjell | Bulk carriers |
| 2022 | Newbuild | Aasfoss | Bulk carriers |
| 2020 | Newbuild | Invotis 10 | Bulk carriers |
| 2022 | Newbuild | TBA | Bulk carriers |
| 2016 | Retrofit | Star Laguna | General cargo ships |
| 2019 | Retrofit | Hagland Captain | General cargo ships |

*source: DNV Data on Battery operated ships, accessed 1.26.22*

**Feasibility of vessels at anchor**

The electrification for marine vessels has now been considered as a proven technology contributing to a decarbonized sustainable maritime sector. We are witnessing a fast-evolving climate friendly global technological shift that requires more integrated approaches entailing alternative fuels, wind and solar energy, renewable hydrogen, fuel-cell technologies, zero emission dockyards many more to overcome the evidence based expected ecological catastrophe.

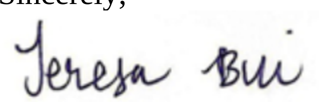
While ocean going vessels may not make the transatlantic trip fully zero emission (yet), hybrid ocean going vessels can switch to battery technology or green hydrogen on a dual fuel engine when they are at anchor.

A 2013 study by the Sandia National Lab shows that power barge for ships at anchor is technically feasible[2]. In addition, there are companies that are developing battery-swapping technology that could be applicable for ships at anchor. The International Council on Clean Transportation will be coming out with a study on zero at berth/at anchor technology options in the fall. For all these reasons, we urge CARB to expand the existing At-Berth emissions to include At Anchor.

**Tanker vessels**
We urge CARB to accelerate the implementation of tanker vessels to take effect in 2024, not the 2025 and 2027 implementation schedule, given the outsize impact it has in Richmond, Stockton and Long Beach ports. According to CARB's own data, tanker represents 50% of statewide at berth PM 2.5 emissions in 2020 and 70% of visits to Richmond Port. We are starting to see the development of zero emission tankers: Asahi Tanker announced that it would build two of the world's first zero-emission electric propulsion tankers[3], that are expected to be completed consecutively from March 2022 to March 2023. As we wait for that market to mature, in the meantime, tankers should be forced to use shorepower by 2024 to achieve earlier health and environmental benefits.

Thank you for your consideration of these comments.

Sincerely,



Teresa Bui
State Climate Policy Director

cc:
Angela Csondes, Manager, Marine Strategies Section, CARB
Bonnie Soriano, Chief, Freight Activity Branch, CARB

[2] Vessel Cold-Ironing Using a Barge Mounted PEM Fuel Cell. Sandia National Lab.
[3] The World's First Zero-Emission Electric Tankers In Japan (intelligentliving.co)

PMSA
PACIFIC MERCHANT SHIPPING ASSOCIATION

June 30, 2022

Bonnie Soriano
California Air Resources Board
1001 I Street
Sacramento, California 95814

***Submitted electronically to*** *shorepower@arb.ca.gov*

Subject: Interim Evaluation - Amended Ocean-Going Vessels At Berth Regulation

Dear Ms. Soriano:

PMSA appreciates the opportunity to submit the following comments in order to inform the California Air Resources Board's (CARB) preparation of the Interim Evaluation of the amended Ocean-going Vessels At Berth Regulation. PMSA hopes the Interim Evaluation can be a tool to make adjustments to the rule that will ensure its success. Below are some of the issues that we believe are critical issues to address in order to facilitate the successful implementation of the amended At Berth Rule by the time new compliance requirements go into effect beginning on January 1, 2023.

If left unaddressed, PMSA is concerned that these outstanding issues regarding the amended rule will impede its implementation such that it is less effective and successful than those results seen under the original Ocean-going Vessels At Berth Rule as adopted in 2007. In the meantime, the maritime industry continues to comply with, and significantly reduce emissions pursuant to, the originally adopted At Berth Rule.

In addition to these specific issues, PMSA would also like to further remind CARB that since the amended rule has been adopted, the maritime industry, the supply chain, and the stakeholders have been roiled by COVID-19 and its follow-on effects that all have felt. The resulting impacts to supply chains, equipment availability, and the difficulty in moving key personnel around have resulted in changed circumstances from when the rule was adopted. We appreciate the partnership of the CARB staff and leadership during the pandemic to provide our industry with the tools and flexibility necessary to continue to provide essential services to California's ports during this critical time.

*Lack of Available Alternative Control Technologies*
The amended rule's feasibility and effectiveness was premised on the increased availability of alternative control technologies. Unfortunately, today, fewer verified systems exist than when the rule was adopted. With six months until new requirements are planned to go into effect, there is a single operating system in San Pedro Bay and none in any other California port. While there is ongoing testing for at least one new system and proposals for others, there is no assurances as to when they will become available.

In fact, the lack of available alternative control technology systems is not only greater today than when the rule was adopted as a result of fewer verified systems in the marketplace but also as a result of the supply chain crisis. As additional ocean carriers have begun serving California ports and existing ocean carriers have deployed new vessels to address supply chain constraints, these added services will require additional alternative control systems.

Without deployment of CARB-certified alternative control strategies, an "every vessel, every call" standard is impossible to meet. PMSA requests that CARB evaluate the availability and deployment of alternative control technologies and consider modifications to the amended rule that extend schedules or increase the number of VIEs/TIEs to address the lack of availability of alternative control technology systems. Alternatively, deferral of the effective date of January 1, 2023, leaving current compliance requirements for ocean-going vessels under the original rule in place, would result in no additional significant emissions from ocean-going vessels but avoid this complication. This is particularly important in ports without any CARB-certified compliance options.

*Lack of Ro/Ro Shore Power Standard*
As CARB staff knows, a global shore power standard for Ro/Ro vessels has been in development for some time. Unfortunately, that standard, which will serve as a universal model for this vessel type, is not yet complete. That makes it impossible for engineers to design systems that will meet the standard's requirements prior to finalization. This is unlike the timeline of the development of the shore power rule for containerships, where the global standard was modeled on the pioneering efforts of the ports of Long Beach and Los Angeles. To be effective, this global Ro/Ro standard will necessarily precede any implementation of shore power for Ro/Ro vessels and is being designed to meet needs of Ro/Ro vessels and facilities globally. As a result, vessel retrofit designs cannot be completed until the standard is complete. Combined with the delays in sourcing parts and equipment, limited drydock space, and limited engineering personnel with the necessary skills to implement the shore power retrofits on vessels, it is not possible to retrofit vessels (or terminals) in time for the 2025 deadline (see below). We would request that the Interim Evaluation recommend that CARB's sub-national rule implementation align with the timeline of finalization of the global standards.

*Time Retrofit of Vessels/Terminals Significantly Extended*
Information provided by PMSA members indicate that typical shore power retrofits take nearly two years (see attachment). Vessel retrofit requires design, procurement, installation, and commissioning. Since every vessel is unique, even among sister ships, every vessel requires individual design. In addition, the need to maintain operations and the limited trained engineering personnel capable of conducting these installations globally limit the number of retrofits that can be conducted concurrently. Finally, availability of drydock and other facilities have been reduced by the impact of COVID-19. In particular, facilities in China have been significantly disrupted due to lockdowns and other pandemic-related measures. More time beyond 2023 for containerships/cruise ships and 2025 for Ro/Ro vessels will be necessary to retrofit vessels for an "every vessel, every call" standard of shore power.

In addition, the Port of Long Beach's *Feasibility Report Shore Power for Container Terminals Tanker and Ro-Ro Vessels at Non-Container Terminals* indicates that completion of shore power infrastructure will take five years. Ignoring the constraints associated with retrofitting vessels, the terminals will not be ready in time to meet the requirements of the rule. Without a significant adjustment to the rule, Ro/Ro vessels and terminals will be in a perpetual state of non-compliance in 2025.

Ocean carriers and terminal operators do not have capacity to simultaneously deploy shore power infrastructure and alternative control technologies, nor should they have to. Since the adoption of the original Ocean-Going Vessels At-Berth rule CARB's intention, and the primary goal of the maritime industry in successfully implementing this rule since 2007, has been to place primary focus on shore power infrastructure on vessels and terminals. That alignment achieves the greatest reductions of hoteling emissions from vessels, but comes with reduced flexibility and significant time necessary for implementation. As originally drafted, the amended At Berth Rule did not provide adequate time for the significant time to retrofit vessels and to expand terminal infrastructure and as a result the schedules contained in the rule must be re-evaluated based on current circumstances.

PMSA notes again that continuation of the effective date of January 1, 2023, leaving current compliance requirements for ocean-going vessels under the original rule in place, would result in no additional significant emissions from ocean-going vessels and provide for additional time for new infrastructure and vessel retrofit work to take place.

*Clean Air Act Waiver Not in Place*
No waiver for the amended At Berth Rule is in place or has been applied for. Until a Clean Air Act waiver for the amended rule is in place, the currently enforceable rule is the shore power regulation adopted in 2007. Luckily, the emission reductions of the original At Berth rule and the amended rule are identical through 2025. Therefore, while potential delays in the granting of a waiver may necessitate a delay in the January 1, 2023 effective date, such a delay need not immediately compromise any emission reductions.

PMSA encourages CARB to submit a waiver request to U.S. EPA as soon as possible if CARB intends to implement the rule as currently scheduled. A longer delay in submitting a waiver request will increase the likelihood that a waiver will not be granted by the end of this year and before the January 1, 2023 planned effective date.

*Ports of Long Beach and Los Angeles Treated Separately*
Under the original rule, the ports of Long Beach and Los Angeles are treated as a single port complex for fleet compliance. Under the new rule, the two ports will be handled separately for the purpose of determining VIEs. This change was the result of change in definition ('California Ports' under the 2007 At Berth Rule) and not the rule parameters, the impact may have been overlooked. Since ocean carriers frequently move vessels between terminals in San Pedro Bay during a given year, this change significantly reduces operational flexibility while not materially changing the emissions benefit. PMSA requests that CARB staff give ocean carriers the option to treat San Pedro Bay as a single port.

*Line-Hauling Containerships*
Occasionally, containerships must be line-hauled to provide access to shore power infrastructure for another vessel. Doing so requires temporarily disconnecting and reconnecting the vessel to shore

power. This process requires the consent and cooperation of both ships (which may be operated by different vessel operators) and the terminal operator. It appears that this may be treated as a separate visit under the amended At Berth Rule. In order to encourage cooperation and prevent incentives that would encourage a party from withholding permission, PMSA requests that consideration be given to treating such circumstances as a single visit that does not penalize parties for working cooperatively to maximize emission reductions.

*Berth Shifting*
Other instances that result in multiple visits under the new rule. As one example, a vessel may complete a visit at one terminal and move to another for the sole purpose of loading empty containers, resulting in two visits under the rule. If that vessel is not equipped with shore power, it is likely to incentivize the drayage of thousands of empty containers from one terminal to another resulting in worse impacts than the vessel moving. PMSA requests that CARB develop an approach to consider that if a vessel shift is the less impactful approach, that it could occur without penalty (i.e., expenditure of a VIE).

*Con/Ro Vessels*
Container/Roll-on/Roll-off vessels serve both container terminals and Ro/Ro terminals. Unfortunately, the shore power standards for containerships and Ro/Ro vessels will likely be different. Under the amended At Berth Rule, it is unclear what would happen if a Con/Ro vessel equipped to a container terminal shore power standard arrived at Ro/Ro facility equipped to the Ro/Ro shore power standard. This issue must be clearly laid out in a manner fair to all parties. PMSA requests that CARB specifically work with Con/Ro carriers to address these issues.

*Vessels at Anchor*
As part of the interim evaluation, CARB will be examining emissions at anchor. Anchorage emissions from containerships are separate and apart from emissions of vessels at Berth and should be addressed separately and apart from the vessel at Berth regulation. While anchorage emissions did increase temporarily during the early part of the pandemic, these were uncharacteristic of our typical industry operations as delays throughout the supply chain crisis resulted in vessels anchoring outside port. In response, the maritime industry collectively implemented a virtual vessel queueing program. The program assured vessels their place "in line" for a berth at the time of departure from the last port of call. Having a confirmed place, vessels could then rationalize their transpacific voyage in order to resume "just-in-time" arrivals to San Pedro Bay. This has significant benefits. First, containerships at anchorage returned to historical average near-zero range of vessels (see attachment). Second, vessels could slow steam across the Pacific significantly reducing emissions, including greenhouse gas emissions, on route. Given the complete lack of safe and proven technology and the comprehensive manner in which industry has addressed the issue, PMSA does not believe that action on anchorage emissions is warranted.

*General Cargo Ships*
CARB will also be reviewing the application of the At Berth Regulation to general cargo vessels. PMSA believes that the conclusions that CARB reached excluding general cargo from the At Berth Rule still apply. General cargo vessels represent a tiny fraction of emissions at California ports, but face

significant challenges for implementing shore power. General cargo vessels are not repeat visitors to California ports making shore power an impractical solution, while operational considerations, such as line hauling, make both shore power and alternative control systems, difficult to safely implement.

*Conclusion*

While many of the issues outlined above may require modifications to the amended At Berth Rule, PMSA respectfully submits that this was precisely why CARB wisely decided to create the Interim Evaluation process here, as an opportunity for course correction in what is a significant and complicated rule. The operating environment even under the existing regulation, which is much less complex and more straightforward to implement, has faced difficulties due to the global pandemic and ensuing supply chain crisis. This has resulted in even more implementation challenges for the new amended rule.

CARB will be presenting the results of the Interim Evaluation to its Board in 2023. PMSA is concerned that several of the issues raised here should be addressed prior to end of the year and requests that CARB work with stakeholders to address issues ahead of 2023.

PMSA would like to point out that CARB has the opportunity of relying on continued utilization of the original regulation during the implementation period, which would allow for ongoing emissions reductions at roughly the same levels as intended under the newly amended rule should this result in delays.

PMSA and its members would like to collectively and individually meet with CARB staff to discuss elements of the Interim Evaluation and their ongoing experience. We look forward to working with you and hope that CARB can conduct a series of meetings to further explore each of the issues raised in this letter and collaborative propose modifications to the amended At Berth Rule as a part of the Interim Evaluation that will improve the rule and its odds of successful implementation.

Sincerely,

Thomas Jelenić
Vice President

Attachments

To: [redacted]

May. 24, 2022
Terasaki Electric co., ltd.
Ref No. 22KK0520-PCC

# Lead time of AMP retrofit for Pure Car Carriers

This letter explains the lead time of AMP retrofit for servicing pure car carriers (PCC) considering the current situation of IEC standard and parts procurement status.

## 1. Trends in international standards of AMP for PCC

IEC standard for AMP for PCC: IEC 80005-1 Annex G is still under discussion and has not come into effect. Since the AMP system must comply with the IEC standard, specific designing and parts procurement of AMP system will start after IEC 80005-1 Annex G comes into effect.

The effective date is currently undecided, but it is expected to come into effect in the first half of 2023.

## 2. Current status of parts procurement

Since COVID-19 epidemic, procurement of various parts used for AMP system has become longer than before COVID-19 epidemic due to a global shortage of semiconductors etc. Some parts take more than half a year to be delivered.

Example : PLC, CPU, Relay, Base board, POD etc

For some parts, which alternatives can be used, we will procure alternatives and change the design if possible, and strive to avoid inconvenience to customers such as delays in delivery as much as possible.

However , in the current situation, even for alternative products take long time to deliver due to the flood of orders from various buyers.

## 3. Expected schedule of AMP retrofit for PCC

We inform you the expected schedule of AMP retrofit work for servicing PCC vessel, taking the situation of above item no.1 and 2 into account.

Please refer to the attached schedule.

For the first ship, it is necessary to study the specifications in advance as "pre consideration" (including the discussion for the specification with you), and under the current situation where material procurement is prolonged, the lead time for AMP retrofit is expected to be about 22 months from the start of the consideration.

In the case of the sister vessels, the lead time is about 18 months because pre-consideration is not necessary.

However please note that the first vessel for each specification needs pre-consideration. The delivery and modification for subsequent vessels will require adjustment of production and engineers' schedule. Delivery and modification schedule of subsequent vessel will be decided through discussion between [redacted] and Terasaki.

The IEC80005-1 Annex G is expected to come into effect around the spring of 2023, so even if the pre-consideration is started before the effectuation and the detailed design of the AMP system is started immediately after the IEC80005-1 Annex G comes into effect, the first AMP retrofit work in a shipyard is expected to be carried out in the fall of 2024. After that, the period for which the second and subsequent vessels can be modified by the end of 2024 is only about one or two months. It is expected that AMP retrofit work for most vessels will be possible after 2025.

According to CARB regulation, PCC are required to apply AMP system as of 2025, but under the present circumstances, it is difficult to complete AMP retrofit work for all of your PCCs before January 2025.

Regarding future plans, we will continue to study the specification, and once IEC 80005-1 Annex G comes into effect, we will promptly start designing and manufacturing AMP system for your PCCs.

We ask for your understanding and continued cooperation.

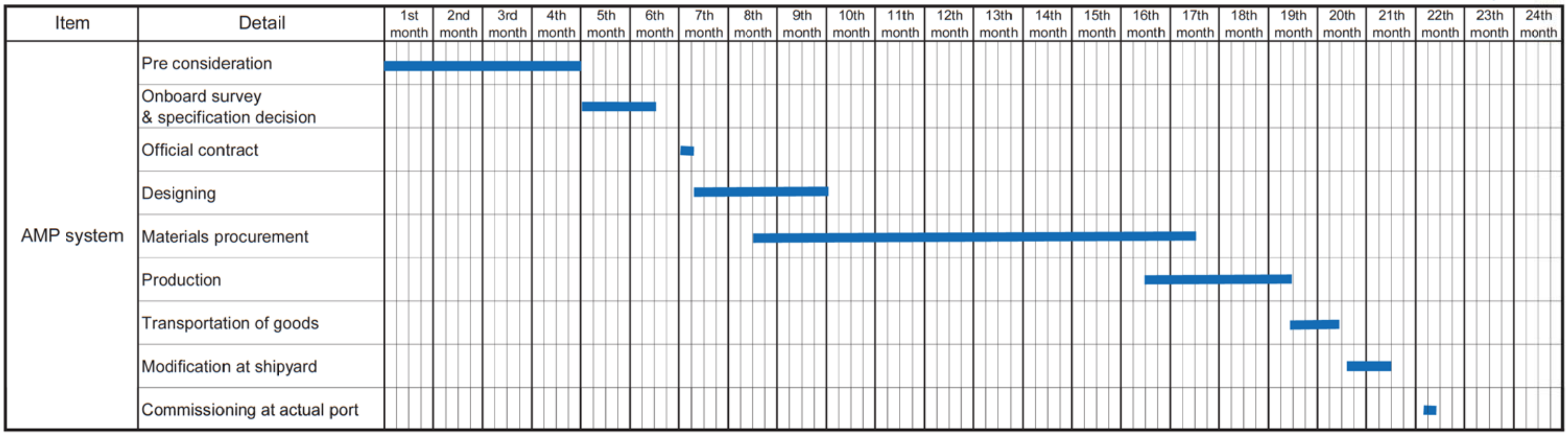
Yours faithfully,

Y.Yamaji / Manager
Marine Sales Dept., System Division
Terasaki Electric Co., Ltd.

K.Kawamoto / Assistant manager
Marine Technical Dept., System Div.
Terasaki Electric Co., Ltd.

# *Tentative production schedule of AMP system for servicing PCC*

May.24,2022

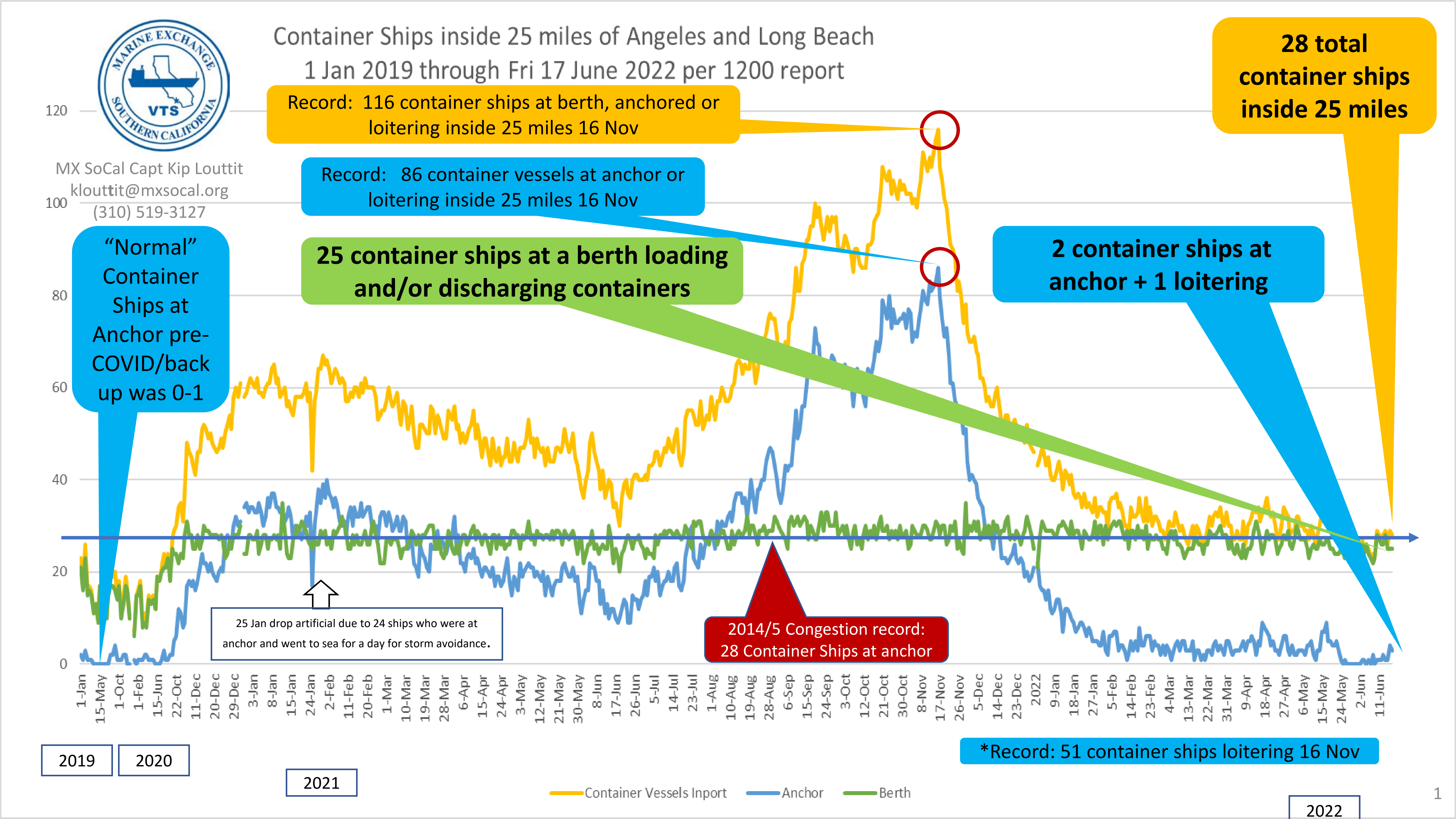



Remark :

1. Pre consideration is required on the first vessel in each specification if there are multiple vessels with different specifications.

2. Effective date of IEC80005-1 Annex G has not been decided yet. Above schedule will be changed depending on the effective date of IEC80005-1 Annex G.

3. The actual production schedule will vary depending on the specifications and the parts procurement status when the official order is placed.



Container Ships inside 25 miles of Angeles and Long Beach
1 Jan 2019 through Fri 17 June 2022 per 1200 report
MARINE EXCHANGE SOUTHERN CALIFORNIA VTS
MX SoCal Capt Kip Louttit
klouttit@mxsocal.org
(310) 519-3127
Record: 116 container ships at berth, anchored or loitering inside 25 miles 16 Nov
Record: 86 container vessels at anchor or loitering inside 25 miles 16 Nov
28 total container ships inside 25 miles
"Normal" Container Ships at Anchor pre-COVID/back up was 0-1
25 container ships at a berth loading and/or discharging containers
2 container ships at anchor + 1 loitering
25 Jan drop artificial due to 24 ships who were at anchor and went to sea for a day for storm avoidance.
2014/5 Congestion record: 28 Container Ships at anchor
*Record: 51 container ships loitering 16 Nov
120
100
80
60
40
20
0
1-Jan 15-May 1-Oct 1-Feb 15-Jun 22-Oct 11-Dec 20-Dec 29-Dec 3-Jan 8-Jan 15-Jan 24-Jan 2-Feb 11-Feb 20-Feb 1-Mar 10-Mar 19-Mar 28-Mar 6-Apr 15-Apr 24-Apr 3-May 12-May 21-May 30-May 8-Jun 17-Jun 26-Jun 5-Jul 14-Jul 23-Jul 1-Aug 10-Aug 19-Aug 28-Aug 6-Sep 15-Sep 24-Sep 3-Oct 12-Oct 21-Oct 30-Oct 8-Nov 17-Nov 26-Nov 5-Dec 14-Dec 23-Dec 2022 9-Jan 18-Jan 27-Jan 5-Feb 14-Feb 23-Feb 4-Mar 13-Mar 22-Mar 31-Mar 9-Apr 18-Apr 27-Apr 6-May 15-May 24-May 2-Jun 11-Jun
2019
2020
2021
2022
Container Vessels Inport
Anchor
Berth

Port of LONG BEACH
THE PORT OF CHOICE

June 27, 2022

Richard Corey
Executive Officer
California Air Resources Board
Clerk's Office
1001 I Street
Sacramento, CA 95814

*Submitted by email: shorepower@arb.ca.gov*

**Subject: Port of Long Beach Comments to Inform the California Air Resources Board At Berth Regulation Interim Evaluation**

Dear Mr. Corey,

The Port of Long Beach (Port) appreciates this opportunity to provide comment on the implementation of the California Air Resources Board (CARB) At Berth Regulation and the development of the Interim Evaluation. Fundamentally, we continue to support control of emissions at berth for non-container vessels, including roll-on, roll-off (RoRo) and tanker vessels. As vessels are the largest source of emissions at the Port, we believe this rule is one of a number of important strategies to mitigate vessel-related air pollution.

The January 1, 2025 deadline for RoRo and tanker vessel/terminal compliance at the San Pedro Bay Ports is only 2.5 short years away, and little progress beyond development of Port and Terminal Plans has been made due to a number of significant challenges. CARB approval has not been achieved for any emission control strategy (CAECS) capable of scrubbing emissions from RoRo and tanker vessels since the rule was adopted by the CARB Board in August of 2020. Further, due to the lack of internationally approved design standards for RoRo vessels, complexity of design, construction, and delivery schedules, shore power installations will be nearly impossible to complete over the course of the remaining 2.5 years, assuming implementation started upon CARB approval of Port and Terminal Plans. This approval was only received 3+ months after submission of the plans by the December 1, 2021 deadline. Information on shore power installation timelines, and costs, for each regulated non-container terminal should they pursue shore power as their primary compliance pathways is provided in the attached Port of Long Beach 2021 Shore Power Feasibility Report (Report). The terminals plans submitted by Port tenants indicate that Chemoil and SSA/Crescent (both at Pier F) intend to install shore power as their primary solution. However, the Report indicates these installations will only come at great expense to the terminal operators and cannot be completed on the CARB compliance timeline.

An additional feasibility parameter that continues to be a challenge is the availability of berth space to serve barge-based CAECS. At least two terminal operators, including Marathon and Toyota, intend to utilize barge-based CAECS. All terminal operators appear open to using a CAECS system if it is available, and required. However, terminal operators have not made

long-term commitments to CAECS providers as none of them have demonstrated the ability to meet CARB requirements for non-container vessels. Meanwhile, interest from CAECS providers for berth space has increased as they work to build the business case for such technologies. It is unclear how the Port can possibly accommodate the potential demand for berth space in light of space constraints and an ever-evolving landscape of CAECS providers. Decisions around which provider the terminals will utilize likely will not be made until CARB approved CAECS exist.

In addition, public investment in this space has been woefully inadequate. Little funding has been allocated above and beyond the $10 million solicitation CARB released for CAECS capable of capturing emissions from tanker vessels. Because the timeline for implementation is so stringent, nearly all grant funding is off the table for design, build, and demonstration of these systems. Comparatively, hundreds of millions of public dollars were made available to the container and cruise industry to make shore power and CAECs viable options for compliance. Investment in this space is paramount to the success of the program, and can only be done with an extension of the compliance timelines.

Finally, the innovative concept applications submitted to CARB by December 1, 2021 have not been approved, and a lengthy public review process was added after the rule was adopted. After allowing substantial time for public comment on the innovative concept applications, and incorporation of feedback by the applicants into their updated innovative concept applications, CARB does not expect to receive final innovative concept submissions until August 19, 2022. Another round of review from CARB staff will then be required. Should an applicant learn their innovative concept falls short of CARB expectations in Fall of 2022, they will have lost substantial time (nearly a year) and will need to pivot to traditional rule compliance with minimal hope of meeting the 2025 deadline.

For these reasons, the Port of Long Beach respectfully recommends that CARB extends the January 1, 2025 deadline for both tanker and RoRo terminals at the San Pedro Bay Ports to January 1, 2027. This timeline is consistent with previous requests the Port had made throughout the rulemaking progress. This would allow greater funding opportunity for terminal operators, and would allow for necessary time for the finalizations of the shore power standard for RoRo vessels.

If you have any questions about this comment letter, please contact Morgan Caswell, Manager of Air Quality Practices at morgan.caswell@polb.com or 562-283-7100.

Sincerely,

Matthew Arms
Director of Environmental Planning
Port of Long Beach

# Port of Long Beach

## Feasibility Report
## Shore Power for Container Terminals
## Tanker and Ro-Ro Vessels at Non-Container Terminals

Prepared In Association With EnSafe

P2S ENG

ENSAFE

www.p2sinc.com

December 6, 2021
(Supersedes September 27)
P2S Project # 21-0320

# TABLE OF CONTENTS

# EXECUTIVE SUMMARY

The California Air Resources Board adopted a new Control Measure for Vessels At Berth, commonly known as the At Berth Regulation, effective January 1, 2021, which expands shore power requirements for container, passenger, and refrigerated cargo vessels, and introduces emission control requirements for roll-on, roll-off (Ro-Ro), and tanker vessels at berth. The expanded requirements begin for container vessels in 2023, Ro-Ro vessels in 2025, and tanker vessels in 2025 for the San Pedro Bay Port Complex and 2027 for the rest of the State. The Port of Long Beach (POLB) container, Ro-Ro and tanker terminals were reviewed by P2S Engineering and EnSafe at a high level to assess the state of infrastructure and to recommend solutions to install or expand shore power systems for ships at berth. The study considered any electrical infrastructure requirements to support land-based emission capture and control systems.

-Pier B Petro Diamond (B82-B83)

-Pier B Marathon Petroleum (B76-B79) on the inner part of Channel 2 and LBT (B84-B87)

-Pier B Toyota Logistics (B82-B83)

-Pier F Chemoil Marine Terminal (F208-F209)

-Pier F SSA (F204-F207).

-Pier T Marathon Petroleum (T121)

Some of the limitations of this study are discussed within this document and the applicable standards are reviewed. Recommendations per terminal are presented. Costs associated with the recommendations are included, as well as a timeline to design and construct the options presented. Costs for tanker terminals are heavily impacted by the need for a new dolphin to house shore power infrastructure equipment. A summary of costs by terminal is presented in Table ES-1 and Table ES-2 in 2021 dollars. Costs per terminal are heavily impacted by the number of shore power outlets (SPOs). Table ES-1 presents the costs for one SPO per berth. Table ES-2 presents the costs for two SPOs per berth. The exact number of SPOs for a specific terminal will vary based on the configuration of the terminal and the vessels that are anticipated to call. Table ES-3 provides costs for land-based alternative infrastructure and movable supply equipment.

| Table ES-1 Shore Power Cost by Terminal with One SPO* | | | | | | | |
|---|---|---|---|---|---|---|---|
| Terminal | Berth | Design Cost[1] | Construction Cost | Design/Constructi on "Soft" Cost[2] | Total Cost | Project Contingency Cost[3] | Total Cost w/ Contingency |
| Pier B Petro Diamond | B82 & B83 | - | - | - | - | - | - |
| Pier B Marathon Petroleum | B77 & B79 | $7,600,000 | $38,000,000 | $20,900,000 | $66,500,000 | $26,600,000 | $93,100,000 |
| Pier B Marathon Petroleum | B85 & B87 | $7,600,000 | $38,000,000 | $20,900,000 | $66,500,000 | $26,600,000 | $93,100,000 |
| Pier B Toyota Logistics | B82 & B83 | $660,000 | $3,300,000 | $1,815,000 | $5,775,000 | $2,310,000 | $8,085,000 |
| Pier F Chemoil Marine | F209 | $3,800,000 | $19,000,000 | $10,450,000 | $33,250,000 | $13,300,000 | $46,550,000 |
| Pier F SSA | F204 - F207 | $1,320,000 | $6,600,000 | $3,630,000 | $11,550,000 | $4,620,000 | $16,170,000 |
| Pier T Marathon Petroleum | T121 | - | - | - | - | - | - |
| **Total Non-Container Shore Power** | | **$20,980,000** | **$104,900,000** | **$57,695,000** | **$183,575,000** | **$73,430,000** | **$257,005,000** |

* Costs are presented in 2021 dollars and do not include the planning and construction required for SCE infrastructure/service.
(1) Estimated to be 20% of Construction Cost
(2) Estimated to be 55% of Construction Cost
(3) Estimated to be 40% of Construction Cost

| Table ES-2: Shore Power Cost by Terminal with Two SPOs* | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Terminal** | **Berth** | **Design Cost[1]** | **Construction Cost** | **Design/Construction "Soft" Cost[2]** | **Total Cost** | **Project Contingency Cost[3]** | **Total with Contingency** |
| Pier B Petro Diamond | B82 & B83 | $ - | $ - | $ - | $ - | $ - | $ - |
| Pier B Marathon Petroleum | B77 & B79 | $12,620,000 | $63,100,000 | $34,705,000 | $110,425,000 | $44,170,000 | $154,595,000 |
| Pier B Marathon Petroleum | B85 & B87 | $12,620,000 | $63,100,000 | $34,705,000 | $110,425,000 | $44,170,000 | $154,595,000 |
| Pier B Toyota Logistics | B82 & B83 | $900,000 | $4,500,000 | $2,475,000 | $7,875,000 | $3,150,000 | $11,025,000 |
| Pier F Chemoil Marine | F209 | $6,300,000 | $31,500,000 | $17,325,000 | $55,125,000 | $22,050,000 | $77,175,000 |
| Pier F SSA | F204 – F207 | $1,820,000 | $9,100,000 | $5,005,000 | $15,925,000 | $6,370,000 | $22,295,000 |
| Pier T Marathon Petroleum | T121 | - | - | - | - | - | - |

* Costs are presented in 2021 dollars and do not include the planning and construction costs required for SCE infrastructure/service.
(1) Estimated to be 20% of Construction Cost
(2) Estimated to be 55% of Construction Cost
(3) Estimated to be 40% of Construction Cost

| Table ES-3: Alternative Compliance Infrastructure and Supplemental Shore Power Equipment Cost* | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Terminal** | **Berth** | **Design Cost[1]** | **Construction Cost** | **Design/Construction "Soft" Cost[2]** | **Total Cost** | **Project Contingency Cost[3]** | **Total with Contingency** |
| Land Based Unit Infra-structure | N/A | $500,000 | $2,500,000 | $1,375,000 | $4,375,000 | $1,750,000 | $6,125,000 |
| Movable Supply Equipment | N/A | $20,000 | $600,000 | $330,000 | $1,050,000 | $420,000 | $1,470,000 |

* Costs are presented in 2021 dollars and do not include the planning and construction required for SCE infrastructure/service.
(1) Estimated to be 20% of Construction Cost
(2) Estimated to be 55% of Construction Cost
(3) Estimated to be 40% of Construction Cost

Table ES-4 provides the estimated duration for entitlements (e.g., CEQA), design, bidding, and construction of the available at-berth compliance solutions.

| Table ES-4: Design and Construction Duration by Installation Type* | | | | | |
|---|---|---|---|---|---|
| Solutions | Duration | | | | |
| | Entitlements | Design | Bidding | Construction | Total |
| Tanker Terminal Shore Power | 6 Months | 24 Months | 6 Months | 24 Months | 60 Months |
| Ro-Ro Terminal Shore Power | 6 Months | 24 Months | 6 Months | 24 Months | 60 Months |
| Electrical Infrastructure Land-Based Alternative | 6 months | 24 Months | 6 Months | 18 Months | 54 Months |
| Movable Supply Equipment | N/A | 2 Months | 6 Months | 12 Months | 20 Months |

* Durations do not include the planning and construction of SCE infrastructure.

Durations assumed that the terminal-specific solution has been selected and do not include iterative deliberations between the Port, tenant, vessel operators, and related stakeholders. Shore power installations are assumed to qualify for a Categorical Exemption under the California Environmental Quality Act (CEQA). All recommendations will require coordination with terminal operators and POLB procedures.

With the exception of Berth T121, **none of the non-container terminals involved in this study, specifically Ro-Ro and tanker terminals, have adequate capacity to provide electrical power to the vessels visiting their terminals**. Therefore, with the exception of T121, all the non-container terminals will need to obtain new electrical services from SCE to establish shore power capability.

Please note that SCE required service, associated planning, construction, and costs are not included in Tables ES-1, ES-2, ES-3, and ES-4. Previous shore power projects took three years for SCE planning and design and two years for construction. SCE's work is further discussed in the body of the report but is expected to run in parallel with the Port's design and construction timeline.

Costs and schedule presented in this report are based on data and assumptions as currently understood. New data will necessitate additional review as they may change the recommended solutions as well as the estimated cost and schedule to implement them.

# PURPOSE

This report is intended to assess the state of existing infrastructure, as well as the necessary additional infrastructure required to ensure adequate shore power capability for compliance with Regulation Order of California Code of Regulations, Title 17, Division 3, Chapter 1, Subchapter 7.5, Sections 93130- 93.134.14 (CARB's At Berth Rule) while ships are at-berth for container and non-container terminals at the Port of Long Beach (POLB). This assessment will maximize berth use and provide flexibility for shore power.

This report examines the means to provide shore power to tanker and Ro-Ro vessels that call at POLB non-container terminals where there are no existing shore power outlets (SPOs). These non-container terminals are limited to:

-Pier B Petro Diamond (B82-B83)

-Pier B Marathon Petroleum (B76-B79) on the inner part of Channel 2 and LBT (B84-B87)

-Pier B Toyota Logistics (B82- B83)

-Pier F Chemoil Marine Terminal (F208-F209)

-Pier F SSA (F204-F207)

-Pier T Marathon Petroleum (T121)

Stakeholders should be aware of the limitations of this preliminary investigation given the high level of uncertainty for each terminal's future operations.  These stakeholders include, but are not limited to, regulators, port administrators, terminal operators, vessel owners and operators, designers of vessels and terminals, and organizations that develop standards for such applications.

# BACKGROUND

## IEC/IEEE STANDARD

The only recognized world standard for "Cold Ironing" of ships is the "IEC/IEEE 80005-1: Utility connections in port - Part 1: High Voltage Shore Connection (HVSC) Systems - General requirements".  This standard defines the technical requirements for a given ship's electrical modifications and the electrical installations on shore to allow the ship to connect to shore power system for the purpose of "cold ironing", i.e. turning off the ship's auxiliary generators and running on the shore power system. Ships that do not conform to these technical requirements of the standard may find it impossible to connect to compliant shore power supplies. Because of this fact, reference is made in this report to this standard, highlighting certain requirements in the standard that apply to the subject matter outlined below.  Tanker vessels and Ro-Ro vessels that must comply with this standard are electrically sized to require more than 1 MVA of power to operate.  1 MVA is equal to 1000 KVA or 1,000,000 VA. MVA stands for Mega-Volt Amperes. KVA stands for Kilo-Volt Amperes and VA stands for Volt Amperes.

The "IEC/IEEE 80005-3: Utility connections in port - Part 3: Low Voltage Shore Connection (HVSC) Systems - General requirements" is intended to be a global standard that ships and ports around the world must comply with, to successfully "cold iron" ships at ports, where ships require up to 1 MVA while at berth. Since in this study it is assumed there are no vessels to be considered that require less than 1 MVA power, there will be no further discussion regarding this particular standard.

For "cold ironing" purposes, the IEC/IEEE 80005-1 standard, identifies the electrical service voltage per vessel type. For tanker vessels that voltage is 6.6 KV, or 6,600 Volts. For Ro-Ro vessels that voltage is 11 KV, or 11,000 Volts.

With the MVA known and the KV established, the electrical modifications for both ship and shore can proceed to be designed and coordinated, so that any ship can successfully "cold iron" at any port. For the United States it is assumed that all ship will require shore power at 60 HZ. However, some vessels are designed to operate at 50 HZ. If POLB tenants will be required to accommodate both 60HZ and 50HZ, then a frequency converter will be required. Such a frequency converter is expensive and costs for such equipment are not included in this report.

## CONTAINER TERMINAL

POLB has Shore Power Outlet (SPO) installations at the following container terminals:

1. Pier A, SSA Terminal: 3 Berths, A90 - A94.
2. Pier C, SSA/Matson Terminal: 2 Berths, C60 - C62.
3. Pier E, LBCT Terminal at Middle Harbor: 3 Berths[1], E22- E26.
4. Pier G, ITS Terminal:
    a. 2 Berths, G232 - G236
    b. 2 Berths, G227 – G235.
5. Pier J, PCT/SSA Terminal:
    a. 2 Berths, J245 – J247.
    b. 3 Berths, J266 – J270.
6. Pier T, TTI Terminal: 4 Berths, T132 – T140.

[1] 2 Berths are in use and 1 Berth recently completed construction.

All POLB container terminals are equipped presently with SPOs that are designed for providing shore power to all container ships.  However, ships sometimes do not berth where a convenient SPO may be accessible and thus the need arises to accommodate those ships for cold ironing purposes, with Movable Supply Equipment commonly referred to as a cable reel system.  An example Movable Supply Equipment unit is presented in Figure 1 below.


FIGURE 1: Example Movable Supply Equipment

## SPO LOCATIONS AND LIMITATIONS

Container terminals at the Port are equipped with multiple SPOs per berth.  The multiple SPOs are intended to provide flexibility for the variety of container ship sizes and configurations that may call a terminal.  Some container terminals were designed with SPOs equidistant apart (e.g., 200 ft between SPOs).  Other terminals were designed based on the configurations of forecasted vessel calls.  In the latter case, SPOs are not necessarily equidistant and instead may be closer or further from each other based on a berthing analysis performed during the design of the shore power system.  Both approaches have their limitations and can result in a lack of flexibility when servicing the wide variety of container ship sizes.

To increase shore power flexibility terminal operators may consider adding SPOs to a berth.  Terminal operational requirements may necessitate the installation of additional SPOs, perhaps because many vessels require a more convenient SPO to connect to, than what is installed on the wharf. Another SPO may be added to the system by merely abandoning an existing SPO and replacing with a new one at another location or adding a new SPO without abandoning an existing one.

Complications may arise when adding an SPO without abandonment. Adding an SPO is not the only work needed on the wharf, but also extending conduits and wiring from the wharf to the backland area where the electrical substation is located. Additional equipment will have to be installed at the substation which will consist of a power switch and a grounding switch that each require a footprint of 3 ft. wide and 6 ft. deep. If multiple SPOs are to be installed, then multiple of these switches will also have to be installed.  In short, adding SPOs has its own limitations and cannot be freely placed on the wharf as desired without causing an interference with other requirements.

The IEC/IEEE 80005-1 standard, in Paragraph 10.4 requires that a compatibility assessment study be performed to make sure a ship may be able to “cold iron” at a particular berth. Among other requirements, one requirement is to determine if the ship has sufficient cable length to reach the SPO intended for use. This assessment should be performed collaboratively by the terminal and vessel operator. If such assessments are not conducted and the burden of satisfying this requirement is left to the ship only or the terminal operator only, it places an undue burden on either party to utilize cold ironing installations efficiently.

## NON-CONTAINER TERMINAL

The non-container terminals addressed in this report were selected by POLB based on a review of applicability of the At Berth Rule as of July 2021.

Non-container terminals at the POLB referenced within this document include terminals where tanker vessels and Ro-Ro vessels will be berthing, and where the At-Berth Regulations requires them to connect to shore power, or use an alternative emission control strategy, to limit auxiliary engine emissions.

## ALTERNATIVE TO SHORE POWER

The At-Berth Regulation also allows alternative methods for eliminating emissions from ships at berth, provided that the method is approved by CARB. The only alternative method approved by CARB historically for container vessels is “capture and control systems” that can be deployed on a barge or land side.

The barge or land-based alternative captures the emissions from a ship’s smokestack, while allowing the ship’s generators to stay in service and provide the electrical power that the ship requires while at berth. However, the capture and control system itself will require power, while serving a ship at berth. Land-based systems will most likely utilize grid electricity and therefore will require a dedicated electrical connection. It is not feasible to connect barge-based systems to the grid while in operation. Therefore, the barge-based systems will utilize on-board generators or equivalent to supply the system power. Per the CARB At Berth Rule, these generators must be “grid neutral” in terms of greenhouse gases. This grid neutral requirement means that the capture and control system generator cannot emit more greenhouse gas emissions than the average emissions of the California grid.

## SCE UTILITY SERVICE

In light of the large size of electrical services required for the non-container terminals at POLB, it would be of benefit to briefly outline the impact of the electric services involved. There are several alternative methods for obtaining this utility service. However, for purposes of this report, it is assumed that Southern California Edison (SCE) will be the utility company that will provide these electrical services.

With the exception of Berth T121, **none of the non-container terminals involved in this study, have adequate capacity to provide electrical power to the vessels visiting their terminals**. Therefore, with the exception of T121, all the non-container terminals will need to obtain new electrical services to establish shore power capability.

In order to service new shore power installations, SCE may have to install additional transmission lines, or perhaps upgrade their existing lines. Considering the geographical locations of the non-container terminals, there could be two such line extensions involved. One line serving the Pier B non-container terminals and another for Pier F terminals. SCE has preliminarily indicated there is capacity on the circuit feeding Pier F but a detailed application for service will be required to confirm the circuit's capacity to meet additional shore power demand. SCE has indicated that a line extension would be necessary to service new shore power for the non-container terminals on Pier B. For reference, Figure 2 provides a sketch of the Port showing the relative positions of the Piers.

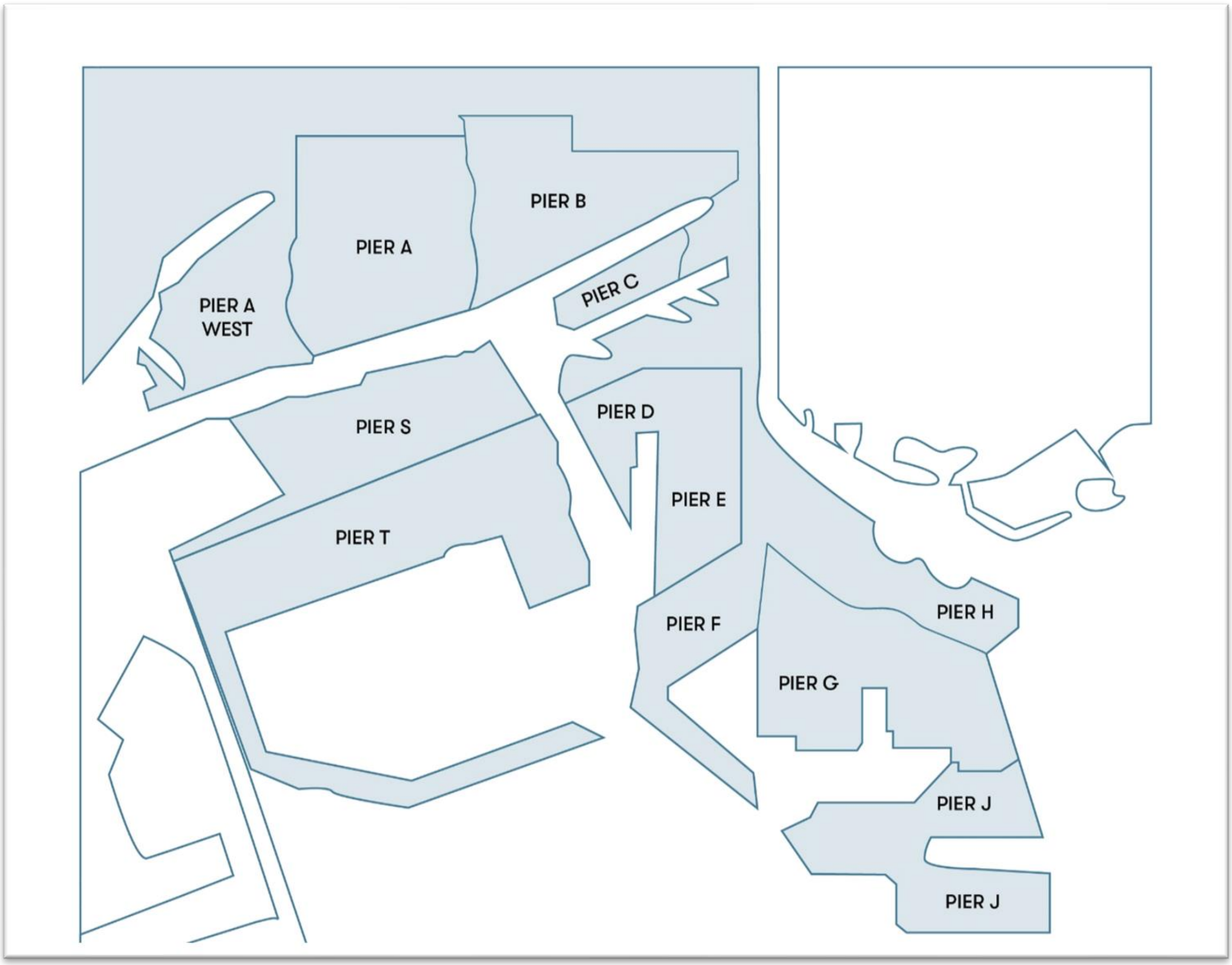



FIGURE 2: Pier Map, Port of Long Beach

Typically, SCE is required to obtain approval from California Public Utilities Commission (CPUC) in order to construct facilities required for such a project as providing electrical services for tanker and Ro-Ro vessels, unless SCE qualifies for an exemption authorized by the CPUC. CPUC approval may require up to 48 months, while the Exemption process can sometimes require about 6 months. For this study, it is assumed that SCE will be able to proceed with an Exemption. The timeline for SCE's work is expected to run in parallel with the Port's design and construction timeline.

There are two scenarios for SCE to provide these services:

1. If the existing SCE transmission lines serving these terminals have adequate capacity to serve the vessels, then a tenant may obtain additional power by submitting a service request, as is often done routinely. This report does not address legal or regulatory issues and the allocation of the cost for such service is beyond the scope of this report.
2. If the existing SCE transmission lines serving these terminals do not have adequate capacity to serve new shore power systems, then SCE will have to install new transmission lines extending them to the terminals before they can provide additional power to the terminals, as described in preceding paragraph (1). Based on past container terminal projects for shore power, such an installation will require three or more years for preparing plans and obtaining necessary approvals and an additional two years for installation. That would be a total of 5 years duration assuming that SCE proceeds at the same pace as it did in 2009 for additional service to Pier G, which POLB considered to be unduly slow. This assumption does not take into account developments since 2009. Cost for planning and approvals are estimated to be around $750,000, but the actual figure would need to be confirmed with SCE. The SCE cost for design and installation will most likely be in excess of $25 Million for Pier B and another $25 Million for Pier F if additional transmission lines are required. These ballpark costs estimates are based on SCE's cost to extend additional service to Pier G in 2009, the most recent relevant example project at the Port. The allocation of these costs is beyond the scope of this report.

The estimated time for the Port to complete the entitlements, design, bidding, and construction of shore power for tanker and Ro-Ro terminals is 60 months (5 years). If SCE's works in parallel with the Port's effort and takes no longer than the 2009 Pier G project (5 years), the necessary infrastructure could be available without adding significant time to the overall project duration. However, delays in SCE's work could cause delays in the overall timeline to deliver new shore power for Ro-Ro and tanker terminals.

# ELECTRIFICATION OF NON-CONTAINER TERMINALS

## TYPES OF SHIPS

Based on a preliminary inspection of the non-container terminals and the cooperation of the terminal operators, it was concluded that the tanker vessels and Ro-Ro vessels were visiting the following non-container terminals, as follows:

-Pier B Petro Diamond (B82-B83): Tanker vessels

-Pier B Marathon Petroleum (B76-B79) on the inner part of Channel 2 and LBT (B84-B87): Tanker vessels

-Pier B Toyota Logistics (B82-B83): Ro-Ro vessels

-Pier F Chemoil Marine Terminal (F208-F209): Tanker vessels

-Pier F SSA Berth 204-207: Ro-Ro vessels

-Pier T Marathon Petroleum (T121): Tanker vessels

Ro-Ro ships are explicitly identified in the applicable standard IEC/IEEE 80005-1 with requirements that Ro-Ro ships must comply with. Similarly, for the tanker vessels, the same standard has explicitly identified tanker vessel with specific requirements that tanker vessels must comply with. However, the requirements for these ships differ such that if shore power for one type of ship is fitted on the wharf, the same installation CANNOT serve tankers or container ships.

Presently there are no Ro-Ro-type ships that have been retrofitted to accept shore power visiting the POLB. Although there may be some Ro-Ro vessels in the global fleet that are retrofitted to accept shore power, they do not necessarily follow the IEC/IEEE standards. There are Ro-Ro ships that claim to have retrofitted in accordance with the IEC/IEEE 80005-1 standard, however no such vessel has visited any of the non-container terminals at the POLB as of this date.

In summary, all non-container terminals need to comply with the IEC/IEEE standard. Table 1 is a summary of the non-container terminals and the applicable Annexes for the vessels being served.

Table 1: Non-Container Terminals and Applicable Standards

| Non-Container Terminal | IEC/IEEE 80005-1[2] | Type of Vessels |
|---|---|---|
| Pier B Petro Diamond (B82-B83) | (Annex F) | Tanker |
| Pier B Marathon Petroleum T2 (B76-B79) on the inner part of Channel 2 and LBT (B84-B87) | (Annex F) | Tanker |
| Pier B Toyota Logistics (B82-B83) | (Annex B) | Ro-Ro |
| Pier F Chemoil Marine Terminal (F208-F209) | (Annex F) | Tanker |
| Pier F SSA Berth 204-207 | (Annex B) | Ro-Ro |
| Pier T Marathon Petroleum (T121) | (Annex F) | Tanker |

## AVAILABLE SOLUTIONS

At the POLB, the non-container terminals mentioned in this report, with the exception of T121, have no "cold ironing" facilities as of this writing. The POLB container terminals all have shore power capacity. However, some berths may exhibit limited flexibility due to the location of the SPOs. The following options are available to enhance the ability of the Port's terminals to comply with the CARB At-Berth Rule. These options are further detailed in this section

- Shore Power installation at Tanker Terminals
- Shore Power installation at Ro-Ro Terminals
- Alternative Compliance via Land-based or Barge-Based Emission Capture and Control
- Movable Supply Equipment at container terminals with existing shore power capability.

[2] Assumed no tanker vessel or Ro-Ro vessel of 1 MVA or less will visit POLB non-container terminals.

The above options are recommended for considerations and subject to interpretation and approval by authorities having jurisdiction, such as the local building officials, terminal operators, Board of Harbor Commissioners and CARB personnel. Table 2 provides the locations of diagrams of each of the available non-container terminal compliance options.

| Table 2: Operations and Solutions Summary | |
|---|---|
| Operations | Solutions |
| a) Tanker Vessels | See Diagram on Sheet E4 |
| b) Ro-Ro Ships. | See Diagram on Sheet E5 |
| c) Land-Based Alternative | See Diagram on Sheet E6 |

## TANKER VESSEL

Attached Drawing Sheet E4 shows a typical site plan for a tanker vessel "Cold Ironing" application, complying with IEC/IEEE 80005-1, Annex F.

The cables delivering electrical power to a tanker vessel will be spooled on a cable manager, as specified in paragraph 7.2 of the IEC/IEEE 80005-1 standard. This "Power Cable Manager" will have three cables, each with a power rating of 3.6 MVA. The voltage serving the vessel shall be 6.6 KV. Detail 2 on Sheet E4 shows a Power Cable Manager that is presently in use at T121 of the POLB.

For tanker vessels, the IEC/IEEE 80005-1 standard has another requirement to provide a "Control Cable Management System", in addition to the cable manager for power cables. Therefore, two cable managers will be necessary to be provided, one for power cables and another one for control cables. Detail 2 on Sheet E4 shows a "Control Cable Management System".

Furthermore, unlike the Movable Supply Equipment that is permitted by the IEC/IEEE 80005-1 standard within a container terminal and with container ships, such "cable reel" is not permitted for use in a tanker vessel application due to the fact that the standard requires the "cable reel" for a tanker vessel be located on shore, whereas the "cable reel" for a container ship may be located on the ship itself. Additionally, the IEC/IEEE 80005-1 standard, in paragraph F.4.6.4, requires that the equipment used for "cold ironing" of a tanker vessel at berth be located outside the hazardous classified areas[3]. This report then will use these

[3] In general, the hazardous classified area are those regions of a tanker vessel and terminal where fire or explosion hazards may exist. The National Electric Code (NEC) and the International Electrotechnical Commission (IEC) include extensive definitions and discussion of classified areas as well as constraints on electrical systems within those areas. The cost to install and operate a shore power system within the hazardous classified area would likely be prohibitively expensive.

requirements for tanker vessels as established in the IEC/IEEE 80005-1 standard in describing the modifications required on shore.

It is assumed that tanker vessels will have a crane to lift the shore power cables from shore to the ship. This is unlike the container ships where they lower the cables from the ship to the wharf for a shore power connection. Most likely this lifting crane and the ship connectors will be at the stern of the ship to meet the requirements of the IEC/IEEE 80005-1 standard, particularly if the equipment have to be located out of the hazardous classified areas.

To add flexibility to berthing locations of tanker vessels, the “Power Cable Manager” and the “Control Cable Management System” is recommended to be mounted on a platform to allow moving the system along the wharf. Wharf space constraints may make such a movable system impractical at some terminals. These terminals may require special shore power designs or wharf modifications to meet the IEC/IEEE Standard.

## RO-RO SHIP

The attached Drawing Sheet E5, shows a site plan for Ro-Ro ships, complying with IEC/IEEE 80005-1, Annex B.

A previous study, prepared on behalf of the Port, identified the typical power demand at a Ro-Ro berth as approximately 1.5 MVA[4]. This is substantially less than the IEC/IEEE 80005-1 standard which requires that one cable be used for the Ro-Ro system and the maximum power demand to be 6.5 MVA. This report will use the 6.5 MVA that is included in the Standard.

The IEC/IEEE 80005-1 standard in paragraph B.4.6.4 specifies that the electrical equipment installation needed for the “cold ironing” of Ro-Ro ships shall not be installed in areas that may become hazardous areas. For nominal voltage, the standard IEC/IEEE 80005-1, paragraph B.5.1 specifies the use of 11 KV.

The IEC/IEEE 80005-1 standard, in paragraph B.7.2.1 requires the cable management system serving a Ro-Ro ship to be located on shore-side facility.

To add flexibility to berthing locations of Ro-Ro ships, it is recommended to provide a crane on shore, that can lift the cables from shore to ship and can also travel along the wharf.

## BARGE SOLUTION OR LAND-BASED ALTERNATIVE

Barge-based alternatives are expected to operate independently of the terminal infrastructure and therefore terminal upgrades are not anticipated for this solution. For a land-based alternative, an electrical outlet will be provided on wharf as shown in Drawing Sheet E6.

[4] 03-30-2004. *Cold Ironing Cost Effectiveness Study*. Environ.

For this report, the discussion of power to the land-based unit will be limited to the extent of providing electrical outlets at the wharves where a capture and control system may connect to grid power. One such outlet is suggested per berth.

## MOVABLE SUPPLY EQUIPMENT

Movable Supply Equipment, commonly referred to as a "cable reel system" may be an alternative where a vessel's own cable does not reach the SPO at a particular berth. The "cable reel" solution will provide the physical means to allow vessels, with insufficient cable lengths to reach an SPO and make connection.

In the course of IEC/IEEE 80005-1 Standard development the terms "movable supply", "managed cable extension", and "cable reel", were used interchangeably and thus may have confused the readers. In this regard the Standard's final version in Paragraph 7.1 clearly states that "Ship-to-shore connection cable extensions shall not be permitted". This requirement applies to all vessels, except for the container vessels. Annex D of the Standard, in Paragraph D.6.1 states "The supply point ashore can be fixed or movable….". In short, Movable Supply Equipment is allowed for container vessel cold ironing application only. Tanker and Ro-Ro terminals can not use Movable Supply Equipment and therefore must rely on other strategies to provide berthing flexibility (e.g., additional SPOs).

Movable Supply Equipment for "cold ironing" applications are now available in a number of design configurations. The designs vary based on manufacturer and application, although they have similarities. Nevertheless, a customer will need to specify some requirements for their particular wharf and use. Hence, there will be some planning and preparation involved. Even if the customer decides to purchase a nominally identical unit that the manufacturer had constructed previously, some planning and preparation will be involved to assure compatibility of the cable reel fabricated with the application it is intended for.

# COST OF AVAILABLE SOLUTIONS

The non-container terminals have an extensive number of berthing scenarios. This presents design challenges to ensure that shore power is accessible to all vessels and all berthing configurations. As an example, if a ship berths at the same facility in any manner it chooses, such as starboard or port side, then twice as many connection points will needed than if the same ship berthed the same side consistently. Furthermore, if ships of different sizes visit the same berth, additional SPOs and substations will have to be provided on wharf to accommodate facilities on shore for "cold ironing" of these ships. It should be noted that the IEC/IEEE Standard does not limit the length of shore power cables. However, practical considerations, such as available storage space on the wharf and the weight of the cables, will limit the viable length of cables. That said, longer shore power cables can provide additional flexibility when designing shore power systems.

As noted above, the allocation of costs between various entities is beyond the scope if this report.

For cost estimating purposes, this report will assume that each non-container terminal will be equipped with a shore power system designed to service tanker vessels or a shore power system designed to service Ro-Ro vessels. Therefore, the cost of implementing the available solutions, within the limits as described, is presented in this section. Design cost will be taken at 20% of the construction cost. Program and construction management are assumed to be 55% of the construction cost. A 40% contingency is assumed based on the early phases of planning and preliminary design.

## TANKER VESSEL

Attached drawing Sheet E4 shows a typical site plan for a tanker vessel "Cold Ironing" application.

The existing electrical services for the tanker terminals are not adequate for providing shore power to tanker vessels. Therefore, a new electrical service from the utility company, Southern California Edison Co. (SCE) will be required to provide shore power at tanker terminals.

Per the IEC/IEEE Standard, a minimum of one "Power Cable Manager" and one "Control Cable Manager" is needed for each tanker vessel. Two sets will be required if some flexibility is desired for tanker vessels berthing portside or starboard side, or if a vessel has its inlet connectors at opposite ends of the vessels. However, the cost estimate included in this report is for one set only, unless specifically stated otherwise.

To give further berthing flexibility, movable platforms can be provided to adjust the cable manager to the proper location with respect to the connection points on the ship. Ideally the cable manager must be located vertically under the connection points of the tanker vessel, with no more than 10 degree deviation.

1. A crane on the wharf needs to be available to lift the cables from the wharf deck to the tanker vessel's deck.
2. A cost for such a crane is also included in the estimate.

Dolphins will be required at some of the non-container terminals to mount the electrical equipment necessary to provide shore power to the tanker vessel.

A total cost of $46.6M is estimated for serving a tanker vessel and includes one dolphin as shown on Sheet E1. Cost for an additional dolphin, if necessary, is estimated to be $16M in raw construction cost and a total of $39.2M including design, management, and contingency. Further details of the cost estimate are included in the Appendix.

## RO-RO SHIP

Attached drawing Sheet E5 shows a site plan for Ro-Ro ships, complying with IEC/IEEE 80005-1, Annex B.

The existing electrical services for the non-container terminals are not adequate for providing shore power to a Ro-Ro ship. Therefore, the total cost estimate includes a new electrical service from the utility company, SCE.

For the non-container terminals, the shore power system can be installed on the wharf deck. A power trench and a crane for lifting the cables from the wharf deck to the ship's deck and the cable manager can be integrated together to provide a flexible shore power outlet to the Ro-Ro ship.

A total cost of $8.1M is estimated for an installation as shown in the drawing Sheet No. E5. Further details of the cost estimate are included in the Appendix.

## LAND BASED ALTERNATIVE

For a land-based unit an electrical outlet will be provided on wharf, as shown in Drawing Sheet E6.

The existing electrical services for the non-container terminals have limited additional capacity. As such they are unlikely to have adequate power to support a land-based unit. Therefore, the total cost estimate includes a new electrical service form the utility company, SCE.

For this report, we will estimate the cost on the basis that 480 V shore power will be made available for this operation.

The cost shown in Table 3 is for grid power at the wharf only. This total cost is $6.1M per one outlet on the wharf. Preliminary estimates for a "capture and control" system is $10M[5] and is not included in Table 3. Further details of the cost estimate are included in the Appendix.

## MOVABLE SUPPLY EQUIPMENT

The cost for Movable Supply Equipment that meets the IEC/IEEE 80005-1 standard varies due to the cable reel's particular application, but mainly due to the cable length required. A cable reel with approximately 200 ft. of cables will cost approximately $300,000, whereas a cable reel with about 600 ft. of cables will cost approximately of $500,000. For cost estimation purposes a price of $600,000 has been used in this report to account for terminal variability.

# DESIGN AND CONSTRUCTION SCHEDULE

This section will address the time required to plan and design for the recommended solutions as well as the construction duration. For this report to put some boundaries for the design and construction periods, the assumption is made that these periods begin when there is a clear definition of all the design parameters. This is a significant assumption, because most projects would require a number of meetings involving POLB management and terminal operators to evaluate and review the options they have to consider before they are able to conclude what is needed to design and construct.

The time period for construction of any of the solutions is also assumed to begin when the POLB Board approves the Notice to Proceed (NTP) date. The end of construction period will be when the POLB Board determines that the project is substantially complete. The estimated durations for entitlements, design, bidding, and construction are summarized in Table 5 for the options presented in this report.

[5] As of this report capture and control systems are not readily available commercially and therefore costs are difficult to estimate. A recent CARB grant of $10M was awarded for the construction and demonstration of a capture and control system for tankers.

| Table 5: Design and Construction Duration by Installation Type | | | | | |
|---|---|---|---|---|---|
| Solutions | Duration | | | | |
| | Entitlements | Design | Bidding | Construction | Total |
| Tanker Terminal Shore Power | 6 Months | 24 Months | 6 Months | 24 Months | 60 Months |
| Ro-Ro Terminal Shore Power | 6 Months | 24 Months | 6 Months | 24 Months | 60 Months |
| Electrical Infrastructure Land-Based Alternative | 6 months | 24 Months | 6 Months | 18 Months | 54 Months |
| Movable Supply Equipment | N/A | 2 Months | 6 Months | 12 Months | 20 Months |

## TANKER VESSEL

Attached figure Sheet E4 shows a site plan of a typical berth in a terminal showing the components required to deliver shore power to a tanker vessel.

The time required to build such a facility represents construction involving one dolphin with cable managers on a movable platform. The movable platform is needed to accommodate a variety of tanker vessel sizes that may visit the terminal.

Design duration is estimated to require a 2-year period. Construction duration for such an installation will be 2 years. Entitlements and bidding are each estimated to require 6 months.

## RO-RO

Attached drawing Sheet E5 shows a site plan of a typical berth and the components required to deliver shore power to a Ro-Ro ship.

The duration presented for this option, includes the time required to build a movable crane that can lift the shore power cables necessary to deliver electrical power to a Ro-Ro ship. The movable crane is needed to accommodate a variety of Ro-Ro ship sizes that may visit the terminal.

Design of a Ro-Ro shore power system will be new at the Port. Although IEC/IEEE 80005-1 provides the fundamental requirements for Ro-Ro shore power, there are many design options that much be considered to best serve the terminal and anticipated vessel calls. As shown in drawing Sheet E5 a power trench may be used for the crane to move on. Additional major considerations include the number of SPOs and proximity of the substation. However, there are other options, and this being a new type of installation will draw the attention of the terminal operator, vessel operators, workers in the area, city inspectors, Port management, manufacturers, contractors, and designers. All will have input into the system and an agreement needs to be reached on the exact requirements before fabrication and installation takes place. This coordination, until an agreement is reached, is naturally a slow process and time consuming in arranging meetings, demonstrations, and sharing observations together.

Design duration is estimated to require a 2-year period. Construction duration for such an installation will be 2 years. Entitlements and bidding are each estimated to require 6 months.

### LAND-BASED ALTERNATIVE

Attached drawing Sheet E6 shows a site plan for this application.

Design duration is estimated to require a 2-year period. Construction duration for such an installation will be 18 months. Entitlements and bidding are each estimated to require 6 months.

### MOVABLE SUPPLY EQUIPMENT

It is estimated that a cable reel design will require a period of two months. The construction period required, will be 12 months. Entitlements are not anticipated for movable supply equipment. Bidding is estimated to require 6 months.

## RECOMMENDED SHORE POWER SOLUTIONS FOR NON-CONTAINER TERMINALS

In applying the findings in the discussions above, this section will provide the solutions recommended to supply shore power to the non-container terminals in question. Costs presented in this section are inclusive of design, program/construction management, construction, and contingency. A summary of the costs per terminal with a single SPO are presented in Table 3. Table 4 presents costs per terminal with two SPOs each. For cost estimation purposes the following assumptions have been used:

- Design costs are 20 percent of construction costs
- Program/construction management and oversight are 55 percent of construction costs
- Contingency is calculated as 40 percent of the sum of all other costs

| Table 3: Shore Power Cost by Terminal with One SPO* | | | | | | | |
|---|---|---|---|---|---|---|---|
| Terminal | Berth | Design Cost[1] | Construction Cost | Design/Construction "Soft" Cost[2] | Total Cost | Project Contingency Cost[3] | Total w/ Contingency |
| Pier B Petro Diamond | B82 & B83 | - | - | - | - | - | - |
| Pier B Marathon Petroleum | B77 & B79 | $7,600,000 | $38,000,000 | $20,900,000 | $66,500,000 | $26,600,000 | $93,100,000 |
| Pier B Marathon Petroleum | B85 & B87 | $7,600,000 | $38,000,000 | $20,900,000 | $66,500,000 | $26,600,000 | $93,100,000 |
| Pier B Toyota Logistics | B82 & B83 | $660,000 | $3,300,000 | $1,815,000 | $5,775,000 | $2,310,000 | $8,085,000 |
| Pier F Chemoil Marine | F209 | $3,800,000 | $19,000,000 | $10,450,000 | $33,250,000 | $13,300,000 | $46,550,000 |
| Pier F SSA | F204 & F207 | $1,320,000 | $6,600,000 | $3,630,000 | $11,550,000 | $4,620,000 | $16,170,000 |
| Pier T Marathon Petroleum | T121 | - | - | - | - | - | - |
| **Total Non-Container Shore Power** | | $20,980,000 | $104,900,000 | $57,695,000 | $183,575,000 | $73,430,000 | $257,005,000 |

* Costs are presented in 2021 dollars and do not include the planning and construction required for SCE infrastructure/service.

(1) Estimated to be 20% of Construction Cost

(2) Estimated to be 55% of Construction Cost

(3) Estimated to be 40% of Construction Cost

| Table 4: Shore Power Cost by Terminal with Two SPOs | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Terminal** | **Berth** | **Design Cost[1]** | **Construction Cost** | **Design/Construction "Soft" Cost[2]** | **Total Cost** | **Project Contingency Cost[3]** | **Total with Contingency** |
| Pier B Petro Diamond | B82 and B83 | $ - | $ - | $ - | $ - | $ - | $ - |
| Pier B Marathon Petroleum | B77 and B79 | $12,620,000 | $63,100,000 | $34,705,000 | $110,425,000 | $44,170,000 | $154,595,000 |
| Pier B Marathon Petroleum | B85 and B87 | $12,620,000 | $63,100,000 | $34,705,000 | $110,425,000 | $44,170,000 | $154,595,000 |
| Pier B Toyota Logistics | B82 & B83 | $900,000 | $4,500,000 | $2,475,000 | $7,875,000 | $3,150,000 | $11,025,000 |
| Pier F Chemoil Marine | F209 | $6,300,000 | $31,500,000 | $17,325,000 | $55,125,000 | $22,050,000 | $77,175,000 |
| Pier F SSA | F204 - F207 | $1,820,000 | $9,100,000 | $5,005,000 | $15,925,000 | $6,370,000 | $22,295,000 |
| Pier T Marathon Petroleum | T121 | - | - | - | - | - | - |

* Costs are presented in 2021 dollars and do not include the planning and construction required for SCE infrastructure/service.
(1) Estimated to be 20% of Construction Cost
(2) Estimated to be 55% of Construction Cost
(3) Estimated to be 40% of Construction Cost

Table 5 provides costs for land-based alternative infrastructure and movable supply equipment.

| Table 5: Alternative Compliance Infrastructure and Supplemental Shore Power Equipment Cost* | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Terminal** | **Berth** | **Design Cost[1]** | **Construction Cost** | **Design/Construction "Soft" Cost[2]** | **Total Cost** | **Project Contingency Cost[3]** | **Total with Contingency** |
| Land Based Unit Infra-structure | N/A | $500,000 | $2,500,000 | $1,375,000 | $4,375,000 | $1,750,000 | $6,125,000 |
| Movable Supply Equipment | N/A | $20,000 | $600,000 | $330,000 | $1,050,000 | $420,000 | $1,470,000 |

* Costs are presented in 2021 dollars and do not include the planning and construction required for SCE infrastructure/service.
(1) Estimated to be 20% of Construction Cost
(2) Estimated to be 55% of Construction Cost
(3) Estimated to be 40% of Construction Cost

## PIER B PETRO DIAMOND TERMINAL

At Pier B, Petro Diamond terminal, tanker vessels are served. Drawing Sheet E1 shows Berths B82 and B83 where Petro Diamond serves the tanker vessels. However, Petro Diamond has a 3rd preferential agreement for the use of those berths. Petro Diamond is exempt currently from the At Berth Rule requirements due to the number of vessel calls per year at the terminal, which falls below the threshold required by the Rule.

National Gypsum has 1st preferential use of the same berths as Petro Diamond, while Toyota has 2nd preferential use. National Gypsum uses gypsum cement carriers and Toyota uses Ro-Ro ships. Although National Gypsum is mentioned here, the dry bulk vessels that call National Gypsum terminal are not included in the At Berth Rule and therefore are not further addressed in this report.

For Pier B, Petro Diamond Terminal, both berths require no modifications, B82 and B83. Cost: none.

## PIER B MARATHON PETROLEUM T2 (B76-B79) TERMINAL

At Pier B, Marathon Petroleum, T2 terminal, tanker vessels are served. Applying the standard design, Drawing Sheet E1 shows where the terminal would need to provide shore power to the ships.

Electrical substations and associated equipment would need to be installed at each berth for tanker vessels, namely Berth B77 and B79, as depicted on the drawing. The drawings and strategies in this report are preliminary and theoretical.  As such, the exact locations and configuration of shore power equipment will be determined by the Port and terminal operator as part of a more detailed design analysis.

For Pier B, Marathon Petroleum T2 Terminal, both berths modifications, B77 and B79, will be at a cost of $93.1M with one SPO per berth and $154.6M with two SPOs per berth[6].

## PIER B MARATHON PETROLEUM LBT (B84-B87) TERMINAL

At Pier B, Marathon Petroleum LBT terminal, tanker vessels are served. Applying the standard design, Drawing Sheet E1 shows where the terminal needs to provide shore power to the ships.

Electrical substations and associated equipment need to be installed at each berth for tanker vessels, namely Berth B85 and B87, as depicted on the drawing. The drawings and strategies in this report are preliminary and theoretical.  As such, the exact locations and configuration of shore power equipment will be determined by the Port and terminal operator as part of a more detailed design analysis.

For Pier B, Marathon Petroleum LBT Terminal, both berths modifications, B85 and B87, will be at a cost of $93.1M with one SPO per berth and $154.6M with two SPOs per berth.

## PIER B TOYOTA LOGISTICS TERMINAL

At Pier B, Toyota Logistics terminal, Ro-Ro vessels are served.

The Toyota terminal serves only Ro-Ro ships. Applying the standard design, Drawing Sheet E1 shows where the terminal needs to provide shore power to the ships. Electrical substations and associated equipment need to be installed at one berth for Ro-Ro ships, namely Berth B83, as depicted on the drawing. The drawings and strategies in this report are preliminary and theoretical.  As such, the exact locations and

[6] The number of SPOs installed per berth will vary based on terminal operations and forecasted vessel types calling the terminal.  This report includes costs for one SPO, the minimum necessary to delivery shore power. In addition, the costs for two SPOs per berth is presented to provide a sense of the costs for additional SPOs.

configuration of shore power equipment will be determined by the Port and terminal operator as part of a more detailed design analysis.

For Pier B, Toyota Logistics Terminal, the berth modifications at B83, will be at a cost of $8.1M with one SPO per berth and $11.0M with two SPOs per berth.

## PIER F CHEMOIL MARINE TERMINAL

At Pier F, Chemoil Marine terminal, tanker vessels are served. Applying the standard design, Drawing Sheet E3 shows where the shore "Power Cable Manager" and the "Control Cable Management System" is recommended for installation. The drawing also shows that the wharf assigned to Chemoil, and the terminal's backland facilities are detached from each other.  The drawings and strategies in this report are preliminary and theoretical.  As such, the exact locations and configuration of shore power equipment will be determined by the Port and terminal operator as part of a more detailed design analysis.

Per the IEC/IEEE standard, Paragraph F.7.1, these tanker vessels require over 10.8 MVA of electrical power, while at berth.

For Pier F, Chemoil Marine Terminal, the berth modifications, at F209, will be at a cost of $46.6M with one SPO per berth and $77.2M with two SPOs per berth.

## PIER F, SSA, BERTHS 204-206 TERMINAL

At Pier F, SSA, Berths 204-206 terminal, Ro-Ro vessels are served. Drawing Sheet E2 shows where the shore power arrangement will have to be and so is recommended for installation. Electrical substations and associated equipment need to be installed at Berth B204-206. The drawings and strategies in this report are preliminary and theoretical.  As such, the exact locations and configuration of shore power equipment will be determined by the Port and terminal operator as part of a more detailed design analysis.

For Pier F, SSA Terminal, the berth modifications at F204 and F206, will be at a cost of $16.2M with one SPO per berth and $22.3M with two SPOs per berth.

## PIER T MARATHON PETROLEUM, BERTH T121 TERMINAL

At Pier T, Marathon Petroleum, Berth T121 terminal, tanker vessels are served. This terminal has shore power in accordance with the IEC/IEEE 80005-1, Annex F, Standard. As a matter of fact, the standard was written around what was designed and built at Pier T, Berth 121, as an acceptable means for providing shore power to tanker vessels. Photo in Detail 2 of Sheet E4 shows the installation at Pier T and where the "Power Cable Manager" and the "Control Cable Management System" are located.

There is currently no need to do additional work at Pier T since shore power is available and the terminal has space for only one tanker vessel.  If the types of calling the terminal were, to change it is feasible that adjustments to the shore power configuration may be necessary.  Such adjustments to the configuration should not require additional service from SCE.

# CONCLUSION

The existing POLB container terminals and non-container terminals serving tankers and Ro-Ro vessels were reviewed at a high level to assess the state of infrastructure at POLB and to recommend solutions to install shore-power systems for ships at berth. Some of the limitations were discussed and the applicable standards were reviewed. Costs associated with the recommendations are included, as well as a timeline to design and construct the options that were discussed in this report.

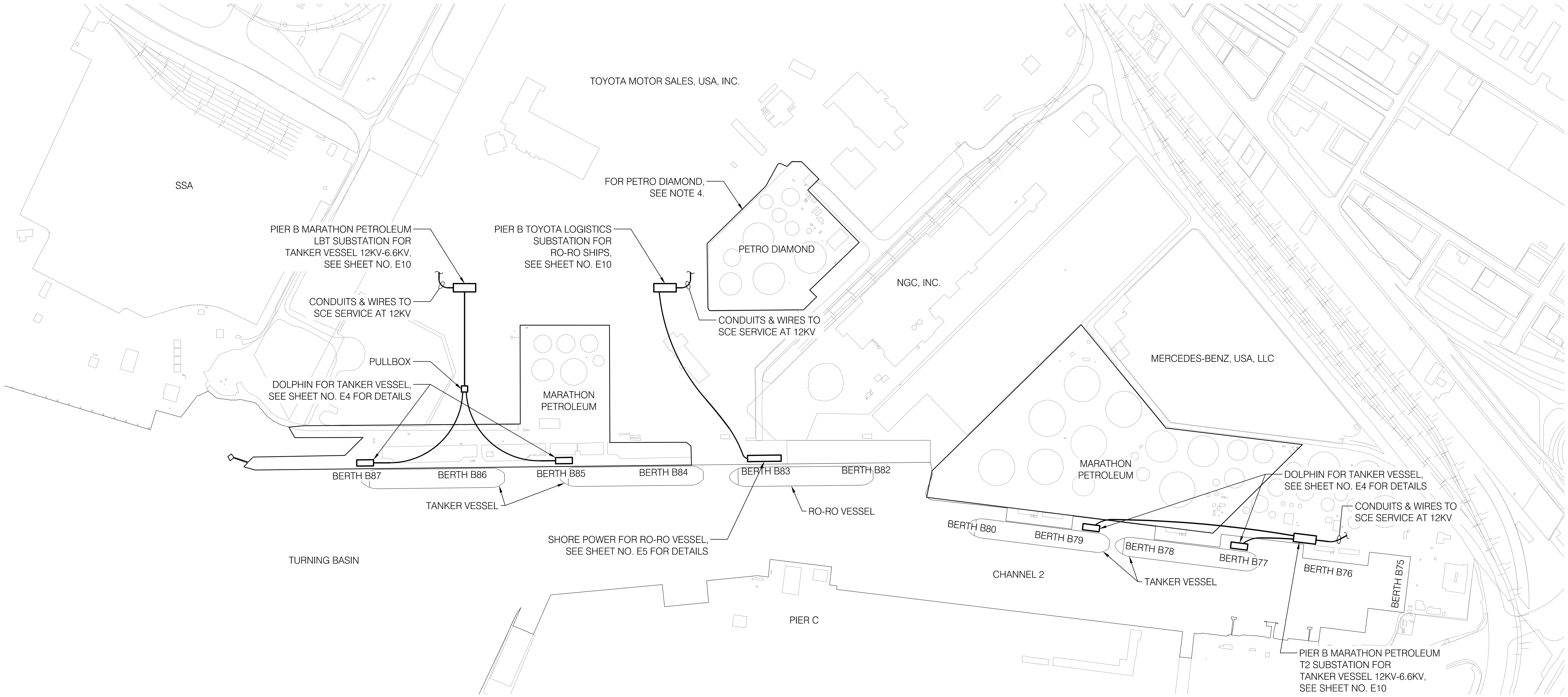
Design standards from IEC/IEEE 80005-1 is available for the safe and effective implementation of shore power for tankers and Ro-Ro vessels. For terminals opting to utilize alternatives to shore power, compliance pathways exist via capture and control solutions. The cost and timeline to implement the solutions presented in this report will be heavily impacted by individual terminal decisions. Ultimately, a terminal operator's compliance strategy will require additional evaluation and coordination with POLB, and SCE.

Costs and schedule presented in this report are based on data and experience at the Port. Additional analysis will be required to refine project costs and timelines.

# FIGURES

## GENERAL NOTES

1) THIS DRAWING ILLUSTRATES HOW SHORE POWER CAN BE MADE AVAILABLE TO SHIPS AT WHARVES.
2) EXACT LOCATIONS AND QUANTITIES OF EQUIPMENT REQUIRED FOR SHORE POWER INSTALLATIONS CAN ONLY BE DETERMINED IF VESSEL PARTICULARS ARE DEFINED, SUCH AS; WHAT VESSEL SIZE IS IN KVA, WHAT TYPE OF VESSEL IT IS (TANKER, RO-RO), WHERE THE VESSEL INLET IS LOCATED AND SIMILAR DATA.
3) SCE SERVICES AND SUBSTATION LOCATIONS ARE DIAGRAMMATIC. FOR EXACT SERVICE LOCATIONS FROM SCE, AND SUBSTATION LOCATIONS, IT IS NECESSARY TO DETERMINE AVAILABLE PROPERTY SITE FOR SUBSTATION AND A RESPONSIBLE PARTY THAT WILL SIGN TO THE SCE METER FOR ELECTRICAL POWER BILLING, AMONG OTHER DATA NEEDED.
4) FOR PETRO DIAMOND, THERE ARE NO PROVISIONS MADE FOR SHORE POWER, BECAUSE OF CARB EXEMPTION.




PIER B SITE PLAN
NOT TO SCALE
1
E1

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PLOT: Monday, August 30, 2021 2:44:48 PM

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Project Title
CARB - POLB
Non-Container Terminals

Revisions
Number Description Date

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|---|---|
| Designed | BC |
| Drawn | SS |
| Checked | KS |
| Approved | MC |

Date

Submittal

Scale None

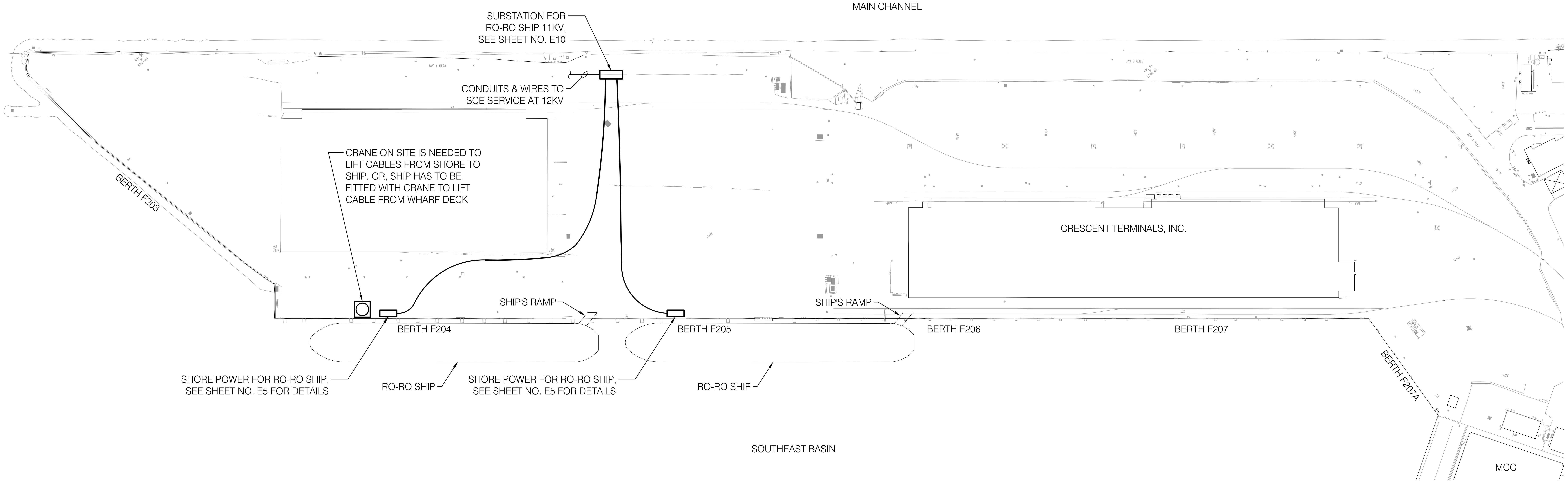
Sheet Title
POLB Pier B Site Plan
Petro Diamond
Marathon Petroleum
Toyota

Sheet Number
E1

P2S No. 21-0320

## GENERAL NOTES

1) THIS DRAWING ILLUSTRATES HOW SHORE POWER CAN BE MADE AVAILABLE TO SHIPS AT WHARVES.
2) EXACT LOCATIONS AND QUANTITIES OF EQUIPMENT REQUIRED FOR SHORE POWER INSTALLATIONS CAN ONLY BE DETERMINED IF VESSEL PARTICULARS ARE DEFINED, SUCH AS; WHAT VESSEL SIZE IS IN KVA, WHAT TYPE OF VESSEL IT IS (TANKER, RO-RO), WHERE THE VESSEL INLET IS LOCATED AND SIMILAR DATA.
3) SCE SERVICES AND SUBSTATION LOCATIONS ARE DIAGRAMMATIC. FOR EXACT SERVICE LOCATIONS FROM SCE, AND SUBSTATION LOCATIONS, IT IS NECESSARY TO DETERMINE AVAILABLE PROPERTY SITE FOR SUBSTATION AND A RESPONSIBLE PARTY THAT WILL SIGN TO THE SCE METER FOR ELECTRICAL POWER BILLING, AMONG OTHER DATA NEEDED.




### PIER F SITE PLAN - BERTH F203-F207

NOT TO SCALE

1 / E2

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CARB - POLB
Non-Container Terminals

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| Designed | BC |
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| Approved | MC |

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Sheet Title

POLB Pier F Site Plan
Berth F203-F207
SSA

Sheet Number

E2

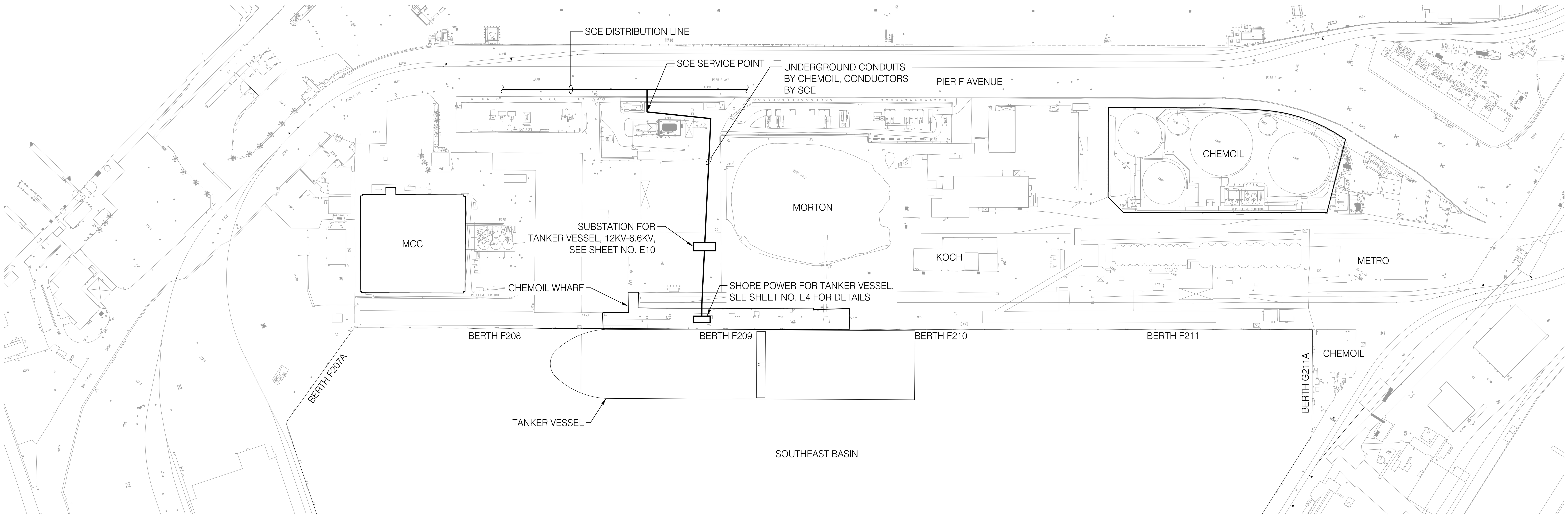
P2S No. 21-0320

## GENERAL NOTES

1) THIS DRAWING ILLUSTRATES HOW SHORE POWER CAN BE MADE AVAILABLE TO SHIPS AT WHARVES.

2) EXACT LOCATIONS AND QUANTITIES OF EQUIPMENT REQUIRED FOR SHORE POWER INSTALLATIONS CAN ONLY BE DETERMINED IF VESSEL PARTICULARS ARE DEFINED, SUCH AS; WHAT VESSEL SIZE IS IN KVA, WHAT TYPE OF VESSEL IT IS (TANKER, RO-RO, DRY BULK), WHERE THE VESSEL INLET IS LOCATED AND SIMILAR DATA.

3) SCE SERVICES AND SUBSTATION LOCATIONS ARE DIAGRAMMATIC. FOR EXACT SERVICE LOCATIONS FROM SCE, AND SUBSTATION LOCATIONS, IT IS NECESSARY TO DETERMINE AVAILABLE PROPERTY SITE FOR SUBSTATION AND A RESPONSIBLE PARTY THAT WILL SIGN TO THE SCE METER FOR ELECTRICAL POWER BILLING, AMONG OTHER DATA NEEDED.




**PIER F SITE PLAN - BERTH F208-F211**
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1 / E3

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| Approved | MC |

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Scale: None

Sheet Title
POLB Pier F Site Plan
Berth F208-F209
Chemoil

Sheet Number
E3

P2S No. 21-0320

## GENERAL NOTES

1) THIS DRAWING ILLUSTRATES HOW SHORE POWER CAN BE MADE AVAILABLE TO SHIPS AT WHARVES.
2) EXACT LOCATIONS AND QUANTITIES OF EQUIPMENT REQUIRED FOR SHORE POWER INSTALLATIONS CAN ONLY BE DETERMINED IF VESSEL PARTICULARS ARE DEFINED, SUCH AS; WHAT VESSEL SIZE IS IN KVA, WHAT TYPE OF VESSEL IT IS (TANKER, RO-RO, DRY BULK), WHERE THE VESSEL INLET IS LOCATED AND SIMILAR DATA.
3) SCE SERVICES AND SUBSTATION LOCATIONS ARE DIAGRAMMATIC. FOR EXACT SERVICE LOCATIONS FROM SCE, AND SUBSTATION LOCATIONS, IT IS NECESSARY TO DETERMINE AVAILABLE PROPERTY SITE FOR SUBSTATION AND A RESPONSIBLE PARTY THAT WILL SIGN TO THE SCE METER FOR ELECTRICAL POWER BILLING, AMONG OTHER DATA NEEDED.

## MAJOR COMPONENTS - TANKER VESSEL

TO "COLD IRON" A TANKER VESSEL AT A TYPICAL POLB FACILITY, THE FOLLOWING MAJOR COMPONENTS ARE NEEDED ON SHORE, IN COMPLIANCE WITH IEC/IEEE 80005-1 STANDARD:

1) ELECTRICAL SERVICE AT 12.47KV FROM UTILITY COMPANY (SCE AT POLB).
2) AN ELECTRICAL SUBSTATION WITH 10.8 MVA CAPACITY AT 6.6KV.
3) "POWER CABLE MANAGER" AND "CONTROL CABLE MANAGEMENT SYSTEM" ON A MOVABLE PLATFORM. TWO SUCH PLATFORMS WILL BE NEEDED PER BERTH, OUTSIDE THE HAZARDOUS CLASSIFIED ZONE.
4) PLATFORM FOR CABLE MANAGERS SHOULD BE ABLE TO TRAVEL ALONG WHARF, TO ALIGN THE CABLES WITH TANKER'S INLET CONNECTORS ON THE TANKER VESSEL.
5) A CRANE ON SITE WILL BE REQUIRED TO LIFT THE CABLES FROM WHARF TO THE TANKER'S DECK. OR, TANKER VESSEL MUST BE FITTED WITH CRANE TO LIFT CABLES FROM WHARF.
6) TANKER VESSEL THAT IS FITTED FOR "COLD IRONING" AT A PORT FACILITY IN ACCORDANCE WITH IEC/IEEE 80005-1 STANDARD.
7) PERSONNEL WHO ARE FAMILIAR WITH THE INSTALLED FACILITIES AND ARE TRAINED IN THE CIRCUIT BREAKER SETTINGS, AS WELL AS THE CONTROLLERS.

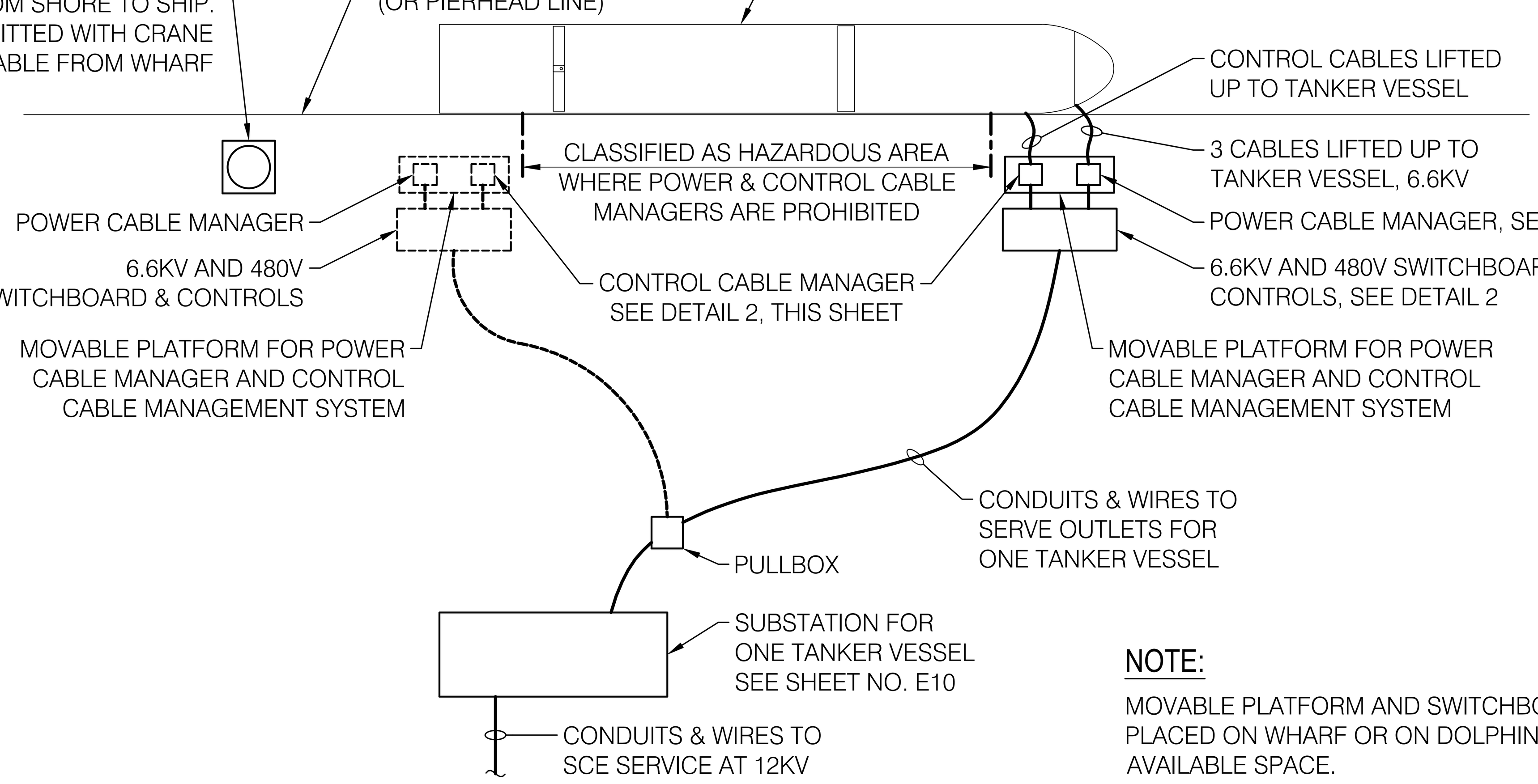

NOTE:

CONTROL CABLE MANAGER, SWITCHBOARD AND POWER CABLE MANAGER ARE SHOWN IN PICTURE, AS INSTALLED ON A DOLPHIN. MOVABLE PLATFORM IS NOT SHOWN.

### TANKER VESSEL - SHORE POWER (TYP.)

NOT TO SCALE

2 / E4




NOTE:

MOVABLE PLATFORM AND SWITCHBOARD CAN BE PLACED ON WHARF OR ON DOLPHIN, BASED ON AVAILABLE SPACE.

### SHORE POWER TO TANKER VESSEL - SITE PLAN (TYP.)

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1 / E4

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| Approved | MC |

Date

Submittal

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Sheet Title

POLB Shore Power Details For Tanker Vessel

Sheet Number

E4

P2S No. 21-0320

FILE PATH & NAME: R:\J21-0320\ELECTRICAL\E004_P18-1699_SHOREPOWERDETS.DWG JOHN VOSO
PLOT: Tuesday, August 10, 2021 10:31:59 AM

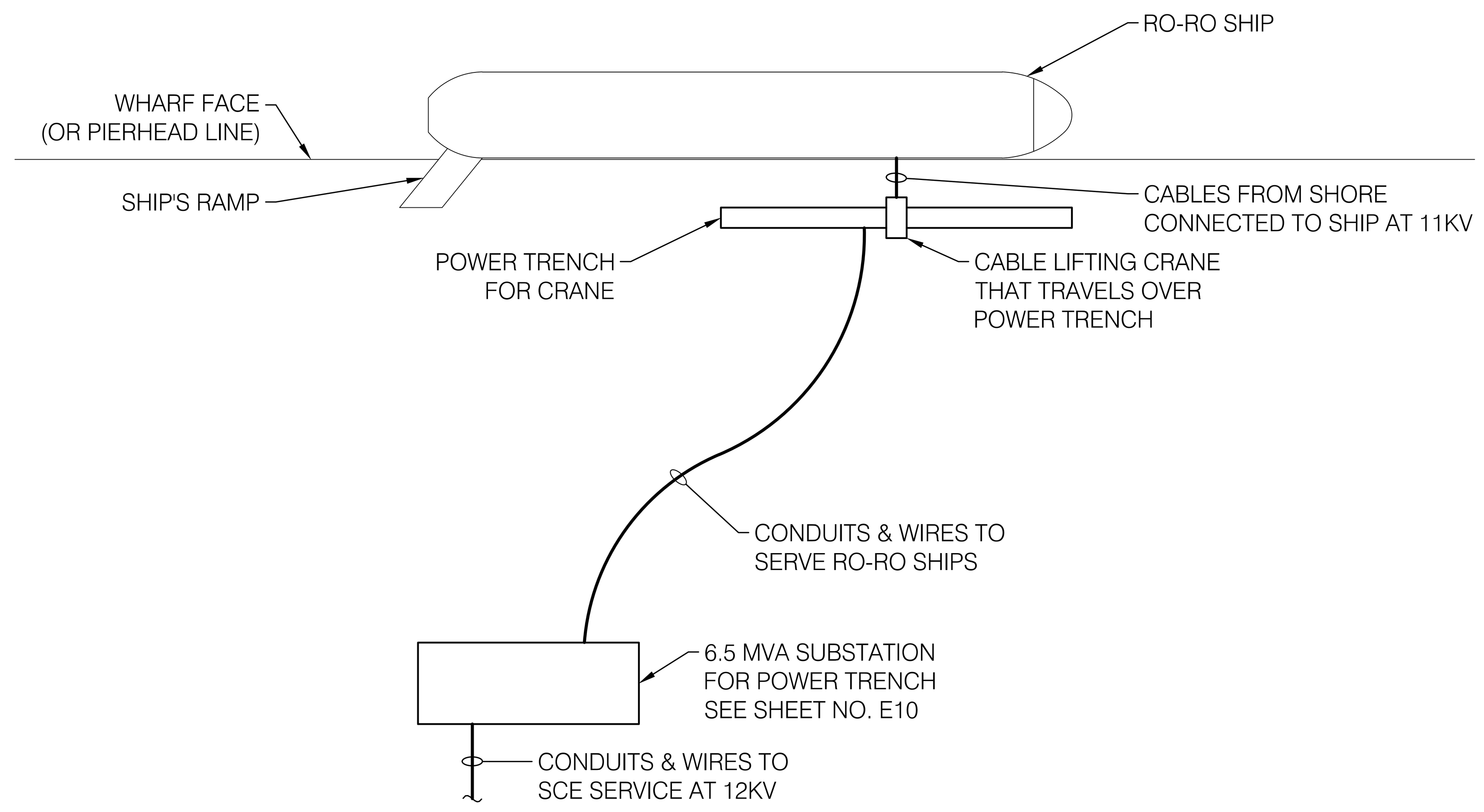
## GENERAL NOTES

1) THIS DRAWING ILLUSTRATES HOW SHORE POWER CAN BE MADE AVAILABLE TO SHIPS AT WHARVES.
2) EXACT LOCATIONS AND QUANTITIES OF EQUIPMENT REQUIRED FOR SHORE POWER INSTALLATIONS CAN ONLY BE DETERMINED IF VESSEL PARTICULARS ARE DEFINED, SUCH AS; WHAT VESSEL SIZE IS IN KVA, WHAT TYPE OF VESSEL IT IS (TANKER, RO-RO, DRY BULK), WHERE THE VESSEL INLET IS LOCATED AND SIMILAR DATA.
3) SCE SERVICES AND SUBSTATION LOCATIONS ARE DIAGRAMMATIC. FOR EXACT SERVICE LOCATIONS FROM SCE, AND SUBSTATION LOCATIONS, IT IS NECESSARY TO DETERMINE AVAILABLE PROPERTY SITE FOR SUBSTATION AND A RESPONSIBLE PARTY THAT WILL SIGN TO THE SCE METER FOR ELECTRICAL POWER BILLING, AMONG OTHER DATA NEEDED.

## MAJOR COMPONENTS - RO-RO SHIP

TO "COLD IRON" A RO-RO SHIP AT A TYPICAL POLB FACILITY, THE FOLLOWING MAJOR COMPONENTS ARE NEEDED ON SHORE, IN COMPLIANCE WITH IEC/IEEE 80005-1 STANDARD:

1) ELECTRICAL SERVICE AT 12.47KV FROM UTILITY COMPANY (SCE AT POLB).
2) AN ELECTRICAL SUBSTATION WITH 6.5 MVA CAPACITY AT 11KV.
3) A CRANE ON WHARF TO LIFT CABLES FROM WHARF TO THE DECK OF RO-RO SHIP.
4) A POWER TRENCH (OR A CRANE ON WHEELS) TO SET CABLES ON DECK OF RO-RO SHIP, WHERE THE SHIP'S INLET CONNECTORS ARE LOCATED.
5) A RO-RO SHIP THAT IS FITTED FOR "COLD IRONING" AT A PORT FACILITY IN ACCORDANCE WITH IEC/IEEE 80005-1 STANDARD.
6) PERSONNEL WHO ARE FAMILIAR WITH THE INSTALLED FACILITIES AND ARE TRAINED IN THE CIRCUIT BREAKER SETTINGS FOR RO-RO SHIP "COLD IRONING".




RO-RO - GENERAL SITE PLAN
NOT TO SCALE
1 / E5

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CARB - POLB
Non-Container Terminals

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Checked KS
Approved MC

Date

Submittal

Scale None

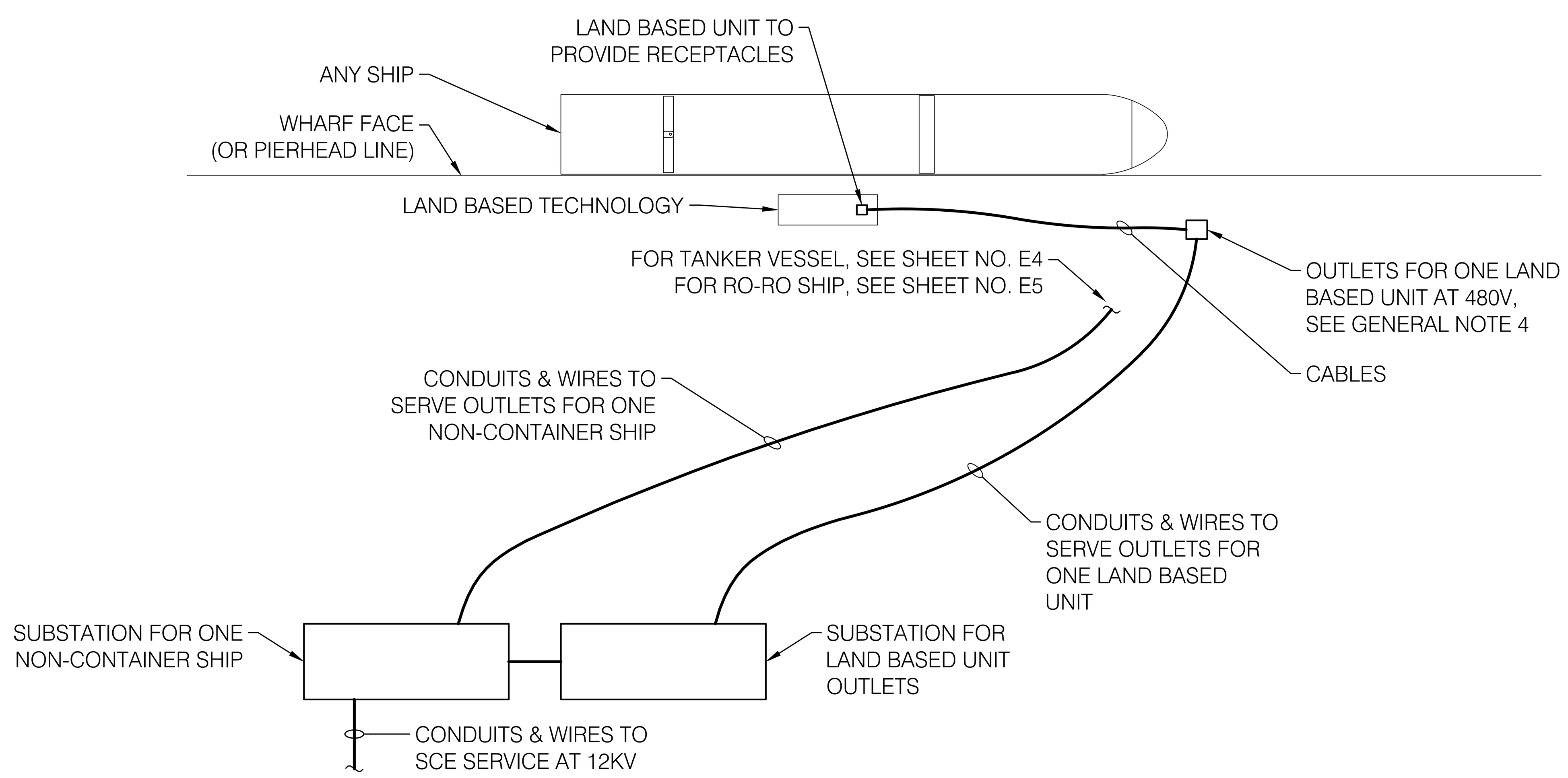
Sheet Title
POLB
Ro-Ro Details

Sheet Number
E5

P2S No. 21-0320

## GENERAL NOTES

1) THIS DRAWING ILLUSTRATES HOW SHORE POWER CAN BE MADE AVAILABLE TO SHIPS AT WHARVES.
2) EXACT LOCATIONS AND QUANTITIES OF EQUIPMENT REQUIRED FOR SHORE POWER INSTALLATIONS CAN ONLY BE DETERMINED IF VESSEL PARTICULARS ARE DEFINED, SUCH AS; WHAT VESSEL SIZE IS IN KVA, WHAT TYPE OF VESSEL IT IS (TANKER, RO-RO), WHERE THE VESSEL INLET IS LOCATED AND SIMILAR DATA.
3) SCE SERVICES AND SUBSTATION LOCATIONS ARE DIAGRAMMATIC. FOR EXACT SERVICE LOCATIONS FROM SCE, AND SUBSTATION LOCATIONS, IT IS NECESSARY TO DETERMINE AVAILABLE PROPERTY SITE FOR SUBSTATION AND A RESPONSIBLE PARTY THAT WILL SIGN TO THE SCE METER FOR ELECTRICAL POWER BILLING, AMONG OTHER DATA NEEDED.
4) IN A NON-CONTAINER TERMINAL, AN ELECTRICAL OUTLET WILL BE REQUIRED AT EACH BERTH, WHERE LAND BASED UNIT WILL BE UTILIZED FOR ALTERNATE EMISSION CONTROL.




### SHORE POWER TO LAND BASED UNIT - SITE PLAN (TYP.)

NOT TO SCALE

1 / E6

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| Checked | KS |
| Approved | MC |

Date

Submittal

Scale: None

Sheet Title

POLB Shore Power
Land Based Unit Site Plan

Sheet Number

E6

P2S No. 21-0320

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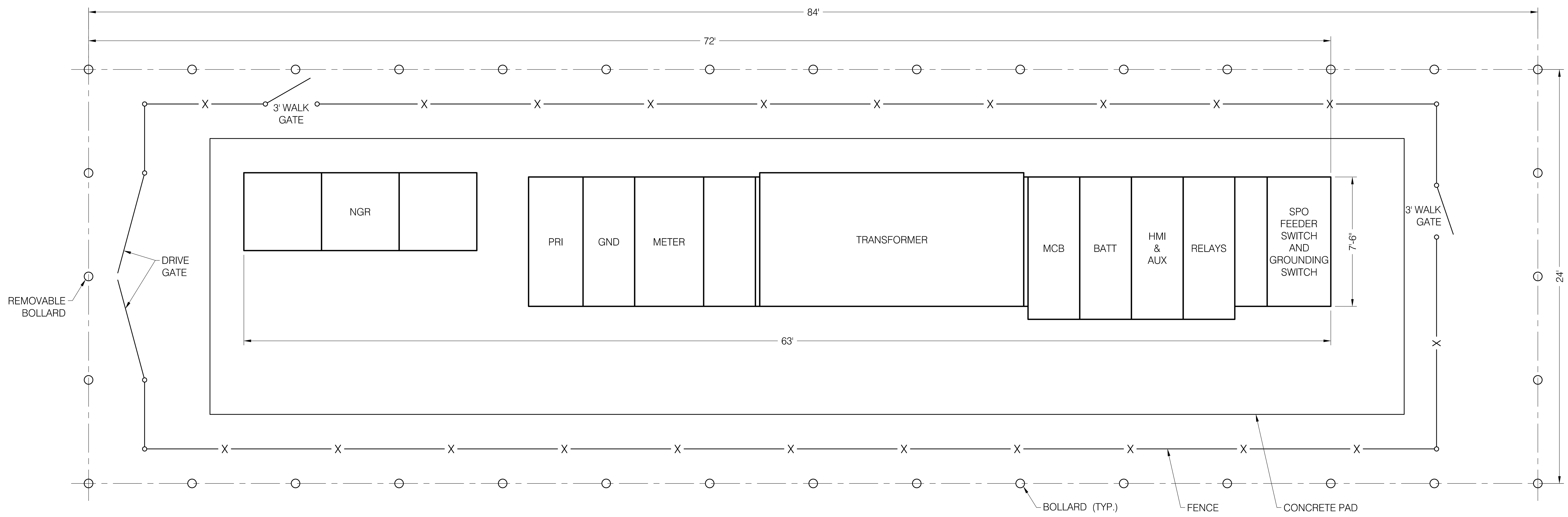
PLOT: Tuesday, August 10, 2021 10:32:05 AM

SYMBOL

SPO - SHORE POWER OUTLET.

NOTES:

1) THIS SET UP IS FOR ONE BERTH, WHERE ONE SPO LOCATION IS PROVIDED FOR BERTH.
2) THIS SUBSTATION IS REQUIRED IN TANKER VESSEL APPLICATION, OR RO-RO SHIP.




SHORE POWER SUBSTATION PLAN - ONE SPO HIGH VOLTAGE (1 / E10)
NOT TO SCALE

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Non-Container Terminals

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| Designed | BC |
| Drawn | SS |
| Checked | KS |
| Approved | MC |

Date

Submittal

Scale: None

Sheet Title

Shore Power
Substation Plan
High Voltage - 1SPO

Sheet Number

E10

P2S No. 21-0320

FILE PATH & NAME: R:\J21-0320\ELECTRICAL\E010_P18-1699_HIGHVOLT1SPO.DWG JOHN VOSO
PLOT: Tuesday, August 10, 2021 10:32:11 AM

# APPENDIX

## SHORE POWER NON CONTAINER TERMINAL EXAPANSION SUPPORT - COST ESTIMATE FOR TANKER VESSEL Per SPO

Estimated by: DI
Checked by: BC
Approved by: BC
Date: 08/02/2021

| Item | Description | Quan | Unit | Material Unit $ | Material Total | Labor MH/Unit | Labor MH | Labor Total | Total Cost |
|---|---|---|---|---|---|---|---|---|---|
| | **Cables/Splice/Manholes** | | | | | | | | |
| 1 | 15KV, 350kcmil Copper Cable | 12000 | LF | $12.67 | $152,040 | 0.06 | 738.5 | $66463. | $218,503. |
| 2 | 15KV Terminations | 8 | EA | $525. | $4,200 | 3.00 | 24.0 | $2160. | $6,360. |
| 3 | 15KV Splice | 8 | EA | $1,050. | $8,400 | 4.00 | 32.0 | $2880. | $11,280. |
| 4 | Ductbank (4) 5" | 1000 | LF | $135. | $135,000 | 0.72 | 720.0 | $64800. | $199,800. |
| 5 | Electrical Manhole | 2 | EA | $80,000. | $160,000 | 120.00 | 240.0 | $21600. | $181,600. |
| 6 | Testing and Commisioning | 1 | LS | | | | | | $80,000. |
| Subtotal Electrical | | | | | $459,640. | | | $157,903. | $617,543. |
| | Sales Tax | 9.25% | | | $42,517. | | | | $42,517. |
| | Contractor Indirect Costs | 20.0% | | | | | | | $123,509. |
| | Contractor OH & P | 20.0% | | | | | | | $123,509. |
| **Total Construction Cost** | | | | | | | | | **$907,077.18.** |
| | Construction Contingency | 15.0% | | | | | | | $136,062. |
| | Design Contingency | 15.0% | | | | | | | $136,062. |
| **OPINION OF TOTAL BID COST** | | | | | | | | | **$1,179,200.00.** |

*This opinion of probable cost is approximate. Actual contruction bids may vary significantly from this statement of probable costs due to timing of construction, changed conditions, labor rate changes or other factors beyond the control of P2S Engineering, Inc.*

## SHORE POWER NON CONTAINER TERMINAL EXAPANSION SUPPORT - COST ESTIMATE FOR RO-RO VESSEL

Estimated by: DI
Checked by: BC
Approved by: BC
Date: 08/02/2021

| Item | Description | Quan | Unit | Material Unit $ | Material Total | Labor MH/Unit | Labor MH | Labor Total | Total Cost |
|---|---|---|---|---|---|---|---|---|---|
| | **Cables/Splice/Manholes** | | | | | | | | |
| 1 | 15KV, 350kcmil Copper Cable | 4000 | LF | $12.67 | $50,680 | 0.06 | 246.2 | $22154. | $72,834. |
| 2 | 15KV Terminations | 4 | EA | $525. | $2,100 | 3.00 | 12.0 | $1080. | $3,180. |
| 3 | 15KV Splice | 4 | EA | $1,050. | $4,200 | 4.00 | 16.0 | $1440. | $5,640. |
| 4 | Ductbank (2) 5" | 1000 | LF | $80. | $80,000 | 0.53 | 533.0 | $47970. | $127,970. |
| 5 | Electrical Manhole | 2 | EA | $80,000. | $160,000 | 120.00 | 240.0 | $21600. | $181,600. |
| 6 | Testing and Commisioning | | | | | | | | $50,000. |
| Subtotal Electrical | | | | | $296,980. | | | $94,244. | $391,224. |
| | Sales Tax | 9.25% | | | $27,471. | | | | $27,471. |
| | Contractor Indirect Costs | 20.0% | | | | | | | $78,245. |
| | Contractor OH & P | 20.0% | | | | | | | $78,245. |
| **Total Construction Cost** | | | | | | | | | **$575,184.81.** |
| | Construction Contingency | 15.0% | | | | | | | $86,278. |
| | Design Contingency | 15.0% | | | | | | | $86,278. |
| **OPINION OF TOTAL BID COST** | | | | | | | | | **$747,740.00.** |

*This opinion of probable cost is approximate. Actual contruction bids may vary significantly from this statement of probable costs due to timing of construction, changed conditions, labor rate changes or other factors beyond the control of P2S Engineering, Inc.*

# SHORE POWER NON CONTAINER TERMINAL EXAPANSION SUPPORT - COST ESTIMATE FOR SWGR -1_SPO_HV

Estimated by: DI
Checked by: BC
Approved by: BC
Date: 08/02/2021

| Item | Description | Quan | Unit | Material Unit $ | Material Total | Labor MH/Unit | Labor MH | Labor Total | Total Cost |
|---|---|---|---|---|---|---|---|---|---|
| | **Cables/Splice/Manholes** | | | | | | | | |
| 1 | 1200A, 480/277V, 35KAIC,Switchboard | 1 | LF | $18,000. | $18,000 | 46.00 | 46.0 | $4140. | $22,140. |
| 2 | 1200Amp Circuit Breaker | 1 | EA | $8,800. | $8,800 | 20.00 | 20.0 | $1800. | $10,600. |
| 2 | MV Transfromer AND Accessories | 1 | MVA | $70,000. | $70,000 | 80.00 | 80.0 | $7200. | $77,200. |
| 3 | HMI and Controls | 1 | EA | $240,000. | $240,000 | 40.00 | 40.0 | $3600. | $243,600. |
| 4 | 1 SPO RO-RO Load (Labor Included) | 1 | LF | $348,133. | $348,133 | 1.00 | 1.0 | $90. | $348,223. |
| 5 | Grounding Switch | 1 | EA | $12,000. | $12,000 | 2.00 | 2.0 | $180. | $12,180. |
| 6 | Equipment Pad | 363 | SF | $28. | $10,164 | 0.20 | 72.6 | $6534. | $16,698. |
| 7 | Bollards | 26 | SF | $1,064. | $27,664 | 1.60 | 41.6 | $3744. | $31,408. |
| 8 | Fence and Gate | 373 | LF | $44.8 | $16,710 | 0.13 | 49.6 | $4465. | $21,175. |
| 8 | Neutral Ground Resistor 75Ohms | 3 | LF | $15,000. | $45,000 | 10.00 | 30.0 | $2700. | $47,700. |
| 9 | Testing and Commisioning | 1 | LS | | | | | | $100,000. |

| | | | |
|---|---|---|---|---|
| Subtotal Electrical | | $796,471. | $34,453. | $713,943. |
| Sales Tax | 9.25% | $73,674. | | $73,674. |
| Contractor Indirect Costs | 20.0% | | | $142,789. |
| Contractor OH & P | 20.0% | | | $142,789. |
| **Total Construction Cost** | | | | **$1,073,193.80.** |
| Construction Contingency | 15.0% | | | $160,979. |
| Design Contingency | 15.0% | | | $160,979. |
| **OPINION OF TOTAL BID COST** | | | | **$1,395,152.00.** |

*This opinion of probable cost is approximate. Actual contruction bids may vary significantly from this statement of probable costs due to timing of construction, changed conditions, labor rate changes or other factors beyond the control of P2S Engineering, Inc.*

Total Costs Calculations for 1 SPO Per Berth

| Tanker Terminal | |
|---|---|
| Description | Costs |
| From Tanker Vessel Sheet | $ 1,179,200.00 |
| Crane | $ 100,000.00 |
| Movable Platform/Cable Mgr | $ 1,000,000.00 |
| Dolphin | $ 15,000,000.00 |
| From 1 SPO HV, Swgr. | $ 1,395,152.00 |
| Total-Tanker Terminal | $ 18,674,352.00 |

| Ro-Ro Terminal | |
|---|---|
| Description | Costs |
| From Ro-Ro Vessel Sheet | $ 747,740.00 |
| Crane | $ 100,000.00 |
| Movable | $ 1,000,000.00 |
| Dolphin-Not Required | $ - |
| From 1 SPO HV, Swgr. | $ 1,395,152.00 |
| Total-RoRo Terminal | $ 3,242,892.00 |

| Land Based-480 Volt | |
|---|---|
| Description | Costs |
| From Barge Sheet of 10/29/2018 | $ 1,067,461.00 |
| Crane-Not Required | $ - |
| Movable-No. Fixed Location | $ - |
| Dolphin-Not Required | $ - |
| From 1 SPO HV, Swgr. | $ 1,395,152.00 |
| Total-Land Based | $ 2,462,613.00 |

Total Costs Calculations for 2 SPOs per Berth

| Tanker Terminal | | | |
|---|---|---|---|
| Description | Costs For 1 SPO | Additional Costs For Second SPO | Costs For 2 SPOs |
| From Tanker Vessel Sheet | $ 1,179,200.00 | $ 884,400.00 | $ 2,063,600.00 |
| Crane | $ 100,000.00 | $ - | $ 100,000.00 |
| Movable Platform/Cable Mgr | $ 1,000,000.00 | $ 750,000.00 | $ 1,750,000.00 |
| Dolphin | $ 15,000,000.00 | $ 11,250,000.00 | $ 26,250,000.00 |
| From 1 SPO HV, Swgr. | $ 1,395,152.00 | $ 4,000.00 | $ 1,399,152.00 |
| Total-Tanker Vessel | | | $ 31,562,752.00 |

| Ro-Ro Terminal | | | |
|---|---|---|---|
| Description | Costs For 1 SPO | Additional Costs For Second SPO | Costs For 2 SPOs |
| From Ro-Ro Vessel Sheet | $ 747,740.00 | $ 560,805.00 | $ 1,308,545.00 |
| Crane | $ 100,000.00 | $ - | $ 100,000.00 |
| Movable | $ 1,000,000.00 | $ 750,000.00 | $ 1,750,000.00 |
| Dolphin-Not Required | $ - | | |
| From 1 SPO HV, Swgr. | $ 1,395,152.00 | $ 4,000.00 | $ 1,399,152.00 |
| Total-RoRo Terminal | | | $ 4,557,697.00 |

SSA Pacific
A Carrix Enterprise

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Long Beach, CA 90802

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June 30, 2022

Bonnie Soriano
California Air Resources Board
1001 I Street
Sacramento, California 95814
*Submitted electronically to: shorepower@arb.ca.gov*

Subject: Interim Evaluation Comments - Amended Ocean-Going Vessels At Berth Regulation

Dear Ms. Soriano:

SSA Marine (SSA) appreciates the opportunity to submit the following comments informing the California Air Resources Board's (CARB) Interim Evaluation of the amended Ocean-Going Vessels At Berth Regulation. SSA looks forward to CARB's evaluation findings and expects that adjustments to the rule will streamline access to viable compliance solutions. Below, please find SSA's comments that we believe are critical issues to address in order to successfully implement the amended At Berth Rule prior to the compliance requirements going into effect beginning January 1, 2023.

**Ro/Ro Shore Power Standards**

As CARB staff has been made aware, a global shore power standard for Ro/Ro vessels has been in development for some time. Unfortunately, that standard is not yet completed for IEC/IEEE adoption, making it impossible for engineers to design systems that will meet the standard's requirements prior to finalization. To be effective, this global RoRo standard will necessarily precede any implementation of shore power for Ro/Ro vessels. As a result, vessel retrofit solutions cannot be performed until the standard is complete. Combined with the delays in sourcing parts and equipment in today's compromised supply chain environment, limited drydock space, and limited engineering personnel with the necessary skills to implement the shore power retrofits on vessels, it is not possible to retrofit vessels in time for the 2025 deadline. SSA requests that the Interim Evaluation recommend that CARB's sub-national rule implementation align with the timeline of finalization of the global standards.

**Shore Power Infrastructure Delivery**

Since the adoption of the original Ocean-Going Vessels At-Berth rule, the primary compliance strategy has focused on shore power. SSA's intention is to migrate to a shore power solution to achieve sustainable and proven hoteling emission reductions from vessels. A shore power solution requires three integrated systems: Delivering terminal infrastructure at each RoRo berth; the electrical utility provider must provide adequate grid-based power service to the terminal infrastructure; and vessel-based systems need to be added to access the shore-based alternative marine power to run their auxiliary and boiler systems while at berth.

As a tenant of the port, SSA can deliver only one of these variables: the terminal's shore power infrastructure. More time is needed to comprehensively implement the complete three-part infrastructure network.

According to the Port of Long Beach's "Feasibility Report Shore Power for Container Terminals Tanker and Ro-Ro Vessels at Non-Container Terminals", the completion of California Edison's off-terminal shore power infrastructure will take 60 months after receiving either California Public Utilities Commission approvals or exemptions. The approval process alone is a 48-

month endeavor while the exemption process is estimated to take 6 months. Assuming there is drydock capacity for RoRo vessels, vessel retrofitting for shore power can take up to 24 months (including design, procurement, installation, and commissioning). Terminal infrastructure (including design, permitting and construction) takes up to 60 months to deploy. The terminals implementing shore power for compliance will not be ready in time to meet the requirements of the rule. All said, after being agreed to by all parties, it can take between 60 and 72 months to install shore power for RoRo use. SSA respectfully requests that the schedules contained in the rule be re-evaluated and extended to allow for more time beyond 2025 to retrofit vessels, terminals, and utility systems for an "every vessel, every call" shore power standard.

**Alternative Control Technologies**

As a marine terminal operator and stevedore, SSA is reliant on third party services to provide market-based capture and control services to vessels not outfitted with shore power capabilities. With five months until new requirements are planned to go into effect, there is a single qualified operating system in San Pedro Bay and none in any other California port. While there is ongoing testing for at least one new system and proposals for others, there is no assurances as to when they will become available. SSA, nor our vessel owner customers, can engage in a capture and control-based business plan on unavailable equipment or solutions lacking and Executive Order from CARB. Without deployment of CARB-certified alternative control strategies, an "every vessel, every call" standard is impossible to meet. SSA requests that CARB evaluate the availability and deployment of alternative control technologies and consider modifications to the amended rule that extend schedules or increase the number of VIEs/TIEs to address the lack of availability of alternative control technology systems.

**Conclusion**

While many of the issues outlined above may require modifications to the amended At Berth Rule, SSA appreciates CARB's process to provide the Interim Evaluation as an opportunity to consider adjustments to the Rule to align with the realities and constraints of current and near-term industry conditions. Amending the At Berth Rule as a part of the Interim Evaluation that will improve the rule and likelihood of successful implementation.

Sincerely,

William Fitz
Regional Vice President
SSA Marine

June 30, 2022

Bonnie Soriano
Branch Chief
Transportation and Toxics Division, Freight Activity Branch
California Air Resources Board
1001 I Street
Sacramento, CA 95814

Re: California Air Resources Board (CARB) Ocean Going Vessel At-Berth Emissions Control for Tankers, Capture and Control Technology Development and Demonstration Readiness Assessment

Dear Ms. Soriano,

Following our April 4 meeting to discuss Terminal Plans for CARB's Ocean-Going Vessel At-Berth Emissions Control for Tankers (At-Berth) Regulation we have prepared this letter with our perspectives on technology readiness for compliance with the At-Berth Regulation. We intend to illustrate the safety issues that remain outstanding and provide scope and context for the work needed to develop safe solutions for compliance with the Regulation. Our teams have gained valuable and relevant insights over the last year and a half through engineering studies, terminal plan development, and participation in technology development efforts that we would like to share with CARB for the Interim evaluation for new technologies and applications.

Tesoro Logistics Operations LLC and Tesoro Refining & Marketing LLC (collectively, Tesoro) are both affiliates of Marathon Petroleum Corporation. Tesoro was engaged with the California Air Resources Board (CARB) for the At-Berth Regulation during its development and final rulemaking. Over the course of the rule development and final rulemaking CARB identified the need for technologies such as shore power, which is supplying vessels with electricity for power demands while at berth, and Capture and Control (C&C), which relies on a system that directs a vessel's stack gasses through a catalyst to reduce oxides of nitrogen (NOx), particulate matter (PM), reactive organic gasses (ROG) or greenhouse gasses (GHG). At the time of the At-Berth Regulation adoption, C&C systems had been demonstrated on container vessels in the Port of Long Beach (POLB) and Port of Los Angeles (POLA) but had never been tested or demonstrated on tanker vessels.

Tesoro's highest priority is to safely deliver crude oil and renewable feedstocks into its plants that produce transportation fuels for California's residents, visitors and businesses every day. Tesoro elected to engage with the South Coast Air Quality Management District (SCAQMD) and STAX Engineering in the technology development Grant from CARB as the C&C technology demonstration partner (the Grant). Tesoro's involvement in the Grant, in conjunction with our independent work developing Terminal Compliance Plans and Innovative Concept Applications, has provided us with a clear perspective on the readiness of technology to be able to safely address emissions from ocean-going tankers. This letter is intended to provide CARB an assessment, from a marine oil terminal operator's perspective on the (1) progress made in developing technologies to be demonstrated on a tanker, and (2) challenges still outstanding with technology development and implementation to meet the requirements of the At-Berth Regulation.

Because of the work Tesoro has done to date to understand the status and timelines of technologies necessary for compliance with the At-Berth Regulation, it is Tesoro's opinion that the implementation timelines of the regulation should be delayed. Tesoro views a timeline of implementation for full compliance of third quarter 2028 for POLB and third quarter 2030 for Martinez to be possible.

I. The South Coast Air Quality Management District and STAX Engineering have been good partners and progress is being made on the readiness for Capture & Control on tanker vessels.

As the demonstration partner in the Grant, Tesoro has had the opportunity to work with the SCAQMD and STAX Engineering in developing C&C technology for tankers. Tesoro has been actively engaging with the SCAQMD and STAX Engineering throughout the process and participated in the initial hazard identification exercise for the concept of operations of a capture and control barge. In addition to the involvement of Tesoro subject matter experts in terminal operations, marine operations, and engineering, we have brought subject matter experts in tanker operations into the hazard identification exercise through Tesoro's relationships with vessel owners. The engagement of these subject matter experts in tanker marine terminal and tanker vessel operations are critical to ensuring the high level of safety necessary to operate a C&C system adjacent to tanker vessels. Their continued involvement in the necessary future hazard identification studies will continue to be paramount.

Additionally, it is important to note that while Tesoro has been actively engaged with the Grant, Tesoro provided no input into the development of the grant schedule and the estimation of the timeline for demonstration.

II. The C&C technology is the sum of three independent components which are all critical to success of the system and not all components exist.

Tesoro views the C&C system technology being developed as a compilation of three primary components: (1) Barge and Treatment Systems; (2) Articulated Boom Capture Arm; and (3) Stack Connection System. Each of the three components is at a different state of readiness. A diagram illustrating the distinction of the components is included as Figure 1. Tesoro views the readiness states as follows:

1. <u>The Barge and Treatment System utilize mature, existing technologies</u>. The application of these technologies on tanker vessels is new and presents some unique challenges. In particular, the wide variation of flow rates and temperatures of exhaust streams from tanker vessels will present challenges for the Selective Catalytic Reduction (SCR) treatment technology referenced in the At-Berth Regulation. More specifically, Tesoro is concerned with the treatment systems being able to adequately address tanker auxiliary boiler emissions. Tanker auxiliary boiler exhaust streams are variable and may cycle between low and high volumetric flow rates within a docking window. As Tesoro has been conducting our feasibility engineering study, through discussions with SCR suppliers, we estimate 18-24 months to engineer and deliver an SCR system capable of the wide range of operating parameters necessary to satisfy the regulation for tanker vessels.

2. The Articulated Boom Capture Arm independently is not novel and is used in several industries to manipulate or maneuver objects into a particular position. The boom is, however, new to the application of maneuvering connection devices with precision to connect to a vessel exhaust system and to maintain the connection while the exhaust stacks are constantly moving during cargo loading and unloading operations without damaging the vessel or causing a safety concern. Vertical movement during vessel cargo operations is unavoidable as the cargo operation changes the vessel stack height. Lateral movement in all horizontal directions may be necessary for the vessel to adjust ballast in order to drain tanks to complete cargo operations. To date Tesoro has not reviewed a design of the boom in order to evaluate its ability to sufficiently place the connection system and adjust for all stack movement necessary to complete cargo operations on tanker vessels.

3. The Stack Connection System for Tankers, or connection devices necessary to connect to multiple exhaust stacks in differing configurations simultaneously is new and does not yet exist. As this is the point of physical contact with the vessel it is viewed as the most critical component in the entire system by terminal and vessel operators and the component with the greatest risk of severely negatively impacting the safety of personnel and the vessel. Conceptual designs have not been discussed with or reviewed by Tesoro for this critical piece. Additionally, because of inconsistent stack configurations on tanker vessels and the high number (upwards of 5) of exhaust stacks that must be connected to at the same time, this is also regarded as the single most challenging design element of the system. In addition to exhaust stacks present at the top of the vessel's funnel, numerous other appurtenances are present which must be accounted for in the connection. Photos illustrating the complexity and number of exhaust stack are included below as Figure 2.

III. Hazard Identification and implementing safeguards to reduce safety risk is essential to the success of the C&C system.

As discussed individually in the description of the components, several significant challenges are still outstanding for the completion and testing of a capture and control system which adequately satisfies the At-Berth Regulation. As these challenges are identified the solutions will need to be scrutinized through a hazard identification (HAZID) process as utilized in the initial study done on the concept of operations. Because the initial safety study was done on a concept of operations only and without sufficient detail to ensure hazards are mitigated it is evident that there is much work yet to be done to bring the technology to a level of development to begin testing on an active tanker vessel conducting cargo operations. Additionally, due to the hazardous nature of the cargo onboard the vessel, the emissions control strategy must be complementary to and not interfere with existing safeguards presently in use to ensure safe, efficient vessel operations. Several iterations of HAZIDs are anticipated to incrementally progress the mitigation of hazards prior to testing on a tanker. Consistent with Tesoro's safety practices, a final HAZID will need to be performed and recommendations from the HAZID be resolved. Tesoro views the following as necessary steps that must be complete in order to conduct the final HAZID:

1. Physical construction of the entire C&C system;

2. Procedures, including but not limited to operational, navigational, maintenance, personnel, communication, emergency response, and emergency egress;
3. Personnel training and certification requirements;
4. Identification and explanation of safeguards mitigating hazards identified in prior HAZIDs;
5. Matrix of safeguards necessary for specific products carried on a tanker vessel; and
6. Engineering drawings showing the process flow, integration of controls and appropriate safeguards.

Tesoro views the status of HAZIDs as the following:

| | Barge | Articulate Boom Capture Arm | Stack Connection System |
|---|---|---|---|
| Conceptual Operations HAZID | Assessment complete, recommendations not yet resolved | Not started | Not started |
| Detailed Design HAZID | Not started | Not started | Not started |
| Constructed System HAZID | Not started | Not started | Not started |

Once a final HAZID has been completed, all identified hazards from all HAZIDs have been mitigated, and all recommendations have been brought to resolution, only then it is appropriate to begin testing on a vessel. Throughout Tesoro's involvement in developing solutions to satisfy the At-Berth Regulation, the safety of all personnel involved will remain the top priority. Based on Tesoro's perspective on progress to date and outstanding items to be addressed, Tesoro believes it will take an additional 12-24 months as of this writing to develop a single system that can be used for a final HAZID analysis prior to being demonstrated on an active tanker moving cargo.

IV. Compliance solutions will differ by terminal; no one solution is universal.

In parallel to supporting the Grant, Tesoro is working on a project to determine the optimal solutions for its individual terminals. The project development is presently in a feasibility engineering phase where multiple options are being evaluated in order to determine the optimal solution(s) to comply with the At-Berth Regulation. Through this work we have identified several issues which we believe will shape the solutions for the At-Berth Regulation.

1. <u>Barge-based C&C systems will not work at every Port or Terminal.</u> Barge-based C&C systems will have limitations on where they can work due to navigational channel restrictions, passing vessel traffic effects, and mooring restrictions. Some of these restrictions are dependent on the number of vessels which may be calling on a particular terminal at a given time. For example, a barge-based C&C system may work for a vessel when only one vessel is at a terminal but may not fit when another vessel calls at a different berth at that same terminal. Tesoro estimates that for its POLB Terminals that have multiple berths, over 50% of vessel calls will be at a time when more than one vessel is at berth at the same terminal at the same time, adding to congestion and restricting the use of barge-based C&C systems. Passing vessel traffic can cause safety concerns for the C&C barge itself and will need to be studied further. Mooring challenges that are still being addressed include interference with the oil containment boom that is necessary during many

cargo operations as well as the need to avoid cross channel buried utilities when mooring using spuds. Mooring challenges in northern California are increasingly difficult due to the tides and seafloor composition and will require significant further study.

2. Shore-based C&C systems will be necessary in some locations in order to comply with the At-Berth Regulation, however their implementation will be slower. The need for shore-based systems is due to constraints previously listed in point 1 of this section, however the outstanding items associated with C&C discussed under Section II apply to shore-based as well as barge-based systems. Shore-based systems are also expected to require California Environmental Quality Act (CEQA) permitting. Due to CEQA requirements the timeline for implementation is extended.

3. Scaling of CARB-approved C&C will take time. Once a C&C system capable of satisfying the requirements of the At-Berth Regulation is successfully tested on a tanker, and approved by CARB, the ability of the C&C industry to scale sufficiently to meet the demand necessitated by the current regulation schedule may encounter delays due to supply chain limitations or site-specific configurations needed for a system to work at a specific terminal. Tesoro sees the following steps as driving a broad implementation timeline:

    a. Site specific engineering based on anticipated vessel classes and mooring restrictions
        i. Vessel classes present varying exhaust load profiles which will impact design
    b. Permitting
    c. Procurement of long lead items
    d. Construction, assembly
    e. Training of personnel
    f. Testing, commissioning
    g. Receipt of CARB Executive Order for approval

4. Shore power is in limited service today, however widespread adoption will require industry standardization and adoption by multiple stakeholders. Shore power is currently used today at Tesoro's Berth T121 in the POLB, however it is a single installation with a single vessel capable of utilizing the system while at berth. Further adoption of shore power is dependent both on terminal operators and vessel owners, which will prolong full scale implementation. Industry standardization will be necessary to ensure compatibility between vessels and multiple terminals. Shore power solutions will require substantial coordination with electrical utility providers and the ports where the terminals reside. Concerns with grid limitations will need to be evaluated by the electric utility. Lastly, shore power installations are expected to be subject to CEQA permitting which will affect implementation timing.

5. Innovative concepts may be dependent on technologies already discussed in this letter. Innovative concepts may also rely on the successful development and implementation of the same or similar technologies in order to be an effective alternative means of compliance. The implementation of innovative concepts, therefore, are still subject to the timelines discussed in this letter.

In conclusion, a significant amount of work has been completed towards achieving compliance with the At-Berth Regulation. Tesoro maintains our commitment to participating in the Grant and working towards a solution that is well designed, practical, effective, and most importantly does not compromise the safety of the personnel involved.

Respectfully,

Tim Hayes

Marathon Pipe Line, LLC

LA Basin Region Manager

Figure 1, Drawing not to scale: (1) Treatment systems (red); (2) Articulated boom capture arm (blue); and (3) Stack connection system (orange).

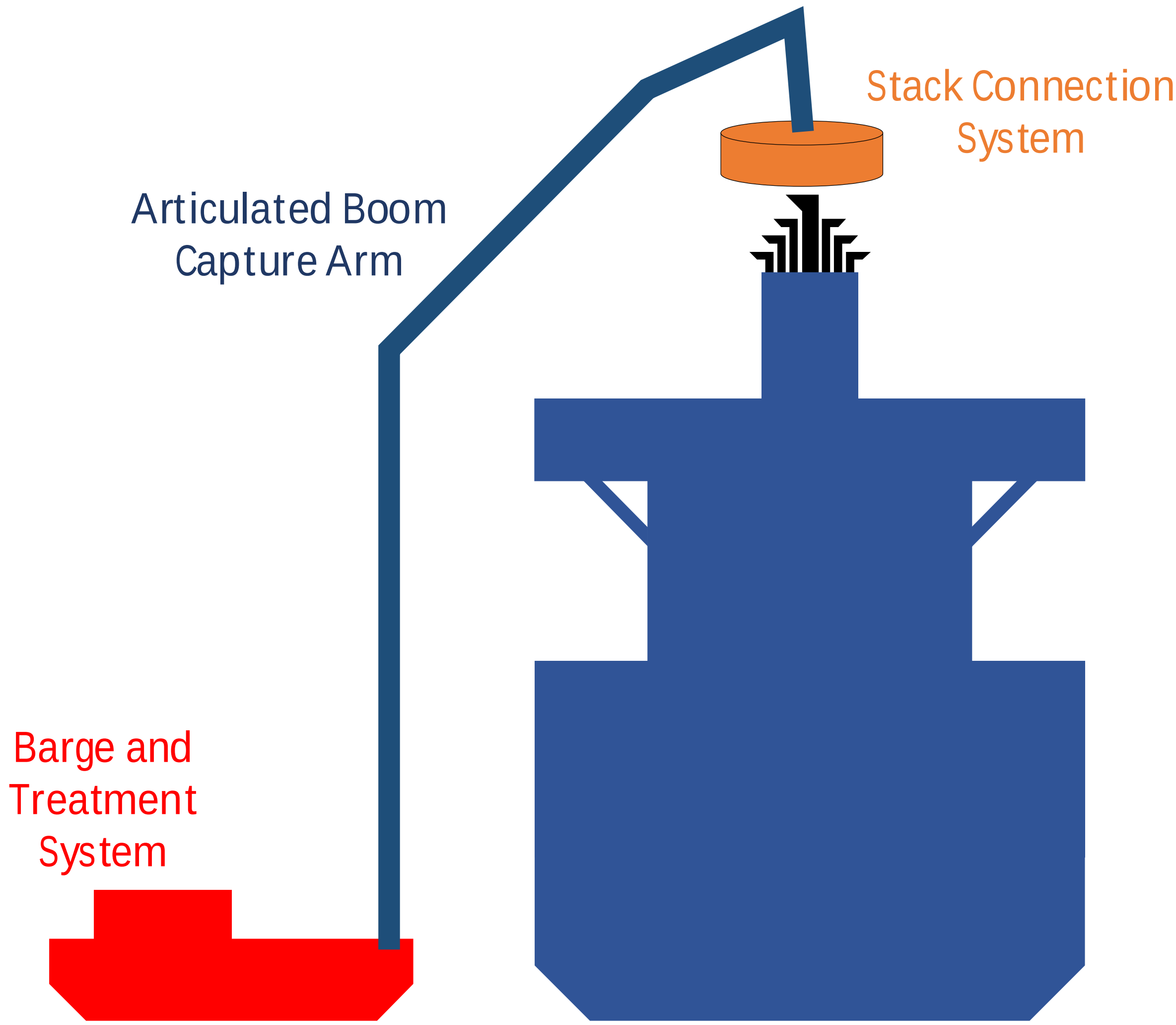


Figure 2: Examples of Stack Configurations on Tanker Vessels

TOYOTA

**TOYOTA MOTOR NORTH AMERICA, INC.**
Sustainability and Regulatory Affairs
1630 W. 186th Street, Gardena, CA 90248

June 27, 2022

California Air Resources Board
Marine Strategies
1001 I Street
Sacramento, CA  95812

Re: Interim Evaluation Comment for At-Berth Regulation

Dear CARB At-Berth Regulation Team:

Toyota Motor North America ("Toyota") appreciates the opportunity to provide comments on the California Air Resources Board's ("CARB") Interim Evaluation of the Control Measure for Ocean-going Vessels At-Berth ("At-Berth Regulation"). While Toyota is committed to complying with the At-Berth Regulation, we are concerned with the timing of its implementation given that there are no viable, available, compliance pathways as of this Interim Evaluation. If compliance options remain unavailable by April 1, 2023, Toyota requests that CARB consider a delay of the compliance start date to provide the regulated community sufficient lead time for the implementation of compliance options once they become available.

Toyota plans to proceed with either barge-mounted capture control or on-shore mobile capture control and plans to utilize a rental capture control system as the primary compliance option. This was described in Toyota's terminal plan submission dated November 23, 2021.

With 21 Roll on-Roll-off ("Ro-Ro") vessels supporting our vehicle deliveries through our Port of Long Beach terminal, a combination of shore power and capture control may be required as long-term solutions to address CARB's At-Berth Regulation. However, the technical challenges noted in our November 2021 terminal plan remain equally true today and are outside of the control of Toyota and the broader regulated community.

Specifically, CARB has yet to approve a CARB Approved Emission Control Strategy ("CAECS") for barge-mounted capture control systems for Ro-Ro vessels. Toyota understands that such approval is pending due to the need to schedule trials for Ro-Ro vessels, but it is unclear when, and if, such systems will receive CARB approval. Vendor selection cannot proceed until there is a CAECS for Ro-Ro vessels and as a result, uncertainty in the CARB-approval timeline creates uncertainty in its implementation. While capture control systems are approved for Container Vessels, Ro-Ro vessels have a wider power range while at berth and require a taller mast with longer reach. These unique requirements must be considered and require a separate approval apart from other vessels. To the extent that capture control for Ro-Ro vessels is not certified by Q1 of 2023, Toyota may need to re-evaluate its compliance plans.

With respect to shore power, the technical challenges noted in Toyota's November 2021 terminal plan remain today. Primarily, in discussion with Ro-Ro carriers, we have learned that there is still a lack of a technical standard for shore power connections for Ro-Ro vessels. The American National Standards Institute ("ANSI")/ International Electrotechnical Commission ("IEC") process for setting this standard kicked off summer of 2021, however, the final document is not expected until 2022-2023.

Second, to implement shore power, both shore facilities and incoming ships require modification. Such modifications cannot be made until the ANSI/IEC standard is formally approved. In addition, ship modifications must by accomplished while each ship is in dry dock. Both the timing of ANSI/IEC standard adoption and the ship modification requirements create a long lead time to implement shore power. The anticipated schedule for shore power conversion exceeds the regulatory timeframe mandated in the At-Berth Regulation.

In sum, Toyota will continue to actively assess the availability of compliance options for the At-Berth Regulation. Toyota requests that CARB consider providing compliance extensions should compliance options not become available before April 1, 2023. Toyota is willing and interested in having further dialogue with staff on our comments. Please contact Glenn Choe, Principal Engineer, at glenn.choe@toyota.com or 502-542-9078. Thank you.

Sincerely,

Fred Turatti
General Manager
Sustainability and Regulatory Affairs
Toyota Motor North America

cc: Tom Stricker
Kelley Kline

**Ramine Cromartie**
Senior Manager, Regulatory Affairs

June 30, 2022

(Submitted via email to shorepower@arb.ca.gov)

Shorepower (Marine Strategies)
California Air Resources Board
1001 I Street,
Sacramento, CA 95814

**Re: Comments on Interim At Berth Evaluation**

Western States Petroleum Association ("WSPA") appreciates the opportunity to provide comments on the California Air Resources Board's ("CARB") interim evaluation as set forth in section 93130.14(d) of the 2020 amendments to the Control Measure for Ocean Going Vessels at Berth ("At-Berth Regulation"). WSPA is a non-profit trade association representing companies that explore for, produce, refine, transport and market petroleum, petroleum products, natural gas and other energy supplies in California and four other western states.

Specific to tanker vessels, CARB's interim evaluation will assess progress made in adopting control technologies to reduce emissions from tankers at tanker terminals. It will also include a review of control technologies to reduce emissions from tankers at anchor and potential regulatory requirements. In the *At Berth Frequently Asked Questions* ("FAQ"), CARB explained that relevant information should be provided no later than June 2022. In the May 17, 2022 webinar, CARB clarified that relevant information should be provided no later than June 30, 2022.

In November 2021, a robust technology assessment of emission control technologies for tankers at-berth was completed by DNV-GL USA, Inc., an independent expert in maritime risk management and quality assurance, one of the world's leading certification bodies and classification societies and a recognized leader across the maritime industry. This technology assessment involved gathering and assessing information from an extensive array of subject matter experts and stakeholders, including CARB, WSPA, the U.S. Coast Guard, major ports, tanker and tanker terminal operators, and third-party technology providers. This comprehensive technology assessment documented that the emission standards and compliance deadlines in the At-Berth regulation cannot be safely and reliably met by capture and control and shore power technologies for tankers at ports and terminals, and cannot be met by the compliance deadlines currently in the At-Berth Regulation. Accordingly, CARB staff should recommend a substantial delay in the compliance deadlines of the At-Berth Regulation in its interim evaluation. WSPA is not aware of any more recent developments in these technologies that would change this assessment, but requests CARB to make any such information, if it exists, available for public comment and review before relying on it as a basis for rulemaking.

WSPA shares CARB's desire to see regulations that meet California legal requirements, that can be feasibly implemented, and that are cost-effective so that CARB's claims of real-world air emission reductions are actually achieved and sustained. In our view, a realistic rulemaking schedule and early and meaningful stakeholder engagement is essential to arrive at a well-designed regulation, where the air quality goals are consistent with the statutory authority of the regulating body and the state of technology. In this regard, WSPA finds that the public engagement process for the interim evaluation falls short of CARB's own standard practices and the requirements of California law. Going forward, WSPA urges CARB to strengthen industry engagements and collaboration before proposing new regulatory concepts for regulating ocean-going vessels.

To our knowledge, CARB has not disclosed for public comment specific technologies or potential regulatory concepts that may be under consideration for tankers. Absent this information, WSPA provides general comments on proposing measures for tankers at-berth and at-anchor, and the suitability of applying the At-Berth Regulation emission standards to tankers at-anchorage.

1. **At-berth control technologies for tankers are still not proven safe or feasible in practice**

   During the rulemaking process for the At-Berth Regulation, WSPA consistently provided comments that the emission control technologies the Regulation would require were not proven to be safe or feasible in practice for tankers, and urged CARB to partner with WSPA to commission an independent feasibility study on these technologies. For shore power, WSPA commented on the lack of international standards for connecting tanker vessels to shore power, and the extensive period to "turn over" the global fleet of tankers after any such standards might be developed and adopted in the future. CARB recognized this reality when, in the Initial Statement of Reasons for the At-Berth Regulation, CARB acknowledged "a lack of global interest in the development of shore power for tankers vessels."[1] This led CARB staff to "anticipate that compliance with the Proposed Regulation will likely involve capture and control systems at tanker terminals," not shore power.

For emission capture and control systems, WSPA again pointed out the lack of any demonstrated control technology actually achieved in practice in the global tanker fleet, and cited multiple safety considerations that had not been analyzed and addressed in available technologies. Among these was, again, a lack of global standards for the interface between tanker and emissions control device, standards which first must be developed and adopted by international regulators of global tanker fleets (e.g. the International Maritime Organization (IMO) and classification societies) over years before they can even be installed on actual tanker vessels. Attempting to install a novel tanker control technology – or ***any*** on-board technology – in the absence of safety standards significantly increases dangers to life and limb in such contexts as the execution of emergency disconnection, generation of static electricity or other ignition sources, and mismanagement of inert gases, leading to serious risks of fire and explosion on vessels carrying flammable cargo. WSPA added that these safety considerations were in addition to other operational, design, and environmental concerns (e.g. sufficient operating window, shoreside space, impacts to sensitive habitats), which were also generally greater for Northern California terminals.

In late 2020, WSPA engaged DNV-GL to conduct a technology assessment ("Technical Assessment") of the emissions control strategies considered in the At-Berth Regulation, specifically shore- or barge- based capture and control and shore power. The objective of the Technology Assessment was to determine if emissions control technologies can be designed for tanker vessels that could safely and reliably comply with the Regulation, while also meeting mandatory international safety regulations and other statutory requirements. Assuming technologies could be so designed, the Technology Assessment also established design requirements, estimated cost, and estimated the minimum timelines required to implement each emissions control strategy.

To ensure a comprehensive assessment, the technology assessment involved an extensive array of subject matter experts and key stakeholders from government and public entities (e.g., CARB, U.S. Coast Guard, Port of Long Beach, Port of Los Angeles) industry and industry groups (e.g., Marathon ("Tesoro"), Chevron, ConocoPhillips, PBF Energy, Shell, Phillps66, Intertanko, Oil Companies International Marine Forum, Valero) and third-party technology providers (e.g., Clean Air Engineering – Maritime (CAEM),

[1] CARB, *Public Hearing to Consider the Proposed Control Measure for Ocean-Going Vessels at Berth*, *Staff Report: Initial Statement of Reasons*. October 15, 2019

GMB Marine Services, AECOM, Cavotec). Over the course of multiple technical workshops, the experts discussed in detail the degree of technical feasibility and maturity, safety concerns and safeguards, operational considerations, environmental aspects and regulatory dependencies for each technology. The Technology Assessment report was completed and finalized in November 2021 and is attached to this letter.

A year after the At-Berth Regulation was adopted, the Technical Assessment reached the same conclusions WSPA had highlighted to CARB throughout the rulemaking process—that capture and control systems and shore power are not proven safe or feasible in practice for the population of tankers that berth at California ports and terminals.

Concerning shore- or barge-based capture and control technology, the Technology Assessment concludes that “currently, a ready to use capture and control technology, either shore based, or barge based deployable for tankers does not exist.” In reaching this conclusion, the report highlights unique risks relevant to utilizing the technology on tankers, including but not limited to:

- performance constraints, reliability concerns, with respect to safe and efficient handling of stack size and exhaust rate variability from auxiliary boilers and auxiliary engines, potential additional emission sources
- potential interference with hazardous zones on the ship and terminal
- compliance with Marine Oil Terminal Engineering and Maintenance Standards (MOTEMS) requirements in cases of terminal modifications and upgrades
- safety concerns including short circuits, fire and explosion hazards, collision, disruptions to vessel operations, safe evacuation of personnel
- environmental concerns such as potential damage to existing underground installations, noise pollution, potential obstruction of traffic in narrow channels
- design constraints such as terminal water depth, operational interference, physical space constraints, operational boundaries
- shore-based technology might have space constraints related to the terminal design and could require significant modifications to the terminal infrastructure
- barge-based technology has risks related to marine operations, environmental conditions, and emergency procedures
- shore-based has marine civil/structural challenges engineering unique to each facility requiring significant modifications to terminal infrastructure

Concerning shore power technology, the Technology Assessment concludes that “the technology needs further development for large-scale implementation in the tanker segment". In reaching this conclusion, the report finds that key implementation challenges include, but are not limited to:

- missing and/or gaps in existing industry standards, regulations, and classification societies rules to meet the specific shore power requirements for tankers including the requirements to setting up power generation and distribution system to cover main and emergency switchboard to be powered externally using shore power
- lack of standardization for tankers with regards to location of the shore power connection point on the ship, a common point of interface with terminal systems, i.e., limitation of shore power connection within hazardous zones
- the wide range of the length of the tankers and the vessel orientations at the terminals, which when combined with the lack of connection point standardization, may seriously restrict the vessels able to use the infrastructure.
- a suitable location for cable management system on shore and onboard, including material handling requirements to deploy electrical cables between shore and connection point on the vessel
- technology development of ex-proof certified electrical equipment, severely restricting suitable onboard connection points
- further risk evaluation with regards to handling of hazardous cargo while implementing the technology
- other risks related to personnel safety, emergency evacuation, cybersecurity etc.
- consideration of potential demand on the electrical grid in the ports and terminals, as well as locally accounting for variable power and peak load power demands across vessels while ensuring voltage and frequency compatibility/ stability
- potential physical space constraints, including emergency vehicles
- need to develop maritime industry standards (for terminal and vessel operators) defining tasks and responsibilities, similar to those from International Chamber of Shipping (ICS), OCIMF, and International Association of Ports and Harbors (IAPH), and International Safety Guide for Oil Tankers and Terminals (ISGOTT)

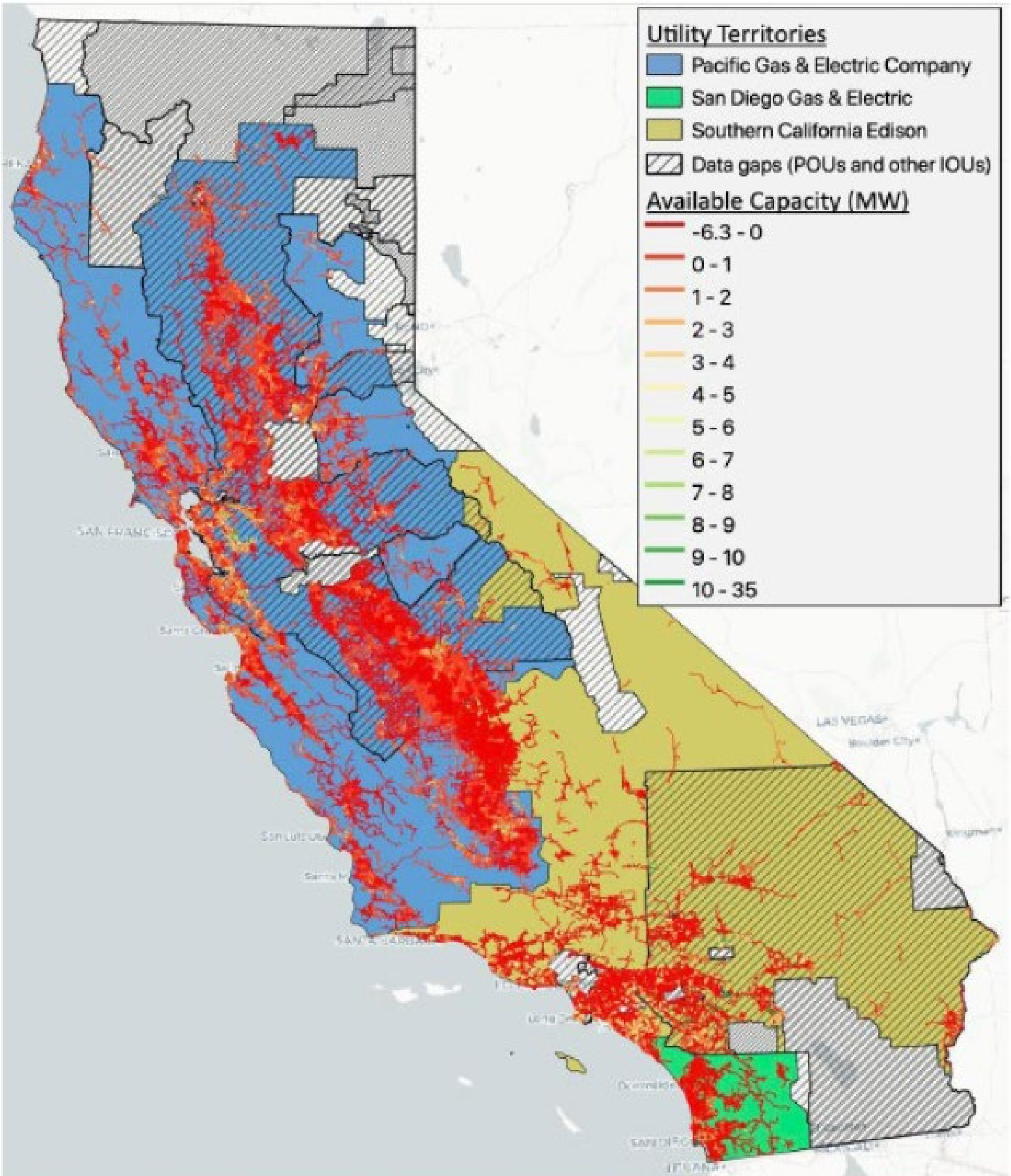
The Technical Assessment also found that installing shore power or land-based capture and control technologies--even if all the considerations above were somehow instantly resolved today--is likely to take 14 years, or longer for larger or more complex terminals. The Technical Assessment concludes that "it is unlikely that any ports or marine oil terminals will be able to comply with the 2020 At-berth Regulation timeline". The Technical Assessment found that barge-based systems will take around 5 years to install, but notes that capture and control systems serving tankers do not currently exist.

Now, only half a year after the Technology Assessment, WSPA is unaware of any developments in capture and control technology or shore power technology for use on tankers at ports and terminals that would materially alter these conclusions. In fact, since the Technical Assessment was published in November 2021, Northern California marine terminals have identified further risks to barge-based capture and control and shore power technologies.

- For barge-based capture and control, barges will not be able to safely moor with spuds alone due to the insufficient cohesion and friction in Bay Mud, a sedimentary geological formation prevalent throughout San Francisco Bay. The Bay Mud also has insufficient bearing capacity for a jack-up system. Hence, for Northern California marine terminals, capture and control barges will additionally need to tie-off to a marine structure.
- Concerning shore power, Pacific Gas and Electric (PG&E) has already commented that it has insufficient electrical capacity at the distribution level system to supply power to a 20 MW shore power substation at one of the Northern California terminals and would be unable to permit and build the required expansion to serve 20 MW by the compliance deadlines. And based on the California Energy Commission (CEC) EDGE model terminals located in the cities of Long Beach and Los Angeles are severely constrained as well.

In the event CARB is aware of any developments that would materially alter the conclusions of the DNV-GL technology assessment, WSPA urges CARB to release, solicit and consider public comment on that information before relying on it to reach conclusions in the interim evaluation.

**Figure B-4: Capacity Analysis from CEC's EDGE Model[126] (dark red indicates no available additional capacity)**



## 2. WSPA urges CARB to improve its stakeholder engagement in the rulemaking process

Public engagement is not only an important requirement of California law, but a critical mainstay of a strong rulemaking process that leads to well-designed regulations. This is particularly so when the subject of regulation is complex and addresses assets that are governed by various International and Domestic regulating agencies.

Tankers calling at California ports and terminals are built in numerous places around the world and feature unique operational needs and hazards when compared to other ocean-going vessels because of the flammable nature of their cargo. Tankers trade globally and can often be limited charters, which means they are incentivized to adopt changes to meet requirements that are applicable not just in one state in one country, but in markets globally. These global requirements are set by the IMO, which in addition to specifying the basis for ship designs, also has set emission reduction targets for the marine industry to achieve net zero carbon emission ambitions later in the century. Given the complexity in regulating globally trading tankers, CARB needs to engage with a broad array of stakeholders, especially the IMO, and meaningfully address concerns so that regulatory concepts for tanker vessels achieve real-world emission reductions.

Looking to the prospect of potential regulation of tankers at-anchor, WSPA is concerned about the public engagement process to-date and urges CARB to prioritize early and meaningful engagement with affected sources and the maritime industry prior to proposing regulatory concepts or emissions control technologies for use on tankers.

### a. Public Engagement on the Interim Evaluation

While CARB is inviting public input on its interim evaluation, WSPA is concerned about the public engagement process because CARB did not timely issue a standard public notice providing sufficient time for public comment and, to our knowledge, CARB has not provided any information to provide comment on.

The invitation for public comment was first discovered in CARB's FAQ, which was issued on Nov 22, 2021. The FAQ notice did not highlight a request for public comment. Instead, the invitation for public comment was found in the FAQ, specifically the response to question #117 out of list of 147 questions, where CARB strongly recommends providing information relevant to the interim evaluation by January 2022, but no later than June 2022. Given the preferred timing (January 2022) was only a month or two after the FAQ was issued, CARB should have widely noticed the request for public input. Later in May 2022, CARB did announce and host a webinar on the At-berth Regulation, including the interim evaluation, but this was one month from the final June 2022 deadline. The June 2022 deadline was only clarified to mean June 30, 2022 during this May 17, 2022 webinar.

If CARB is considering specific technologies or requirements for tankers at-anchor, WSPA urges CARB to release, solicit and consider public comment on such information before reaching conclusions in the interim evaluation. The absence of comments on any such technologies or requirements, simply because the public was not afforded meaningful opportunity to review and comment, should not be construed as a signal that industry endorses or is not aware of any safety, reliability, or feasibility issues associated with such technologies or requirements.

b. Rulemaking Process Recommendations

Looking back at the rulemaking process for the At-Berth Regulation, WSPA offers the following recommendations for CARB to improve engagement with industry on the development of any regulatory concepts for tanker vessels, including those at-anchor:

- coordinate with WSPA and other stakeholders to conduct a robust feasibility study of proposed control technologies, similar to the Technical Assessment
- conduct multiple workshops on each element of the basis for rulemaking, including but not limited to emissions inventories, risk assessments, and cost analysis
- provide all workshop materials in advance of the workshop date; the days in advance should be proportional to the volume and complexity of the subject matter materials, but at least 30 days in advance
- provide responses to stakeholder input during early rulemaking, and in particular, articulate clear rational bases for proposing or rejecting data
- coordinate with other regulatory and standard-setting bodies with jurisdiction over tankers and anchorage operations (e.g., IMO, maritime classification societies, U.S. EPA, U.S. Coast Guard)

WSPA believes meeting these recommendations will significantly improve the quality, design, and effectiveness of potential future regulations. WSPA stands ready and willing to assist in these recommendations, including doing the hard work necessary to complete a feasibility study prior to proposing regulatory concepts, so that CARB is well informed on whether potential emission standards can be safely and reliably met with identified air pollution control technologies.

**3. Regulating tankers at-anchor present uniquely different challenges than tankers at-berth**

To our knowledge, CARB has not provided any information on any potential requirements or emission control technologies it is considering for tankers at-anchor. This prevents the public and affected stakeholders from meaningfully engaging with CARB in the evaluation of whether controls might be appropriate for use at anchor, which controls (if any) might actually be achievable, and what the risks and dangers of those technologies might be in practice. It is important to remember that it is ***CARB's*** burden under California law to document the information it has to support any proposed regulation, not the ***public's*** burden to prove that a proposed regulation lacks support.

In the absence of this critical information, WSPA provides comments that generally apply and specific comments on the suitability of applying the emissions standards for tankers at-berth to tankers at-anchor.

**a.** Emission standards needs to be fit for purpose and achievable

WSPA recognizes CARB has set out to meet ambitious state climate goals and air quality objectives under the Clean Air Act, and wishes to mandate regulatory measures that it considers aggressive and "technology-forcing." WSPA shares with CARB the desire to see regulations that meet federal and California legal requirements, that can be feasibly implemented, and that are cost-effective, so that the emission reductions CARB promises will actually be achieved in the real world.

With tankers, as discussed above, what is achievable depends on certain factors beyond CARB's control. CARB does not develop or enforce international marine vessel safety standards and regulations, nor does it have the power to force the development of global safety standards on California's timeline. Thus, such technology often will lag CARB's air quality goals. The effect of this is seen in the lack of progress of adopting capture and control or shore power control technologies for tankers at-berth. In this way some of the goals of the At-Berth

Regulation are outpacing the state of global technology, and CARB lacks the jurisdiction to force global tankers to catch up on its preferred timeframe.

Looking to potential requirements at-anchor, WSPA strongly recommends CARB coordinate with other relevant regulatory and standard-setting bodies (e.g., IMO, U.S. Environmental Protection Agency, U.S. Coast Guard, maritime classification societies) to gather the critical technical information needed and develop feasible regulations in support of CARB's climate and air quality goals. This approach is consistent with CARB's draft 2022 State Implementation Plan Strategy, where CARB proposes to "petition and/or advocate to U.S. EPA and IMO for cleaner marine standards…CARB will work with U.S. EPA, U.S. Coast Guard, and other partners to urge IMO to adopt more stringent Tier 4 marine standard and establish efficiency requirements for existing vessels"[2].

**b.** The emission standards for tankers at-berth emission are only more infeasible for tankers at-anchor

As described above, DNV-GL concluded in its technical assessment that the At-Berth Regulation emissions standards and compliance deadlines cannot be met safely and reliably by available capture and control and shore power emissions control technologies for tankers at-berth, and cannot be met by the compliance deadlines currently in the At-Berth Regulation. When tankers are at-anchor, many of the safety concerns, performance constraints, and design constraints that exist for the application of these technologies to tankers at-berth also apply and, in many cases, are exacerbated. Additionally, there are some unique considerations for tankers at-anchor. Some of these considerations are provided below, but the list is not exhaustive. If CARB is considering emission standards for tankers at-anchor, then WSPA strongly urges CARB to partner with WSPA members and other stakeholders to conduct a feasibility study on the potential emissions control technologies, similar to the Technical Assessment for tankers at-berth. A feasibility study is necessary to rigorously identify the potential hazards and necessary mitigations for safe and reliable operation of emissions control strategies.

Shore Power:

[2] CARB, *Draft 2022 State Strategy for the State Implementation Plan*. January 31, 2022 https://ww2.arb.ca.gov/sites/default/files/2022-01/Draft_2022_State_SIP_Strategy.pdf

- The availability of adequate shoreside power and infrastructure needs to be robustly evaluated. As discussed above, there is insufficient power capacity for at least one Northern California terminal for shore power at-berth. An expansion of shore power to vessels at-anchor will significantly multiply the demand on shoreside power and infrastructure capacity.
- Anchorages within the U.S. are the responsibility of the United States Coast Guard. The construction, maintenance, and liability of a high voltage underwater electrical distribution system would impose requirements on several entities beyond terminal and vessel owners/operators.
- Design of shore power at anchor has not yet been conceptualized.
- Standards, regulations, and classification society rules for onboard shore power on tankers at-anchor do not exist.
- Detailed and thorough risk analysis should be completed to assess safety of people, vessel, and environment prior to conceptualizing shore power for vessels at anchorage.
- The 'IEC/IEEE International Standard - Utility connections in port' (IEC 80005-1) describes high-voltage shore connection systems for ships and shore. While designs, for broad adoption of shore power are still being developed, for tankers, a shore side facility will be required to provide cabling and cable handling of the 'high voltage cable' and 'communication cables' from shore to anchor.
- Ships built to international standards are not equipped to lift cables onboard. Additional fixed platforms or floating platforms, throughout the anchorage, or some mechanism like this will be required to lift cables onboard at anchorages
- Navigation hazards exists, including cable entanglements with transiting ships, and damage to electric cables laying on seabed from anchoring operations.
- Safety during connection/ disconnection: When vessels connect/ disconnect to shore power, they are typically required to shut down all systems/ machineries momentarily to avoid equipment damage. Performing this operation at anchorage could pose additional risks for vessels at anchorage.

Capture & Control Technology:

- Given the lack of a “shore,” shore-based capture and control is not an option.
- Before considering mandating any capture and control technology, CARB should coordinate closely with the U.S. Coast Guard, which is responsible for managing port congestion and safe navigation of all vessels at or near anchorages.
- The number of vessels at anchorage (one capture barge next to one vessel) will double, leading to increased port congestion and navigational risk
- Every vessel in port will be double banked (moored adjacent to the vessel using mooring lines or using Dynamic Positioning (DP) barges), which significantly increases safety risks associated with navigation in anchorages, responding to emergencies onboard the tanker or barge, disconnecting and separating vessels during severe meteorological and ocean conditions.
- Tankers at-anchor are exposed to stronger winds, waves and currents than tankers at-berth, which increases the risk and severity of human injury and collision between capture and control barges and the tanker. Capture and control barges have high profile windage areas, high center of gravities, flat sides and non-tapered ends. Due to the changing environment, and necessary vessel characteristics, there will be relative motions between the two vessels. These can quickly become hazardous to people and property during mooring, bonnet placement/removal, normal operations and unmooring activities.
- Tankers at anchor are exposed to stronger winds, waves and currents than tankers at-berth, which reduces the operating window of capture and control equipment on the double-banked barge and requires an enhanced design of capture and control equipment that needs to be vetted through a detailed feasibility study.
- Existing capture & control barges are minimally manned vessels. Having these barges double banked to a ship at anchorage will require a detailed review of barge specifications and manning requirements to address emergency scenarios, including emergency disconnect and sail away.
- Capture and control barges have minimal boom reach due to engineering limits and need to be as close to the stack as practical. The aft end of a tanker has curvature and overhang. There is a risk that the barge can become pinched at the aft end of a tanker and cause damage and or put

operators at risk if injury or fatality. This risk is elevated at open anchorages which is exposed to the open sea environment.

- Bay mud in the San Francisco Bay lacks sufficient geotechnical characteristics to solely rely on spud-based mooring or jack-up systems, as discussed above; an adjacent structure at-anchor is necessary to moor the barge.
- There is the potential for marine environmental impacts from the continuous operation of barge-based capture and control (e.g. lighting, noise)

WSPA appreciate this opportunity to comment on CARB's interim evaluation. If you have any questions regarding this submittal, please contact me at (510) 672-1526 or via email at rcromartie@wspa.org.

Sincerely,

Ramine Cromartie

Cc:

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**CALIFORNIA AIR RESOURCES BOARD'S (CARB) OCEAN-GOING VESSELS AT BERTH REGULATION EMISSIONS CONTROL TECHNOLOGY ASSESSMENT FOR TANKERS**

# Report

## Western States Petroleum Association

**Report No.:** 2021-9470 Rev. 0
**Document No.:** 11IHNF43-1
**Date:** 2021-11-30

DNV

| | | |
|---|---|---|
| Project name: | California Air Resources Board's (CARB) Ocean-Going Vessels at Berth Regulation Emissions Control Technology Assessment for Tankers | |
| Report title: | Report | |
| Customer: | Western States Petroleum Association | |
| Customer contact: | Sophie Ellinghouse | |
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| Document No.: | 11IHNF43-1 | |

DNV GL USA, Inc. Maritime
Advisory Americas
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USA

Objective:

Carry out a technical study, with relevant stakeholders' engagement and assessment of technology using a systematic and scientific approach following the DNV technology qualification process. The scope of the study includes the review of safety and reliability aspects of the given emissions control strategies, the timeframe for implementing the technologies, and alignment with applicable tanker/terminal regulations and standards.

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## ABBREVIATIONS & DEFINITIONS

| | |
|---|---|
| **Ship/Terminal related terms** | |
| **AC** | Alternate Current |
| **DC** | Direct Current |
| **HVAC** | Heating Ventilation & Air Conditioning |
| **ROG** | Reactive Organic Gases |
| **OPS** | Onshore Power Supply |
| **PV** | Pressure Vaccuum Valve |
| **MW** | Megawatt |
| **PPE** | Personnel Protective Equipment |
| **DWT** | Deadweight |
| **DG** | Diesel Generator |
| **IGG/IG** | Inert Gas Generator |
| **COP** | Coefficient of Performance |
| **Ex-proof** | Explosion Proof - Refers to fittings that need to be explosion proof |
| **IP** | Insulation Protection |
| **PS** | Port side |
| **SB** | Starboard side |
| **VHF** | Very High Frequency |
| **IR Monitoring/IR Camera** | Infrared Camera |
| **NDT** | Non Destructive Testing |
| **AIS** | Automatic Information System |
| **GPS** | Global Positioning System |
| **NPT** | Non Performing Time |
| **CMS** | Cable Management System |
| **SPO** | Shore Power Outlet |
| **Standards, rules or regulations mentioned** | |
| **MOTEMS** | Marine Oil Terminal Engineering & Maintenance Standards |
| **IEC** | International Electrotechnical Commission |
| **ISGOTT** | International Safety Guide for Oil Tankers and Terminals |
| **IBC** | International Bulk Chemical Code |
| **IACS** | International Association of Classification Societies |
| **CCR** | California Code of Regulations |
| **IEEE** | Institute of Electrical and Electronics Engineers |
| **NFPA** | National Fire Protection Association |
| **NEC** | National Electrical Code |
| **IMO** | International Maritime Organisation |
| **SOLAS** | Safety Of Life At Sea |
| **MARPOL** | International Convention for the Prevention of Pollution from Ships |
| **OCIMF** | Oil Companies International Marine Forum |

| | |
|---|---|
| **PIANC** | The World Association for Waterborne Transport Infrastructure |
| **ABS** | American Bureau of Shipping |
| **MEG 4** | OCIMF Mooring Equipment Guidelines 4th Edition |
| **API RP** | American Petroleum Institute Recommended Practice |
| **GHG** | Green House Gases |
| **NOX** | Nitrous Oxide -Pollutants from emissions |
| **SOX** | Sulphur Oxide - Pollutants from emission |
| **PM** | Particulate Matter - Pollutant |
| **CSLC** | California State Lands Commission |
| **Tier IV** | EPA emissions requirement for diesel engines |
| **USCG** | US Coast Guard |
| **CEQA** | California Environmental Quality Act |
| **ISPS** | International Ship and Port Facility Security Code |
| **MTSA** | Maritime Transportation Security Act of 2002 |
| **Risk assessment tools** | |
| **FMECA** | Failure Mode Evaluation & Criticality Analysis |
| **SIMOP** | Simultaneous Operations |
| **HAZID** | Hazard Identification |
| **HAZOP** | Hazard and Operability Analysis |
| **TQ** | Technology Qualification |

# 1 EXECUTIVE SUMMARY

Western States Petroleum Association (WSPA) engaged DNV to conduct a technology assessment of the emissions control strategies considered in the 2020 amendments to California Air Resources Board's (CARB) Ocean-Going Vessels At- Berth Regulation. The technology assessment determines if the emissions control technologies can be designed for tanker vessels to comply with the regulation safely and reliably, while still meeting other applicable tanker regulations and standards. The technology assessment also establishes design requirements, estimated cost, and the minimum timelines required to implement each emissions control strategy. DNV is an independent expert in maritime risk management and quality assurance, one of the world's leading certification bodies and classification societies and is a recognized leader across the maritime industry.

The amended regulation applies to tanker vessels at California (CA) ports and marine terminals and will require all tanker vessels that berth at a CA port or terminal to meet new emission standards as early as 2025. In order to conduct a thorough and systematic evaluation of the compliance alternatives, DNV conducted a series of workshops using DNV's technology qualification process (DNV Recommended Practice, DNV-RP-A203, September 2019).

DNV included an extensive array of subject matter experts and key stakeholders (see Appendix I – V) from government and public entities (e.g., CARB, U.S. Coast Guard, Port of Long Beach, Port of Los Angeles) industry and industry groups (e.g., Chevron, ConocoPhillips, PBF Energy, Shell, Phillps66, Intertanko, Oil Companies International Marine Forum (OCIMF), Valero, and third-party technology providers (e.g., Clean Air Engineering – Maritime (CAEM), GMB Marine Services, AECOM, Cavotec) for a comprehensive assessment. Over the course of multiple technical workshops, the experts discussed the current CARB-approved emission control technologies (CAECS): 1) shore-based power, 2) shore-based capture and control and 3) barge-based capture and control. The experts evaluated each CAECS and discussed in detail their degree of technical feasibility and maturity, safety concerns and safeguards, operational considerations, environmental aspects and regulatory dependencies

While key findings and conclusions are discussed in detail in subsequent sections, this report concludes:

- Onshore power together with modifications for design of tankers need significant development and risk mitigation before an industry-wide implementation for tankers which operate world-wide
- Capture and control technology for tankers does not currently exist. The systems currently used for container vessels in Southern California are not designed to withstand the variable conditions in Northern California including currents, winds, tide, depth, etc. Further, the equipment design and reliability in terms of taking exhaust quantity from tankers need to be established.
- The current regulatory timeline is insufficient to address and mitigate the outstanding safety and operational risks, some of which introduce their own unavoidable limitations and dependencies (e.g., regulatory permitting).
- An electrical grid feasibility study is needed to determine and assure that shore power demand can be provided safely and reliably.

In the broader context, the maritime industry globally is beginning a significant energy transition to reduce greenhouse gas emissions from the sector, some relevant trends of which are noted here:

- While the overall number of installations globally remains limited, the number of major ports with shore power facilities for cruise and container vessels is growing, increasing the viability of installations for these vessel segments.
- Several jurisdictions beyond California are now implementing or considering regulatory requirements for the use of shore power.
- A shift to a new generation of low or zero carbon fuels may significantly change the need for at-berth emissions management, either through an absolute reduction or a change in emission content from new fuels. Section 9 of this report presents a summary of the main regulatory drivers behind this transition as well as some of the potential alternative fuels being considered for the industry.

**Shore power:**

Assessment of the shore power technology indicates that the technology needs further development for large-scale implementation in the tanker segment. The development timescales may not meet the CARB proposed timeline. Some of the key findings and implementation challenges for tankers are listed below:

- Missing and/or gaps in existing industry standards, regulations, and classification societies rules to meet the specific shore power requirements for tankers including the requirements to setting up power generation and distribution system to cover main and emergency switchboard to be powered externally using shore power
- lack of standardization for tankers with regards to location of the shore power connection point on the ship, a common point of interface with terminal systems i.e., limitation of shore power connection within hazardous zones
- the wide range of the length of the tankers and the vessel orientations at the terminals, which when combined with the lack of connection point standardization may seriously restrict the vessels able to use the infrastructure.
- a suitable location for cable management system on shore and onboard, including material handling requirements to deploy electrical cables between shore and connection point on the vessel
- technology development of ex-proof certified electrical equipment, severely restricting suitable onboard connection points
- further risk evaluation with regards to handling of hazardous cargo while implementing the technology
- other risks related personnel safety, emergency evacuation, cybersecurity etc.
- consideration of potential demand on the electrical grid in the ports and terminals, as well as locally accounting for variable power and peak load power demands across vessels while ensuring voltage and frequency compatibility/ stability
- potential physical space constraints, including emergency vehicles
- need to develop maritime industry standards (for terminal and vessel operators) defining tasks and responsibilities, similar to those from International Chamber of Shipping (ICS), OCIMF, and

International Association of Ports and Harbors (IAPH), and International Safety Guide for Oil Tankers and Terminals (ISGOTT).

**Shore and barge based capture and control technology:**

Currently, a ready to use capture and control technology, either shore based, or barge based deployable for tankers does not exist.

The capture and control technology has certain unique risks relevant to its potential utilization on tankers. To mitigate the risks, the critical recommendations during the design, construction, and implementation are identified through this study. Third-party engineering firms have begun to understand and address these challenges with revised designs with focus on the barge based capture and control technology. A few key considerations are listed below:

- performance constraints, reliability concerns, with respect to safe and efficient handling of stack size and exhaust rate variability from auxiliary boilers and auxiliary engines, potential additional emission sources
- potential interference with hazardous zones on the ship and terminal
- compliance with Marine Oil Terminal Engineering and Maintenance Standards (MOTEMS) requirements in cases of terminal modifications and upgrades
- safety concerns including short circuits, fire and explosion hazards, collision, disruptions to vessel operations, safe evacuation of personnel
- environmental concerns such as potential damage to existing underground installations, noise pollution, potential obstruction of traffic in narrow channels
- design constraints such as terminal water depth, operational interference, physical space constraints, operational boundaries

The workshop also identified risks and benefits of a shore based versus a barge based capture and control technology, i.e.

- barge based has flexibility in terms of position and interface with the ship and the terminal
- shore based might have space constraints related to the terminal design and could require significant modifications to the terminal infrastructure
- barge-based has risks related to marine operations, environmental conditions, and emergency procedures
- shore based has marine civil/structural challenges engineering unique to each facility requiring significant modifications to terminal infrastructure

DNV

**Cost and Timeline**

Key findings related to the high-level expected timeline and cost for implementation for each of the three technologies assessed are below.

**Timeline for permitting, design, and construction:**

Based on a generalized timeline for a shore power or land-based capture and control technology installation a project is likely to take around 14 years once a feasibility study commences. For larger or more complex terminals, this could take longer. Hence, it is unlikely that any ports or marine oil terminals will be able to comply with the 2020 At-berth Regulation timeline.

For barge-based systems, the timeline is around 5 years. While there are currently no capture and control systems serving tankers, at least one vendor is nearly complete with detailed engineering for a capture and control barge. Following construction and a successful test, additional capture and control barges may be built and utilized by the tanker industry. This is a technology that, if successful may be replicated with relative ease, it is even possible some barge-based systems could be in operation on a few tankers prior to the regulatory deadline.

**Timing of Applicable Design and Operational Standards for Shore Power:**

- In DNV's opinion, for wide, large-scale implementation of shore power technology, further development of industry standards, regulations, and classification societies rules is required. To facilitate updating the standards, regulations, and industry guidelines, there need to be an initiative underway but there is currently no timeline for addressing these gaps, and the industry will need to initiate a collaborate effort to develop the standards and guidelines
- The timeline for updating the international standard IEC/IEEE 80005-1 to develop prescriptive requirements for the connection point on a tanker could be 2-3 years and is under discussion but no firm process is underway, since the working group need the industry participation and relevant inputs.
- Updating industry guidelines, e.g., ISGOTT, is also expected to take about 2-3 years.
- The updating of IACS or Classification society rules to cover tanker specific requirement for tankers typically can be completed within 1-2 years. This is also driven by the need from the industry, designers, and ship owners.

**Cost for Shore Power:**

- The costs for vessel upgrades for installation for shore power on new vessels are estimated to be between $350k and $700k.
- For existing vessels, the cost is dependent on the vessel type, size, age, and the need for an onboard transformer, as well the where and how the retrofit is performed, e.g., during a scheduled docking in a shipyard or during voyages. For smaller vessels, costs range from about $70,000 to $500,000, and for larger vessels, the costs range from about $500,000 to $1M. If a vessel requires new electrical cargo pumps/variable frequency drives (VFDs), the cost can increase to $2-3M.

- Costs may be significantly higher if the shore power connections will be at the cargo manifold area and within the hazardous zone that might require the design and construction of a specialized safe room for the connection point for the shore power.
- The costs for shoreside modifications vary greatly depending on the unique challenges of each terminal. This results in wide range of costs but our estimation for the installation of shore power costs between $2.5M – $14M per berth, including interconnections to the grid. Depending on the terminal complexity, costs can easily exceed $20M per terminal.

**Cost for Capture and Control:**

- There is still a lot of uncertainty the costs estimate. For land-based systems, CARB estimated costs at about $16.5 million per berth in capital expenses. In the absence of more information, this is a fair assessment of the capital expenses. For more complex terminals or terminal with limited wharf space, costs may be higher.
- For barge-based systems, the capital costs make up a smaller portion of the total costs due to higher operating and administrative costs. The CARB estimates of $4.9 million for the barge construction understate to total capital costs required for a barge-based system. In addition to the capital costs, there will also be leasing/port fees, fuel costs, labor costs, and maintenance costs, which could make up a higher portion of the total lifetime savings.

# 2 INTRODUCTION

## 2.1 California Air Resources Board's (CARB) ocean-going vessels at berth regulation

California Air Resources Board (CARB) has approved the Ocean-Going Vessels At-Berth Regulation in 2007 ("2007 At-Berth Regulation"). In 2020, CARB amended the Ocean-Going Vessels At-Berth Regulation ("2020 At-Berth Regulation"). Under the amended At-Berth Regulation, all tanker vessels would be required to control their auxiliary engine and auxiliary boiler emissions while at berth at ports and independent marine terminals in California where vessel visits exceed specified activity thresholds. To receive CARB approval, one must demonstrate that the emission control strategy achieves emission rates in Table 2-1. The timeframe for planning and compliance defined in "2020 At-Berth Regulation" is shown in Table 2-2.

**Table 2-1 Emission rates requirement for tankers in "2020 At-Berth Regulation"**

| | Oxides of nitrogen (NOx) | Particulate matter 2.5 (PM 2.5) | Reactive organic gases (ROG) |
|---|---|---|---|
| **Auxiliary Engines** | 2.8 g/kw-hr | 0.03 g/kw-hr | 0.1 g/kw-hr |
| **Boilers** | 0.4 g/kw-hr | 0.03 g/kw-hr | 0.02 g/kw-hr |

**Table 2-2 Timeframe for planing and compliance in "2020 At-Berth Regulation"**

| | Plan Submittal | Interim evaluation for new technologies and applications | Plan Revisions | Compliance |
|---|---|---|---|---|
| **Los Angeles/ Long Beach** | Dec 1, 2021 | Dec 1, 2022 | February 1, 2024 | Jan 1, 2025 |
| **All remaining** | Dec 1, 2021 | | February 1, 2026 | Jan 1, 2027 |
| **Description** | Terminal and port operators shall submit terminal plans to CARB. | CARB staff will assess the progress made in adopting control technologies for use with tanker and ro-ro vessels, as well as the status of landside infrastructure improvements that may be needed to support emission reductions at ro-ro and tanker terminals.<br>CARB staff will review control technologies for use with bulk and general cargo vessels, and for ocean-going vessels at anchor, and potential requirements for these vessel types.<br>CARB staff will evaluate the information provided by the port and terminal plans required by this Control Measure. CARB staff will also consider other public information provided to CARB including terminal-specific engineering evaluations, logistical considerations, public engagement, and independent studies that inform the implementation timeline.<br>By December 1, 2022, staff will publish analysis and findings in a report and make it available for public review at least 30 calendar days prior to presenting the report to the Board at a public meeting. If staff finds that the compliance deadlines for ro-ro or tanker vessels need to be adjusted forward or backward in time, the report will include recommendations to initiate staff's development of potential formal regulatory amendments. | Ro-ro and tanker terminals shall revise and resubmit terminal plans on the following schedule, which must reflect any changes to the terminal since the initial plan | Tanker vessels that visit a berth or terminal shall meet the requirements. |

## 2.2 The study subjects

In "2020 At-Berth Regulation", "tanker vessel" means a self-propelled vessel constructed or adapted primarily to carry liquid bulk cargo and tanker vessels may carry petroleum crude, petroleum products, or non-petroleum-based products - finished and intermediate and are classified as either non-edible and dangerous or edible and non-dangerous. The study has focused on crude oil tankers, product oil tankers, and chemical tankers, i.e., the common tanker types that are visiting California ports and terminals for cargo operations.

The following at-berth technologies were studied:

- Shore power
- Shore-based emissions capture and control
- Barge-based emission capture and control

The above technologies have been evaluated for implementation on generalized tanker vessel designs that berth at generalized versions of a port terminal and marine terminal that are reasonably representative of California port and marine terminals.

## 2.3 Technology qualification process

Implementation of new technology introduces uncertainties that imply risk for its developers, manufacturers, vendors, operators and end-users. TQ is the process of providing the evidence that (for the purpose of this study – Shore power and Capture and Control technologies) will function within specified operational limits with an acceptable level of confidence. The DNV Recommended Practice (RP) A203 "Technology Qualification" is a procedure that covers a systematic approach to the qualification of a technology, and thus a tool to ensure that the technology functions within specific limits with an acceptable level of confidence. The main steps in the TQ work process are shown in **Figure 2-1**.

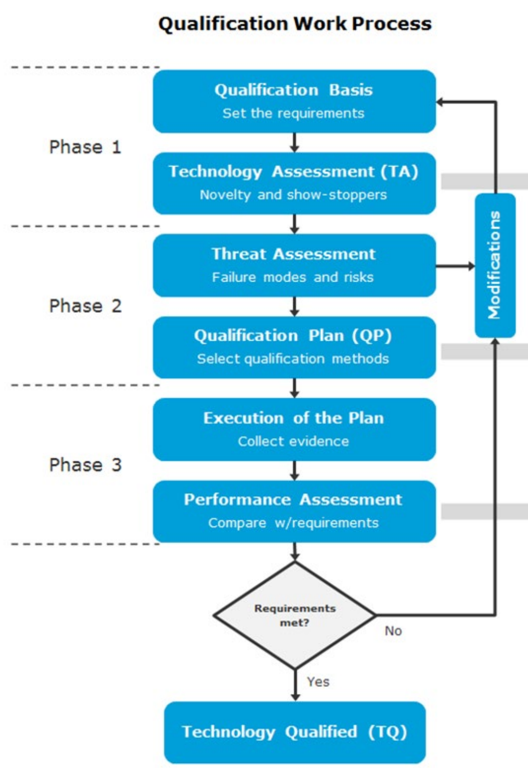



**Figure 2-1 Qualification work processes**

In a full TQ work process, the functional requirements and any critical performance parameters are described in a qualification basis, after which a technology assessment identifies the most significant areas of uncertainty associated with the technology.

Following this, a more detailed threat assessment is conducted, focused on these uncertainties, to identify potential failure modes, risks and concerns.

These identified risks would then be followed up through design and implementation processes, according to an associated qualification plan with clearly identified mitigations.

If the qualification plan is successfully executed and verified, a performance assessment against the qualification basis determines whether the qualification process has been successful, and the technology has met the intended functional requirements and performance.

For the purpose of this study, phase 1 as well as a threat assessment has been carried out. The remaining steps in the process are disregarded as they are not relevant to the scope of this report.

# 3 THE GENERAL CHARACTERISTICS OF THE TANKERS

The current status of the tanker fleet and terminals in California has been reviewed to understand the key stakeholders, the current facility set up, and identify potential challenges in terms of implementation of emission control technology.

The collected information from stakeholders and public resources and historical Automatic Identification System (AIS) data between 2017 January 1st and 2019 December 31st have been analyzed to review the status of the tanker fleet visiting California. (The data in 2020 is deemed as an outlier due to the COVID-19 pandemic.) Based on the analysis of the AIS data, Figure 3-1 shows the number of unique ships per tanker type visiting California terminals from 2017 - 2019. The majority are chemical/oil product tankers, crude oil tankers, and oil product tankers and the study will focus on these tanker segments.

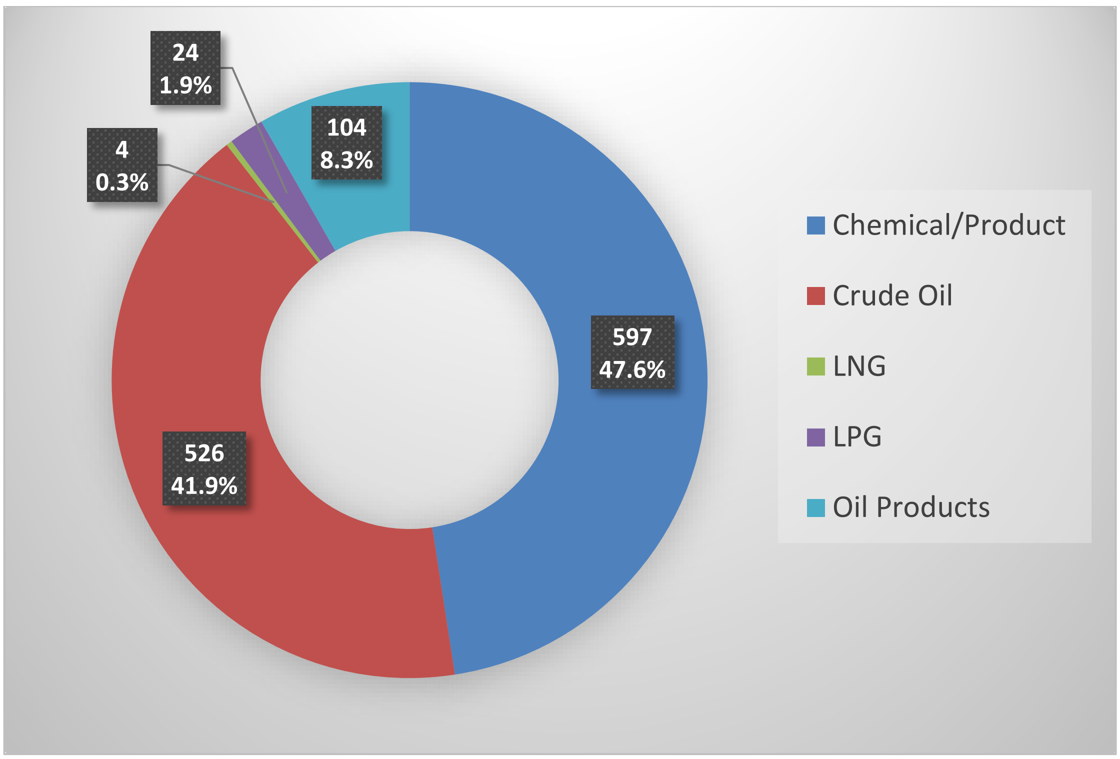



**Figure 3-1 Unique ships that visited California between 2017 January 1st and 2019 December 31st**

A substantial amount of the tankers calling California have deadweight below 80,000 DWT. But there are also many Very Large Crude Carriers (VLCC) and Ultra Large Crude Carriers (ULCC) visiting. It should be noted that the ship call visits based on AIS data includes all vessels classified as tankers visiting California ports and it intended to show the general mix of oil tanker types and sizes that called California in 2017-2019.

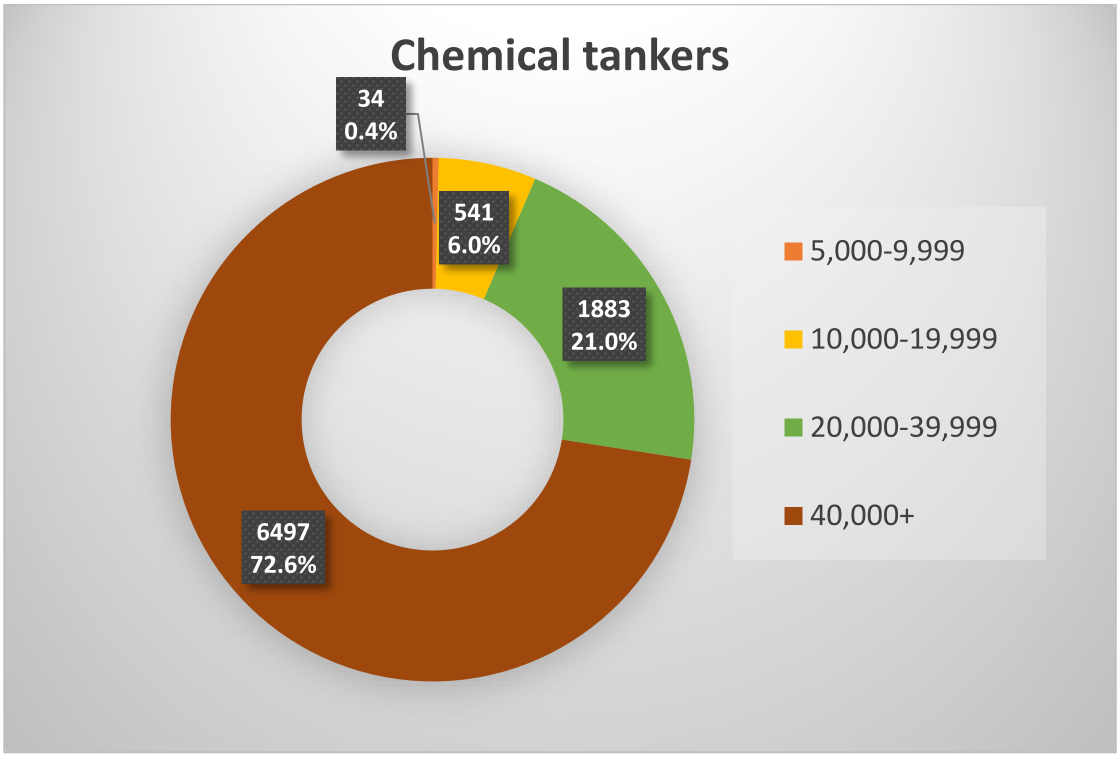



**Figure 3-2 Ship size (deadweight) distribution of chemical tankers that visited California between 2017 January 1st and 2019 December 31st**

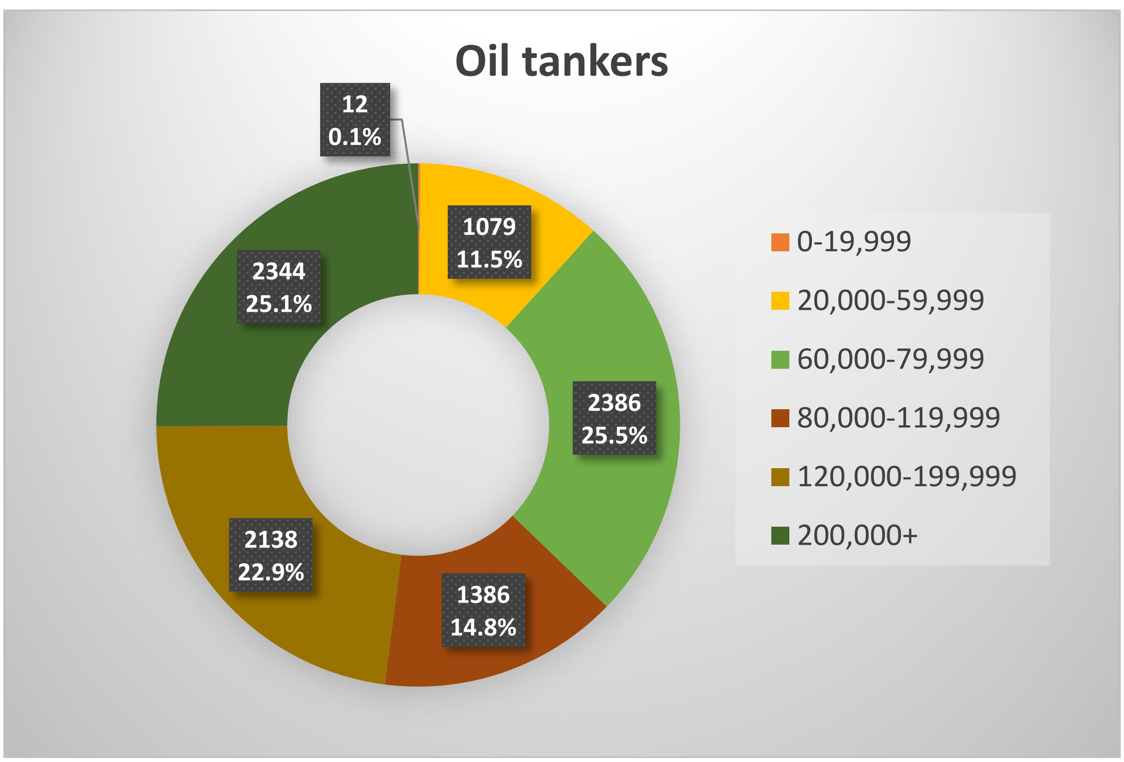



**Figure 3-3 Ship size (deadweight) distribution of oil tankers that visited California between 2017 January 1st and 2019 December 31st**

The following characteristics which are unique to tankers have been reviewed in the study:

- Hazardous zones and risks related to transportation of hazardous cargo
- Wide variation of vessel size
- Significant draft variations during loading/unloading
- Relatively high-power demand from both auxiliary engines and boilers
- Requirement of evacuation during emergency

# 4 THE GENERAL CHARACTERISTICS OF THE RELEVANT TERMINALS

There are 34 marine oil terminals in California where nearly two million barrels of oil and petroleum products are transferred (between ship and shore) daily.[1] The public and stakeholder-provided information from major terminals and ports in California has been reviewed towards developing an understanding of the current facility set up and the generalized settings of terminals that are reasonably representative of California port and marine terminals. The following characteristics of terminals are seen to be relevant to the study:

- The terminal type/arrangement, i.e. "near shore terminals" or "long-wharf (T-head piers)"
    - A majority of the existing oil terminals use the near shore design with a pier that goes into the water, as shown in Figure 4-4. Others new terminals systems are similar to the Marathon 121 in Port of Long Beach and are "platform and dolphin based (Figure 4-5). Most new terminals generally follow this standard.
    - Figure 4-6 shows an example of the long wharf typed marine oil terminal in California.[2] Some terminal infrastructure at San Francisco Bay and Carquinez Straits in Northern California stretched out over a mile into the water. These terminals can be affected by harsher weather conditions and stronger currents than the Southern California counterparts which are in relatively sheltered waters.
- Existence of hazardous zones compared with other type of marine terminals.
- The weather and environmental conditions prevalent at the different terminals such as the Port of Los Angeles and Port of Long Beach in relatively sheltered waters while the terminals at Northern California, such as Richmond and Carquinez strait are more exposed to harsh weather and strong currents. However, it is noted that Port of Richmond terminals are sheltered and not impacted by current or wind like those outside of the sheltered harbor.
- Navigational risks related to potential traffic congestion, collision risks, existence of underground pipelines, turning basins, etc.
- Existing traffic of tankers calling at the ports which impacts the potential energy and power demand

[1] California State Lands Commission

[2] https://ww3.arb.ca.gov/regact/2019/ogvatberth2019/isor.pdf

The next photos show examples of various ports and terminal arrangements discussed above.

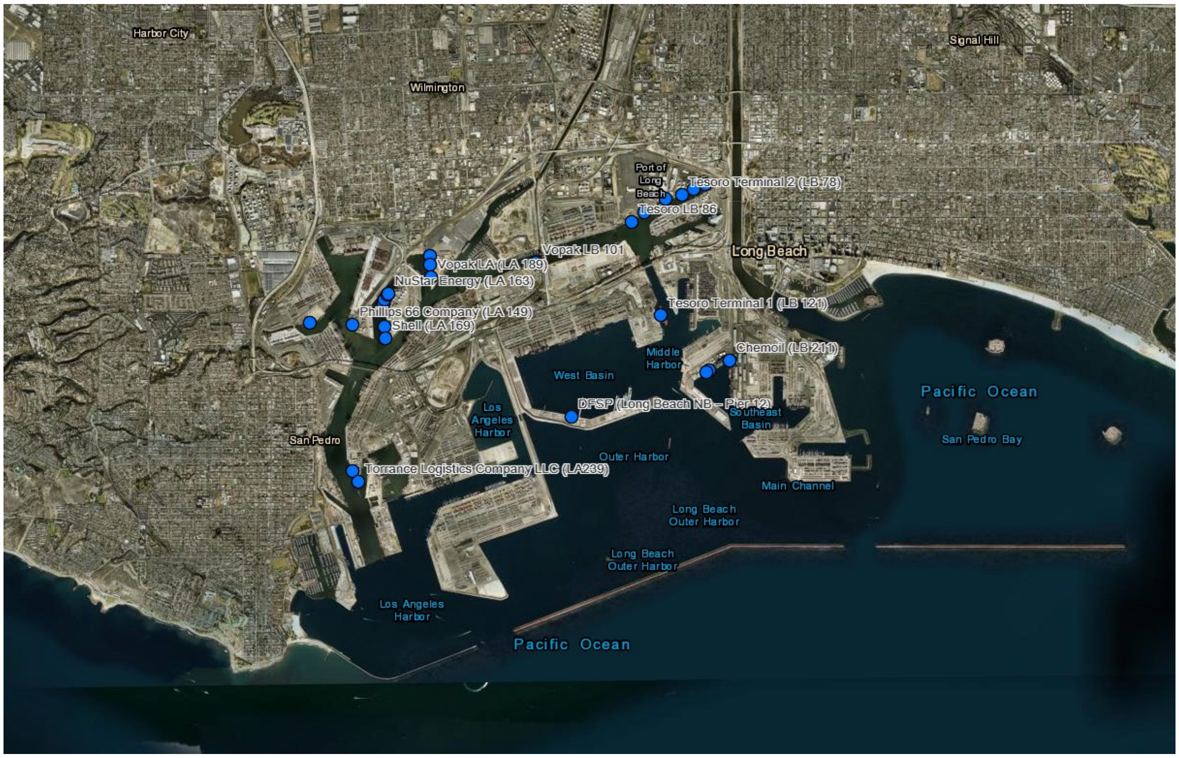



**Figure 4-1 Oil terminals at Port of Los Angeles and Port of Long Beach**[3]

[3] www.arcgis.com

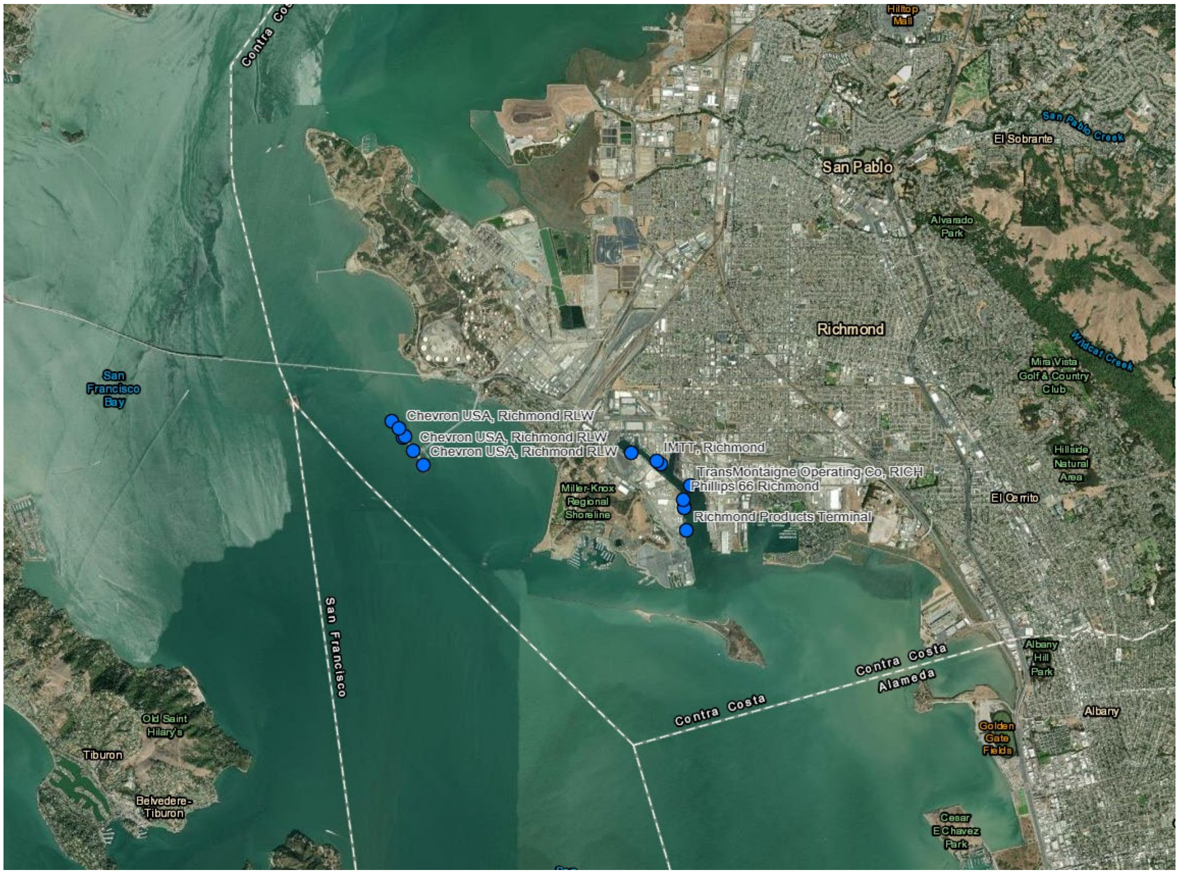



**Figure 4-2 Oil terminals at Richmond**[4]


**Figure 4-3 Oil terminals at Carquinez Strait**[5]

[4] www.arcgis.com

[5] California Energy Commission

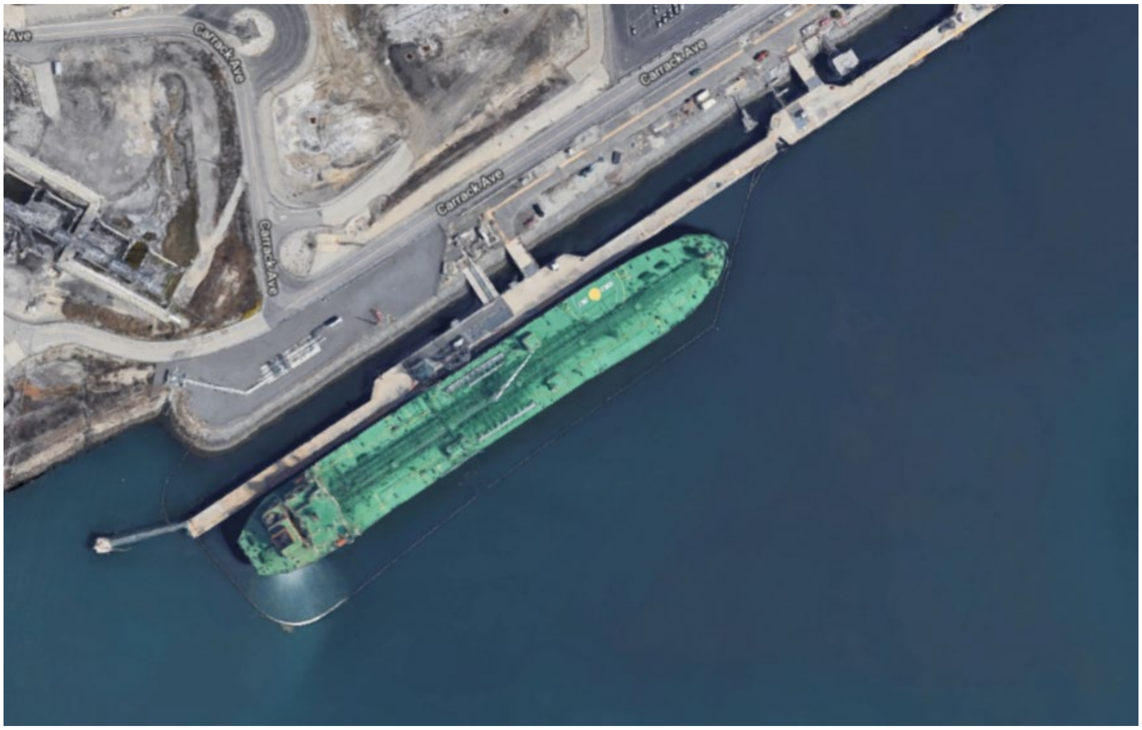



**Figure 4-4 Example of a Port-Based Marine Oil Terminal in Southern California**

**Figure 4-5 Example of a “Platform and Dolphin” based Terminal (Marathon 121 POLB)**

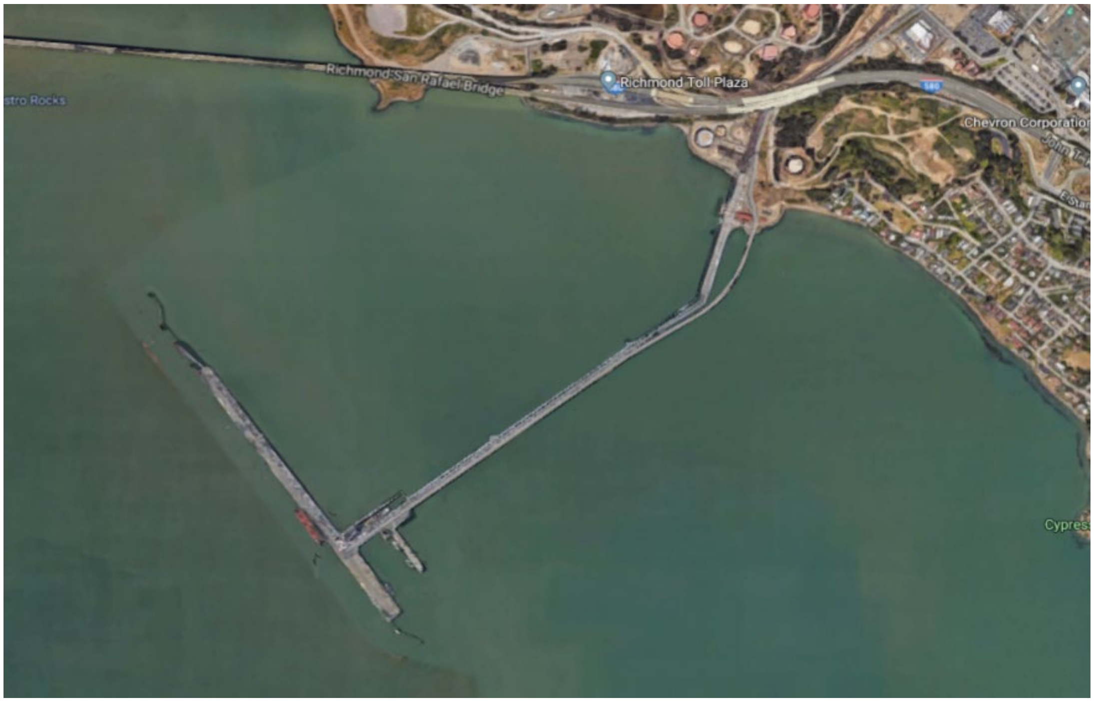



**Figure 4-6 Example of a "Long Wharf" T-shaped Marine Oil Terminal in Northern California**

# 5 STAKEHOLDER ENGAGEMENT

DNV included an extensive array of subject matter experts and key stakeholders (see Appendix I – V) from government and public entities (e.g., CARB, U.S. Coast Guard, Port of Long Beach, Port of Los Angeles) industry and industry groups (e.g., Chevron, ConocoPhillips, PBF Energy, Shell, Philips 66, Intertanko, Oil Companies International Marine Forum (OCIMF), Valero, and technology providers (e.g., Clean Air Engineering – Maritime (CAEM), GMB Marine Services, AECOM, Cavotec) for a comprehensive assessment.

Based on experience from structuring and facilitating stakeholder processes to develop mutually agreeable approaches to policy development and implementation among parties with different and, in some cases, conflicting interests, DNV considers the following approach as relevant to developing and implementing the stakeholder engagement plan.

DNV worked closely with WSPA Steering Committee to develop a clear articulation of WSPA's objectives for the stakeholder process. The objectives for the stakeholder engagement are identified as following:

- Gain recognition from authorities on the feasibility assessment methods applied and the outcomes of the feasibility study.
- Solicitation of fact-based evidence from the stakeholders.

A list of key and potential stakeholders with contact information has been generated together with the Steering Committee. DNV has also utilized internal resources as subject matter experts to provide insights on safety and compliance with relevant tanker technical standards, regulations, and class rules, electrical supply technologies and infrastructure, etc.

DNV developed a stakeholder engagement plan including:

- description of the activity: site tour, review of draft materials, workshops
- objectives of the activity
- list of participants
- the role of the Steering Committee members and DNV staff in the activity

The stakeholder engagement plan has been reviewed and finalized with the Steering Committee.

WSPA's and DNV's own network have been utilized to contact the candidate members, inform them of the objectives, schedule, and expectations of participants, and establish a contact database of those who have agreed to participate.

One-on-one interviews, focused group workshops, email exchanges, and meetings have been performed with selected stakeholders at different stages of the project to ensure engagement.

# 6 TECHNOLOGY ASSESSMENT OF SHORE POWER

## 6.1 Qualification basis

The purpose of the technology qualification basis is to provide a common set of criteria against which all qualification activities and decisions will be assessed.

The technology qualification basis shall describe the technology; define how the technology will be used; the environment in which it is intended to be used; specify its required functions, acceptance criteria, and performance expectations. This includes the performance requirements throughout the life cycle of the technology.

### 6.1.1 Technology Description

In this report, the so-called “shore power technology”, also known as onshore power supply (OPS), means the system supplying a vessel with electrical power using a shore connection while at-berth.

The boundary of OPS starts at the ports’ grid reception point and stops at the ships’ switchboard.

The assessment is mainly performed for assessing the onshore power safety and reliability for tankers while at-berth in California oil terminals.

### 6.1.2 Performance Expectations

This section lists the performance expectations for on shore power.

**Electricity Characteristics and Quality**

**Compatibility of Voltage and Frequency**

When a vessel is powered by the shore power supply, the system voltage and frequency compatibility with the shore utility supply shall be ensured by provision of transformers or other relevant equipment to ensure compatibility.

Based on IEC/IEEE 80005-1:2019, the connections for tankers should be made at a nominal voltage of 6.6 kV. For tankers, the nominal voltage level onboard is normally 440 V AC. Some tankers may have 6.6 kV / 11.0 kV AC. A voltage transformer may be needed for transforming the voltage to be compatible with the ships’ needs.

In terms of frequency, close to 90% of tankers engaged in worldwide trade use 60Hz electricity. This is beneficial for visiting the US where 60Hz electricity is used in the electrical grid. However, tankers generally have a worldwide operating profile. When ships visit the area using 50Hz electricity, the incompatibility on the power supply’s frequency would have to be resolved by the installation of a frequency converter.

**Power Supply Sufficiency and Continuity**

The shore power shall facilitate sufficient power supply for the normal at-berth operation. Further, the shore power shall facilitate power supply that is reliable and maintains the continuity (whether the electrical power is subject to voltage drops or overages below or above a threshold level thereby causing blackouts or brownouts).

**Variation in Voltage Magnitude**[6]

The shore power's voltage and frequency should be stable. It should not cause malfunction of shipboard systems, e.g., ER/Cargo Control Room alarm and monitor system, gas detection, etc.

- The frequency shall not exceed the continuous tolerances ± 5% between no-load and nominal ratings
- For no-load conditions, the voltage at the supply point shall not exceed a voltage increase of 6% of nominal voltage
- For rated load conditions, the voltage at the supply point shall not exceed a voltage drop of -3.5% of nominal voltage

**Voltage and Frequency Transients**

The response of the voltage and frequency at the shore connection when subjected to an appropriate range of step changes in load shall be defined and documented for each high voltage shore supply installation.

The maximum step change in load expected when connected to a high voltage shore supply shall be defined.

Based on the above, it should be verified that the voltage transients' limits of +20% and −15% and the frequency transients limits of ±10 % will not be exceeded.

**Galvanic separation**

The shore-side electrical system shall ensure that each connected ship is galvanically separated from other connected ships and consumers.

**Harmonic Distortion**

For no-load conditions, voltage harmonic distortion limits shall not exceed 3% for single harmonics and 5% for total harmonic distortion.

**Electromagnetic Compatibility**

The shore power instrument should be compatible with (i.e., no interference is caused by) its electromagnetic environment and it should not emit levels of electromagnetic energy that cause electromagnetic interference in other devices in the vicinity.

**Table 6-1 Electricity characteristics for the shore power supply**[7]
**(Only AC supply characteristics are presented)**

| Parameter | Reference(s) | High Voltage Shore Connection (HVSC) | Low Voltage Shore Connection (LVSC) |
|---|---|---|---|
| **Voltage** | IEC/IEEE 80005-1<br>IEC/IEEE DIS 80005-3<br>IACS Unified Requirements Electrical (Rev.1 Sept 2005) | **6.6kV**<br>**11kV** | **400V**<br>**440V**<br>**690V**<br><br>**230V also possible for less demanding consumption <50kW** |
| **Voltage** | | No-Load Conditions: | No-Load Conditions: |

[6] IEC/IEEE 80005-1
[7] EMSA

| | | | |
|---|---|---|---|
| **Tolerances** | | **6% of nominal Voltage increase**<br>Load Conditions:<br>**3.5% max voltage drop** | **6% of nominal Voltage increase**<br>Load Conditions:<br>**5% (3.5%)[8] max voltage drop** |
| **Frequency** | | 50/60 Hz<br>DC for Fast DC Charging systems | |
| **Frequency Tolerances** | IEC/IEEE 80005-1<br>IEC/IEEE DIS 80005-3<br>IACS Unified Requirements Electrical (Rev.1 Sept 2005) | Continuous tolerance: ±5% | |
| **Transient Response** | | **dV** (voltage transient peak variation): -15% < dV < 20% (1.5sec)<br>**df** (frequency transient variation): ±10% (5sec)<br><br>Transient Response should be well known and documented for:<br>1. <u>Shore side</u>, for the voltage and frequency response, when subject to an appropriate range of different load step changes,<br>2. <u>Ship side</u> for the maximum step change in load expected (this can be an Air Conditioning compressor, electrical pump, crane or electrohydraulic group).<br>The part of the system subjected to the largest voltage dip or peak in the event of the maximum step load being connected or disconnected shall be identified;<br>Combining 1 and 2 it should be verified that the voltage transients limits of +20 % and −15 % and the frequency transients limits of ±10 % will not be exceeded. | |
| **Harmonic Distortion** | | For no-load conditions, voltage harmonic distortion limits:<br>< 3 % (single harmonics)<br>< 5 % (for total harmonic distortion) | |

**<u>Safety and Security for Personnel and Property</u>**

The OPS should provide sufficient safety and security during normal operations and emergencies. It should comply with the relevant regulations and rules. The system should also follow the industry standards and guidelines. These are further discussed in Section 6.1.3.

Safety of personnel shall be ensured by means of suitable barriers to reduce or eliminate hazards. Such barriers need to be considered at design and construction stages by choice of relevant components and their place of installation along with a proper interlocking system, operational procedures and controls as well as considerations in terms of suitable protective gear.

Specifically, for emergencies, an independent system for emergency disconnection shall be arranged with an "Emergency Shut-Down" (ESD) system. There must be a provision to disconnect the supply from ship to shore in case of:

- loss of equipotential bonding
- over tension on the flexible cable
- maximum cable payout reached
- loss of safety circuit
- manual activation of alarm

[8] IEC/IEEE DIS 80005-3 – mentions 3.5%, aligning the maximum voltage drop under loading conditions with the HVSC standard (IEC/IEEE 80005-1). Irrespective of the alignment between the standards, it is important to keep the voltage drop under the shore-power loading condition

- activation by a protective relay for e.g., short circuit, overload, undervoltage etc
- disconnection of plugs

In case of emergency shutdown:

- all switches on board ship and shore must open
- plugs, sockets, and cable must be earthed automatically

In case of a black-out situation while on shore supply, potentially creating a critical situation for crew or cargo operation, at least one source of main electrical power should be made available to be readily used in such situations. The process and the details of the requirement to restore ships power is covered in the IEC/IEEE 80005-1 standard, section 8.6, as well as in the relevant section of SOLAS CH II and classification societies rules.

The vessel's designed earthing system/ grid configuration shall be maintained in electrical shore connection operation.

**Suitability for Tanker and Oil Terminals**

The shore power system should be suitable for tankers and oil terminals, especially considering the nature of operations involving hazardous cargo.

Ship-to-shore interconnection systems shall be able to compensate for tidal variations and vessel movements due to cargo operation.

**Environmental Protection**

The shore power should be capable of meeting the environmental requirements imposed by regulations, rules, and standards.

### 6.1.3 Applicable Regulations and Standards

The following regulations and standards are relevant for using shore power onto the tankers and terminals.

**Table 6-2 Regulation and standards for using shore power on tankers**

| Category | Tanker and Terminal |
|---|---|
| **Safety:**<br>**Design and operation** | **IMO Regulation**<br>Safety of Life at Seas (SOLAS) Chapter II-1, Part D<br>Interim Guidelines on safe operation of on-shore power supply (OPS) service in port for ships engaged on international voyages (Draft – MSC 103 defers to MSC 105) |
| | **USCG Marine Inspection Notice 02-11 (May 06, 2011)**<br>High Voltage Shore Power Installation of on US Flagged Ships<br>(refer to 46 CFR Subchapter J and to the draft [at that time] IEC/IEEE 80005- 1 |
| | **California State Lands Commission Regulation**<br>Marine Oil Terminal Engineering & Maintenance Standards (MOTEMS) |
| | **Classification Society Rules** |
| | **European Union Standards**<br>EN 15869-1:2019, Inland navigation vessels - Electrical shore connection, three phase current 400 V, 50 Hz, up to 125 A - Part 1: General requirements |
| | **International Standards regarding Interoperability**<br>– IEC / IEEE 80005-1:2019, High voltage shore connection<br>– IEC / IEEE 80005-2:2016, Communication protocol<br>– IEC / IEEE PAS 80005-3:2014, Low voltage shore connection<br>**International Standards regarding Plugs & Socket Outlets**<br>– IEC 62613-1:2019, Plugs, socket-outlets and ship couplers for high-voltage shore connection (HVSC) systems, Part 1:General requirements<br>– IEC 62613-2:2018, Plugs, socket-outlets and ship couplers for high-voltage shore connection |

| | |
|---|---|
| | (HVSC) systems, Part 2:Dimenstional compatibility and interchangeability requirements for accessories to be used by various types of ships<br>– IEC 60309-5:2019 Interconnectivity<br>**International Standards regarding Electrical Installations in Tankers**<br>IEC 60092-502:1999, Electrical installations in ships – Part 502: Tankers – Special features<br>**International Standards regarding Explosive Atmospheres**<br>IEC 60079-19:2019, Explosive atmospheres - Part 19: Equipment repair, overhaul and reclamation |
| | **Maritime Industry Guidelines**<br>OCIMF - Marine Terminal Operator Competence and Training Guide<br>OCIMF - Linked Ship/Shore Emergency Shutdown Systems for Oil and Chemical Transfers<br>International Safety Guide for Oil Tankers and Terminals (ISGOTT)<br>The World Association for Waterborne Transport Infrastructure (PIANC):<br>- Aspects affecting the Berthing Operations of Tankers to Oil and Gas Terminals (2012)<br>- Recommendations for the Design and Assessment of Marine Oil and Petrochemical Terminals (2016) |
| | **Petroleum Industry Standards**<br>API-RP-500 Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2 |
| **Safety: Personnel** | Standards of Training, Certification, and Watchkeeping (STCW) |
| **Environmental protection** | California Air Resources Board's (CARB) ocean-going vessels at berth regulation |

### 6.1.4 Critical Parameters

The critical parameters are parameters that can lead to an unacceptable level of failure, or risk, either alone or in combination with other parameters that have a similar level of risk or failure. The parameters list documents limits that shall not be exceeded either for or by the technology. Hence, when the project has been completed, the boundary limits for the critical parameters will represent the limits for qualification or operating envelope within which the technology is considered qualified.

Key parameters such as dimensioning loads, capacities, boundary conditions and functional requirements shall be summarized in a critical parameters list used in the TQ process. This ensures that the relevant input parameters used for analyses and tests are updated, as changes in design or procedures are made.

The critical parameters for failure mechanisms shall be identified. The critical parameters list shall include the limits/boundaries of these parameters. Where the qualification covers a range (e.g., sizes of the product or material grades) these ranges should be defined by their respective critical parameters. For uncertain parameters, available information about the level of uncertainty should be included.

The critical parameters list should be established in the initial phase of the TQ process. It is anticipated that both the parameters and their limits shall be refined or changed as the project progresses and the understanding of the failure modes and mechanisms develops.

During the technology assessment workshop on May 20, 2021, the following critical parameters have been identified for shore power. The dimensioning loads and operational parameters are to be included in a list to be used to check that these have been considered and addressed in the qualification tests, and that any change to these parameters is reflected in the qualification activities.

**Table 6-3 Critical parameters for using shore power on tankers**

| |
|---|
| **Ship size**<br>If the terminal has various sizes of tankers visiting, the shore power technology should be capable of accommodating the different sizes of ships. The ship length may vary between 100 meters and 350 meters.<br>This may be decided on a case-by-case basis for each terminal. |
| **Height distance between pier and ship board connection point**<br>The shore power technology should be capable of accommodating the height difference, e.g. 16m, between pier and ship board connection point. The variation from tide e.g. maximum 6m and draft e.g. maximum 15m should also be considered. |
| **Crane reach**<br>The crane reach should be sufficient for the gap between shipboard and pier. |

| |
|---|
| **Weather**<br>The wind speed should not impact the normal safe operation of cranes.<br>The wind speed expected are within 35 knots and gusts within 45 knots. |
| **Temperature**<br>The temperature is generally above 0 °C. |
| **Visibility and illumination**<br>The visibility and illumination should be sufficient for the safe crane operations. A light level of not less than 100 lux is recommended. |
| **Life time**<br>The target service time is around 20 years for shipboard instrument. |

## 6.2 Technology assessment

The purpose of the technology assessment is to break down the system into manageable elements to assess which elements involve new technical aspects and identify the key challenges and uncertainties.

The TQ qualification basis forms the input to the technology assessment. The purpose of the TQ basis is to provide a common set of criteria against which all qualification activities and decisions will be assessed. The TQ basis intends to describe the technology; define how the technology will be used; the environment in which it is intended used; specify its required functions, acceptance criteria and performance expectations. This includes the performance requirements throughout the life cycle of the technology. The output is an inventory of the novel technology elements, and their main challenges and uncertainties. The technology assessment shall include the following steps:

— Technology composition analysis

— Assessing the technology elements with respect to novelty (technology categorization).

The novelty assessment can be complemented with an assessment of the maturity of the technology. As an option, this can be aided by using technology readiness levels (TRLs).

In order to fully understand the novel elements of compound technology and provide a means of communication between people within different disciplines, the technology composition shall be analysed. This is a top-down assessment that starts with the system-level functions and proceeds with decomposing the technology into elements including interfaces. The technology composition analysis was conducted during the workshop on May 20, 2021 and the result is given in the table below.

**Table 6-4 Shore power technology composition analysis**

| ID | Subsystem | Main Function | Major Components |
|---|---|---|---|
| - | Power source | The source of power is the one that supplies electrical energy. It is designed to provide electricity with determined values for parameters such as current, amplitude, phase, or frequency.[9] | The major components could include an electricity grid, or port generators, or energy storage facilities, etc. |
| 1 | Main incoming station | To provide power reception interface and to transform the voltage and frequency and provide power management | - Transformers with on-load tap changer (OLTC) or static frequency converter (IEC recommended way for all installations) and conversion transformers which are installed outside ATEX area<br>- Cooling system if frequency converter is installed<br>- Switchgear/distribution gear, if needed |

[9] EMSA

| ID | Subsystem | Main Function | Major Components |
|---|---|---|---|
| 2 | Power cables | The primary functions of power cables are to transfer electrical power between designated locations, within prescribed performance, operating and environmental conditions and to insulate energized components from earthed structures at rated operating voltages and specified switching and lightning impulses. | - Cables (single or multi-core)<br>- Connections (to provide electrical and mechanical connections between power cable sections)<br>- Terminations (to provide an electrical connection between power cables and other electrical plant, principally overhead lines or substation infrastructure)<br>- Cable link boxes (to provide a waterproof, accessible, and explosion-proof enclosure for components forming part of a cable bonding and earthing system including surge arrestors, stand-off insulators and removable links for testing purposes. Bonding systems may include cross-bonding, single-point bonding and mid-point bonding.)<br>- Monitoring system (for temperature and partial discharge monitoring) |
| 3 | Onshore installations, other than cable management system | The main function of onshore installations, other than cable management system, is to provide power control and monitoring. | - Shore-side control panel<br>- Switchgears with earthing switch<br>- Control and safety circuits |
| 4 | Cable management system | The cable management system is mainly for handling the power-supply and control cables as well as the connection devices. | - Cable management system excluding crane<br>- Crane, if needed (either onshore or onboard the ship)<br>- Control panel for cable management<br>- Plug |
| 5 | Shipboard installation | The shipboard installation is mainly for receiving power-supply and control cables for the ship. | - Shore connection switchboard with protection equipment to connect shore side cables, including socket which needs to match the plug<br>- Quick-release physical mechanism and signal system if deemed necessary<br>- Control interface between shore and a ship<br>- Main switchboard and protection equipment<br>- Safety circuits<br>- Automatic Voltage Regulator (AVR) tuning or upgrade for auxiliary generators, for example, ABB Unitrol<br>- Governor tuning or upgrade for auxiliary engines<br>- Power management system with integrated shore power system<br>- Step-down transformer, where applicable, to match shore voltage with ship voltage<br>- Graphic panel-based human-machine interface (HMI) to operate the shore power system |

The cable management system is a crucial part of the shore power technology. It shall[10]:

- be capable of moving the ship-to-shore connection cable, enabling the cable to reach between the supply point and the receiving point
- be capable of maintaining an optimum length of cable which minimizes slack cable, and prevents the tension limits from being exceeded
- be equipped with a device (e.g. limit switches), independent of its control system, to monitor maximum cable tension and maximum cable pay-out
- address the risk of submersion by prevention or through the equipment's design
- be positioned to prevent interference with ship berthing and mooring systems, including the systems of ships that do not connect to shore power while berthed at the facility

[10] IEC/IEEE 80005-1:2019

- maintaining the bending radius of cables above the minimum bending radius recommended by the manufacturer during deployment, in steady-state operation and when stowed
- be capable of supporting the cables over the entire range of ship draughts and tidal ranges
- be capable of retrieving and stowing the cables once operations are complete

Where the cable management system employs cable reel(s), the high voltage shore connection system rated power shall be based on the operating condition with the maximum number of wraps of cable stowed on the reel that is encountered during normal operations. Where applicable, the cable sizing shall include appropriate de-rating factors.

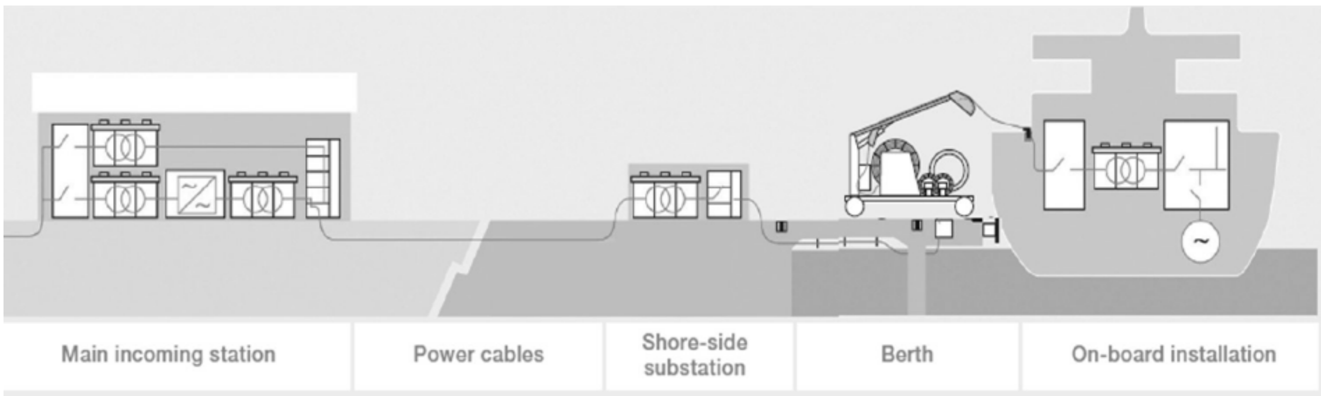



**Figure 6-1 Overview of shore power connection**[11]

Novel technologies typically evolve from existing proven technologies. Normally only some elements of the technology are novel. Therefore, uncertainty is associated mainly with the novel elements. In order to focus on greatest uncertainty, the novelty categorization shown in Table 6-5 has been used. Both the novelty of the technology itself and its application area affect the uncertainty.

Elements categorized as novel (category 2, 3 and 4) shall be taken forward to the next step for further assessment.

Only knowledge and experience that is documented, traceable and accessible to the qualification team should be used to reduce the degree of novelty.

**Table 6-5 Categorization according to DNV Recommended Practice**

| Application area | Degree of the novelty of the technology | | |
|---|---|---|---|
| | **Proven** | **Limited field history** | **New or unproven** |
| **Known** | 1 | 2 | 3 |
| **Limited knowledge** | 2 | 3 | 4 |
| **New** | 3 | 4 | 4 |

This categorization indicates the following:

- **Category 1:** No new technical uncertainties (proven technology).
- **Category 2:** New technical uncertainties.
- **Category 3:** New technical challenges.
- **Category 4:** Demanding new technical challenges.

[11] ABB

Technology in Category 1 is proven technology where proven methods for qualification, tests, load and relevant analysis can be used to document margins to failure. It is assumed that acceptable margins to failure for these items are achieved through the regular project activities in order to ensure a reliable qualification process for the components in this technology category.

Technology defined as Category 2, 3, or 4 is defined as new technology and requires qualification. Components assigned to these categories will later be subject to the threat assessment, i.e. FMECA and HAZOP. For sub-components that fall into Category 2, 3, or 4, further subdivision of these components may be necessary based on the risk ranking and complexity of the sub-components.

The components and functions were assessed with the industry stakeholders and subject matter experts during the workshop. DNV has reviewed the response from the workshop participants and developed the novelty categorization as below. Some high-level challenges/uncertainties which are relevant to using the components onto tanker and oil terminals discussed during the workshop are also listed in the table below. Detailed risk assessments have been performed and presented in Section 6.3.

**Table 6-6 Components and categories**

| System | Category | Challenge/uncertainty |
|---|---|---|
| Power source | - | The power source may not be able to provide a sufficient and continuous power supply for tankers at-berth. |
| Main incoming station | 1 | - The frequency and voltage between the shore power and shipboard electricity may not be compatible with each other.<br>- The accidental or unexpected power loss of shore power may impact the safety and cargo operation. |
| Power cables | 1 | The oil terminal may not have enough space or strength to carry the power cables. |
| Onshore installations, other than the cable management system | 2 | The terminals may not have sufficient space for the shore power installation. |
| Cable management system | 4 | - The wide range of ship length and berthing configurations may limit access to the shore side supply point.<br>- The crane's reach may not be sufficient for mitigating the gaps between the tanker and the pier. |
| Shipboard installation | 4 | - A short circuit may cause fire or explosion during the transfer of hazardous cargo.<br>- Lacking unified standards for shore power especially the plugs and sockets may induce the tankers cannot use the shore power connection due to its worldwide operation profile. |

In addition to the specific challenges and risk identified in Table 6-6, a general challenge is the lack of shore sided critical electrical components with US and international certifications/ex-ratings that will allow installations and use in hazardous zones on the terminal and ship-shore interfaces.

## 6.3 Threat assessment

The objective of this step is to identify relevant failure modes with underlying failure mechanisms for the novel technology elements and assess the associated risks. **It focuses on the unique risks associated with the application onto tankers.**

The inputs to the threat assessment are the technology qualification basis and the list of the novel technology elements developed in the technology assessment. The output is a failure mode register containing all identified failure modes of concern and their associated risks. Risk is defined by the failure probability and consequence of failure. Its determination shall be undertaken as follows:

- A failure mode assessment shall identify all possible failure modes with their underlying failure mechanisms and shall take into account each of the phases in the service life of a system, equipment or component. The failure modes shall be ranked based on their risk (defined by the probability of occurrence and consequence) or their contribution to overall risk.
- All failure modes shall be registered and handled using an appropriate register, keeping track of all inputs to - and results from - the assessment, including assumptions, risk category, category of technology novelty, failure probability and references to sources of evidence used in the threat assessment.

The threat assessment consists of the following key steps:

— Refine the technology composition assessment performed in the technology assessment step, if necessary.

— Define various categories of probability and consequence severity. This is done prior to the identification of failure modes.

— Define acceptable risk by constructing a risk matrix showing fully acceptable combinations (low risk) and unacceptable combinations (high risk) as well as intermediate combinations (medium risk) of the probability and consequence categories.

— Identify all potential failure modes and rank their risk by using the appropriate method.

— For each failure mode, rank the risk by assigning a consequence class and probability class, or by assessing their contribution to overall system risk. This can be based on previous experience, existing evidence and expert judgments. In the latter case, uncertainties shall be reflected by conservative categorization.

— Store the information for each failure mode in the failure mode register.

There are several threat or failure mode identification techniques in common use. The selection of method should take into consideration the complexity and maturity of the compound technology. The threat assessment shall cover all novel elements defined in the technology composition analysis. The output is a record (failure mode register) of all identified failure modes, failure mechanisms, consequences and probabilities and their associated risk. Various methods for risk analysis can be used for the Threat Assessment.

Failure mode, effect and criticality analysis (FMECA) has been used since it is a simple systematic and structured methodology to determine the effect of a failure. It only investigates ONE failure mode at a time and may not identify critical combinations of failures.

Hazard and operability study (HAZOP) has also been used as it is a systematic method that enables identification of the hazard potential of operation outside the design intention or malfunction of individual items.

Consequences of failure have, when relevant, been detailed for:

- the functions of the technology itself
- impact on surrounding and interfacing systems
- operation and repair
- safety, health and environment (SHE).

The threat assessment process has been carried out as workshops facilitated by DNV via Microsoft Teams on June 7, 2021 and June 8, 2021, involving a panel of experts covering the necessary fields of competence and experiences.

The participants of the workshop are given in Appendix 2.

The detailed results of FMECA and HAZOP are given in Appendix 6.

The critical risks which are unique to the application onto tankers are discussed in this section. A common risk matrix, with pre-defined consequence and probability scales, was applied across the threat assessments. The risk matrix utilized towards ranking the different failure modes and hazards are as indicated in Figure 6-2.

The consequence scale has focused on impact to personnel safety, environment & operation of vessels, terminals & operation of the technology itself. The consequence scale for personnel safety ranges from no impact to multiple fatalities while the environment focuses on no impact to massive impact to the environment. The impact on vessel, terminal, and the technology itself focuses on ranges from seamless operation to los of vessel, failure of essential systems and also the potential underperformance of the technology though this is not captured in the risk matrix explicitly.

The probability scale has focused on rare instance of the event occurring to very high chance of the event occurrence.

The consequence and probability are mapped on to a risk matrix that indicates low (L), medium (M) and high (H) risks. This is based on:

- Categorization of failure scenarios or HAZID by severity and occurrences of failures
- Need for further actions
- Ranking by expert judgement

| Consequence | Personnel safety | Environment | Impact on vessel, terminal or its operation | | Probability: Rare<br>Technically to be excluded, or a failure can only occur by combination of two causes | Infrequent<br>Not probable, to be expected that failure does not occur during lifetime of vessel/component under consideration (once in 100yrs) | Moderate<br>Remotely probable, to be expected that failure can occur during lifetime of vessel/component under consideration (once in 10 years) | Frequent and high<br>Probable, to be expected that failure occurs once per year of operation (1 year) | Very high<br>Highly probable, to be expected failure occurs more often than once/yr of operation (<1yr) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1 | 2 | 3 | 4 | 5 |
| | No impact on persons | None | No damage / undisturbed operation | 1 | L | L | L | M | M |
| | Single severe or few minor injuries | Minor effect, non-compliance event | Local damage/Operation of non-essential systems disturbed | 2 | L | L | M | M | M |
| | Multiple severe injuries | Localized effect, response required | Non-severe ship damage/Failure of non-essential systems | 3 | L | M | M | M | H |
| | One fatality | Major effect, significant response required | Severe damage to asset/ops of essential systems disturbed for <1h | 4 | M | M | M | H | H |
| | Multiple fatalities | Massive effect damage over large areas | Loss of vessel/Failure of essential systems | 5 | M | M | H | H | H |

**Figure 6-2 Risk Matrix with consequence and probability scale**

Risk classification & explanation

A low risk, indicated by green color and by letter 'L' in the figure above, means that the risk is acceptable.

A medium risk, indicated by yellow color and by letter 'M' in the figure above, means that the risk is manageable but will require monitoring of the risk.

A high risk, indicated by read color and by letter 'H' in the figure above, mean that the risk is unacceptable and needs mitigating actions or risk transfer or other risk reduction measures.

DNV

### 6.3.1 FMECA

The FMECA focused on potential failure modes and their effects for the operation of the shore power technology. During the workshop, failure modes from perspective of applicability towards all vessel types were considered and later categorized/filtered to identify the failure modes that would be more relevant specifically for tankers. Ranking of the failure modes are captured in the Figure 6-3 below with risk ids denoted with a # followed by number that relates to type of failure mode considered. Also refer to Appendix 6.

| | PROBABILITY | | | | |
|---|---|---|---|---|---|
| CONSEQUENCE | | | | | |
| | | | | | |
| | #5.4 | #0.3 #5.6 | #4.2 #4.3 | | |
| | #5.3 | #1.1 | #5.5 | | |
| | | #0.2 #2.1 #5.2 | #0.1 #4.1 #5.1 | | |

**Figure 6-3 Risk ranking for FMECA**

The overall risk ranking indicated 29 risks in total with one risk left unranked. Out of the 28 risks identified, 14 of them were found more relevant for tankers. These are indicated in the risk ranking figure above. Out of the 14 risks identified, 3 x risks were high risks, 10 x risks were medium risks, and one risk was low risk. This section describes the details of all the risks relevant for tankers when it comes to utilizing the shore power technology.

Without mitigation, the three risks ranked as high may present serious challenges to the feasibility of implementation, namely: insufficient power to meet potential demand, and possible restrictions on the fleet able to utilize shoreside infrastructure due to terminal and berthing arrangements, exacerbated by equipment location restrictions.

#### 6.3.1.1 FMECA 0.1 – Insufficient power supply from the electrical grid for the potential demand from the tankers calling at the ports.

For all tankers, the energy is normally generated by auxiliary engines and boilers while at berth.

For chemical/product tankers, the energy generated by auxiliary engines and boilers at berth is mainly consumed by:

- Accommodation load (lighting, HVAC, etc.)
- Ballast/de-ballast

- Cargo pumping operations (normally there is one cargo pump for each cargo tank)
- Heating/cooling, as applicable to the cargo type
- Inert gas generation, as applicable

For crude oil tankers, the power generated by auxiliary engines and boilers at berth is mainly consumed by:

- Accommodation load (lighting, HVAC, etc.)
- Ballast/de-ballast
- Cargo pumping operations (normally there are 3 cargo pumps)
- Cargo heating system, as applicable in the slop tanks

According to the CARB at-berth regulation, "for tanker vessels with steam driven pumps, **unless the tanker is using shore power to reduce emissions from auxiliary engines**, a person must demonstrate that the CAECS achieves emission rates less than 0.4 g/kW-hr for NOx, 0.03 g/kW-hr for PM 2.5, and 0.02 g/kW-hr for ROG for tanker auxiliary boilers." As such, only the auxiliary engine power output is assessed for the potential power demand of shore power.

The auxiliary engine power output is referred to Fourth IMO GHG Study 2020 and quoted below. It shall be noted that this only provides a high-level estimation. The detailed power output varies a lot depending on the vessel's configuration and actual operations at berth.

**Table 6-7 Potential at berth auxiliary engine power output for tankers**[12]

| Ship type | Size [DWT] | At berth Auxiliary Engine Power Output [kW] |
|---|---|---|
| **Chemical tanker** | 0-4,999 | 110 |
| | 5,000-9,999 | 330 |
| | 10,000-19,999 | 330 |
| | 20,000-39,999 | 790 |
| | 40,000+ | 790 |
| **Oil tanker** | 0-4,999 | 250 |
| | 5,000-9,999 | 375 |
| | 10,000-19,999 | 690 |
| | 20,000-59,999 | 720 |
| | 60,000-79,999 | 620 |
| | 80,000-119,999 | 800 |
| | 120,000-199,999 | 2,500 |
| | 200,000+ | 2,500 |

AIS data in 2017, 2018, and 2019 (2020 has been disregarded due to the impact of the COVID-19 pandemic) has been analyzed for Port of Long Beach, Port of Los Angeles, and Port of Richmond to analyze the tankers' traffic and the port stay duration per the categories given in Table 6-7.

[12] International Maritime Organization - Fourth IMO GHG Study 2020

If it is assumed that all tankers are equipped with shore power technology, combining the estimated at berth auxiliary engine power output in Table 6-7 and the port stay duration based on the AIS data, the monthly potential shore power energy demand [MWh] is shown below.

- For tankers berthing at Port of **Los Angeles**, the **average** estimated monthly auxiliary engine energy output is 708MWh and **maximum** estimated monthly auxiliary engine energy output is 1,019MWh. The average estimated yearly auxiliary engine power output is around 40% of the installed shore power system.[13]
- For tankers berthing at Port of **Long Beach**, the **average** estimated monthly auxiliary engine energy output is 3,108MWh and **maximum** estimated monthly auxiliary engine energy output is 5,422MWh.
- For tankers berthing at Port of **Richmond**, the **average** estimated monthly auxiliary engine energy output is 1,558MWh and **maximum** estimated monthly auxiliary engine energy output is 1,898MWh.

In this analysis based on AIS data, the estimated power is for all the oil terminals in each port and not an analysis per terminal. As can be seen from the above, Port of Long Beach potentially has the highest total shore power demand from tankers.

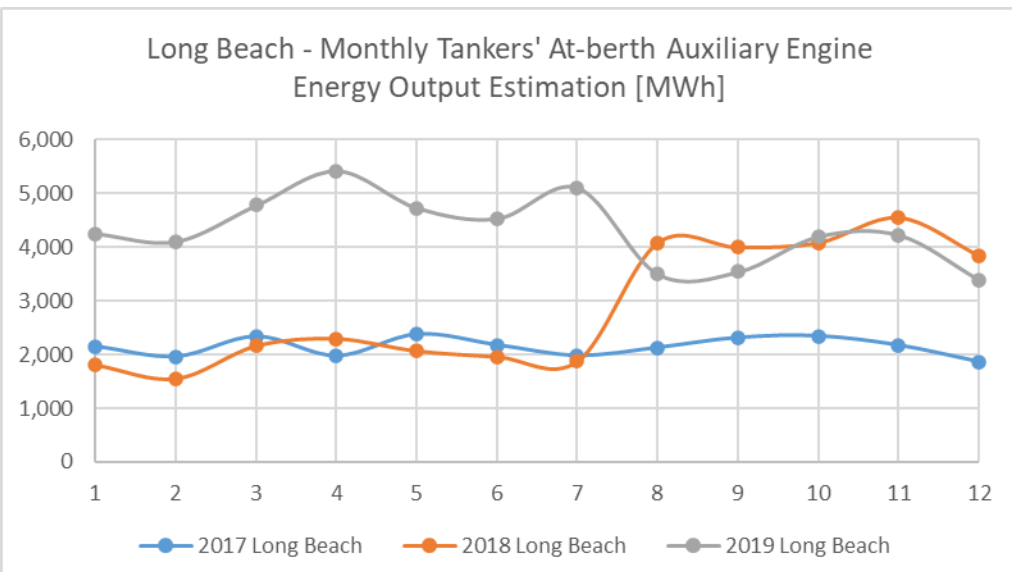



**Figure 6-4 Long Beach - Monthly Tankers' At-berth Auxiliary Engine Energy Output Estimation**

[13] United States Environmental Protection Agency Office of Transportation and Air Quality - Shore Power Technology Assessment at U.S. Ports, March 2017

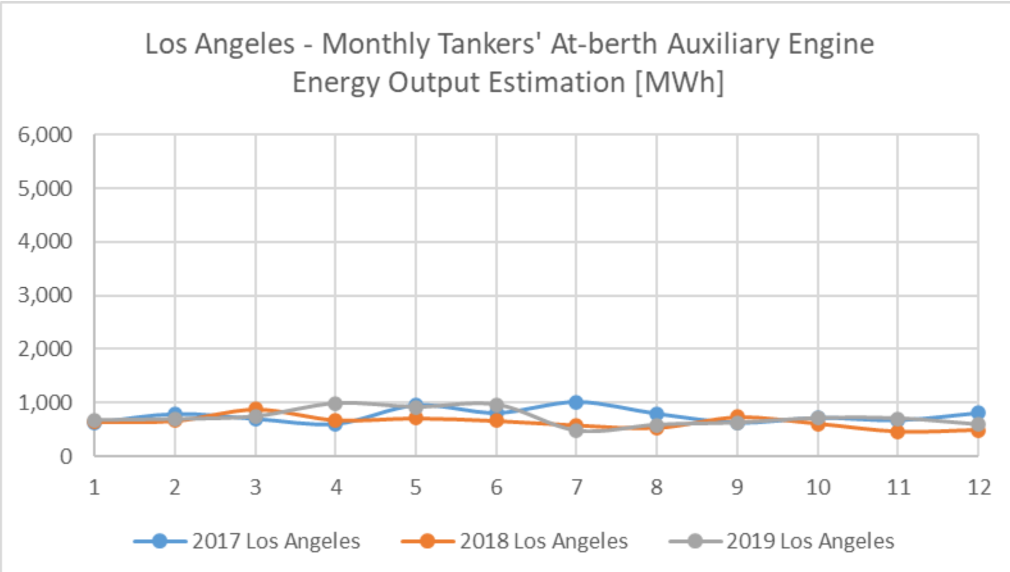



**Figure 6-5 Los Angeles - Monthly Tankers' At-berth Auxiliary Engine Energy Output Estimation**

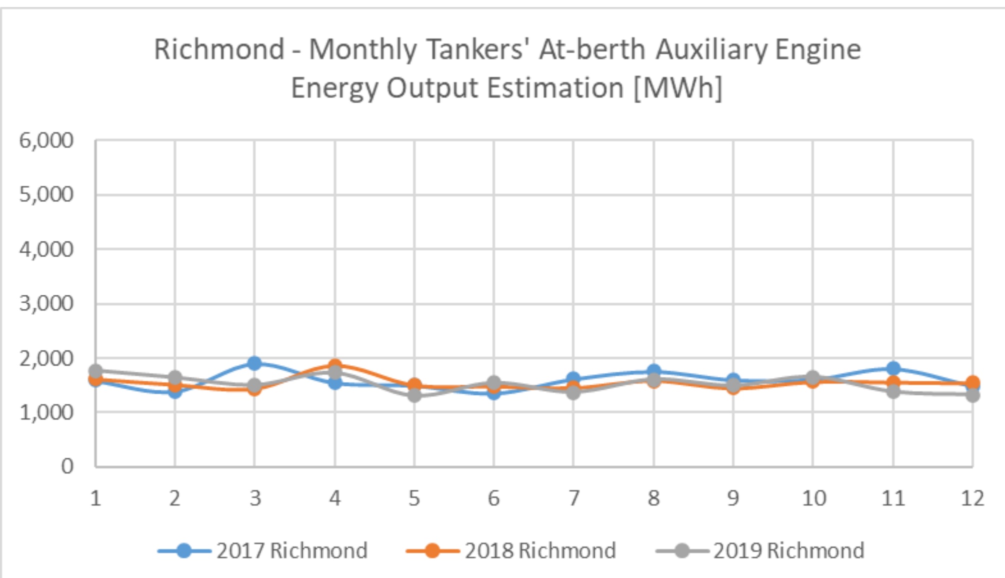



**Figure 6-6 Richmond - Monthly Tankers' At-berth Auxiliary Engine Energy Output Estimation**

The technical specifications for the existing high voltage shore power systems at Port of Los Angeles and Port of Long Beach are cited from "Shore Power Technology Assessment at U.S. Ports, March 2017" and shown below. As shown, to accommodate the potential maximum power demand [MW] from visiting tankers, the capacity of the existing shore power system may need to be almost doubled.

**Table 6-8 Technical specifications for high voltage shore power systems**[14]

| | Vessel Type using OPS | Year of Installation | Maximum Capacity [MW] | Frequency [Hz] | Voltage [kV] | Manufacturer |
|---|---|---|---|---|---|---|
| **Los Angeles** | Container<br>Cruise | 2004 | 40.0 | 60 | 6.6 | Cavotec |
| **Long Beach** | Container<br>Cruise | 2009<br>2011 | 16.0 | 60 | 6.6 & 11 | Cavotec; Cochran Marine |

The auxiliary engines' power output [MW] from tankers while at berth is also estimated based on the following inputs and assumptions:

- The average auxiliary engine output per tanker category is assumed based on IMO 4th GHG study. It shall be noted that this may not be on the conservative side as the auxiliary engines' peak load is not reflected.
- Historical AIS data in 2017, 2018, and 2019 is used to analyze the visiting tankers' number, size, and port stay duration.

As shown in Figure 6-7, for Port of Los Angeles in 2017, 2018, and 2019:

- There has been a maximum of 6 tankers at berth at the same time and on average there are 2 – 3 tankers at berth at the same time.
- On average, the estimated tankers' at berth auxiliary engine output is around 2.8 MW.
- The maximum estimated tankers' at berth auxiliary engine output is around 12.0 MW. This is around 30% of the existing shore power facility's maximum capacity which is at 40MW according to EPA's report about Shore Power Technology Assessment.[15]

As shown in Figure 6-8, for Port of Long Beach in 2017, 2018, and 2019:

- There has been a maximum of 9 tankers at berth at the same time and on average there are 3 – 4 tankers at berth at the same time.
- On average, the estimated tankers' at berth auxiliary engine output is around 4.9 MW.
- The maximum estimated tankers' at berth auxiliary engine output is around 13.9 MW. This is around 87% of the existing shore power facility's maximum capacity which is at 16MW according to EPA's report about Shore Power Technology Assessment.[16]

[14] United States Environmental Protection Agency Office of Transportation and Air Quality – Shore Power Technology Assessment at U.S. Ports, March 2017

[15] United States Environmental Protection Agency Office of Transportation and Air Quality - Shore Power Technology Assessment at U.S. Ports, March 2017

[16] United States Environmental Protection Agency Office of Transportation and Air Quality - Shore Power Technology Assessment at U.S. Ports, March 2017

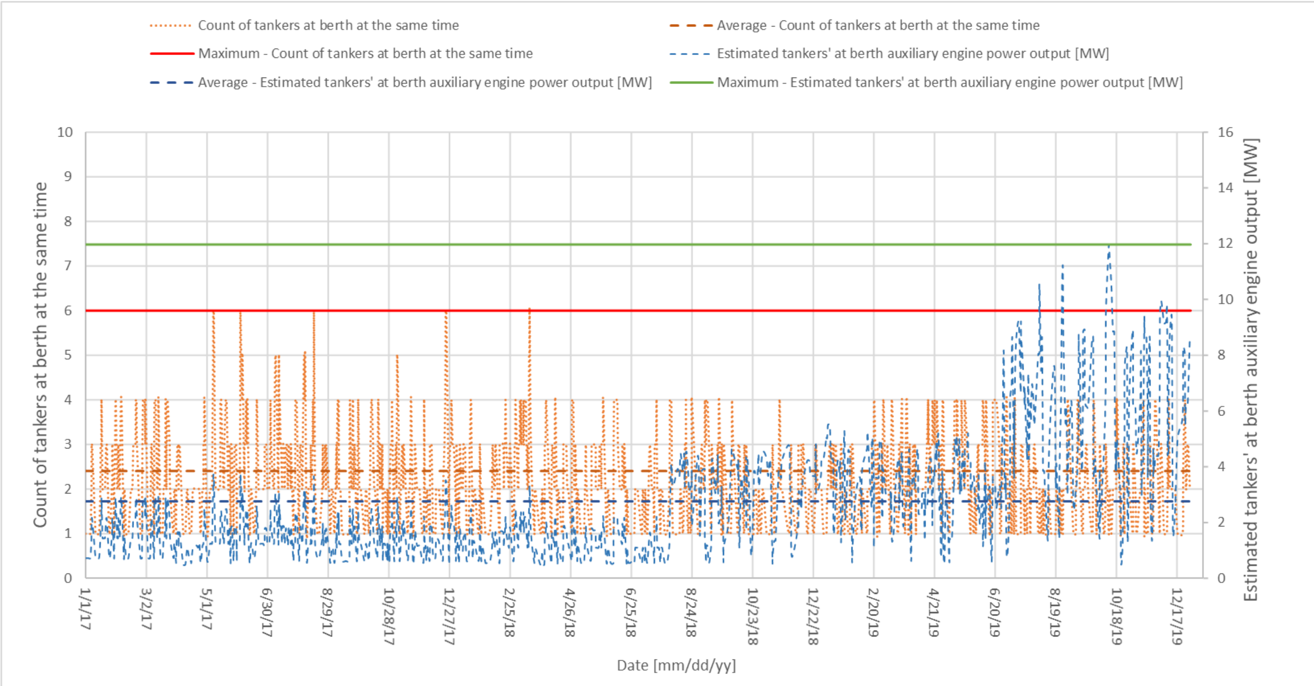



**Figure 6-7 Los Angeles – Count of tankers at berth at the same time and estimated at berth auxiliary engine power output [MW] in 2017 ~ 2019**

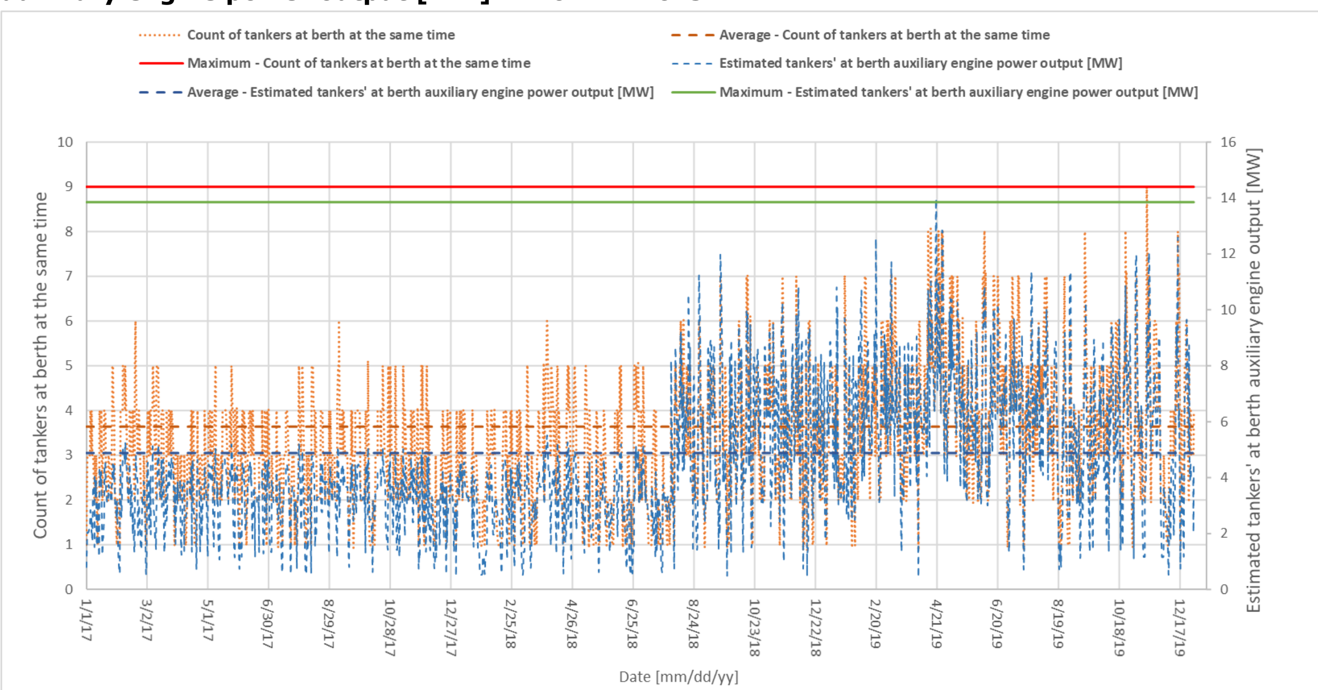



**Figure 6-8 Long Beach – Count of tankers at berth at the same time and estimated at berth auxiliary engine power output [MW] in 2017 ~ 2019**

The potential power demand from tankers depends on the uptake of the shore power technology from the terminals and tankers. Applying shore power onto tankers visiting California will increase the power demand for a port. Ports' existing power infrastructure may not be sufficient to provide the additional power load, particularly with the consideration of hot weather when significant demand and strain have been put on California's energy grid..

To evaluate and mitigate this risk, the energy agencies, ports, and their electrical utility companies (such as Southern California Edison, Pacific Gas and Electric Company, etc.) will need to be involved to review the feasibility and develop a plan for providing the additional power load – adding additional layers of complexity to an implementation process and likely prolonging the timeline.

#### 6.3.1.2 FMECA 4.1 - Limited access to the shore side supply point for some tankers due to varied dimensions and berthing configuration of such tankers

The potential locations of installing the shore power connection points have been discussed in Section 6.3.1.9. If shore power connection points are not installed around the midship, the wide range of tanker sizes and two possible berthing orientations would seriously restrict the number of tankers able to utilize such a connection.

For tankers calling California in 2017, 2018, and 2019, the ship's overall length has been analyzed based on Lloyd's List vessel database. It shows that the tankers' size has large variations variety, and it may be between 104 meters to 340 meters [340 feet – 1100 feet].

**Table 6-9 Tankers' overall length**[17]

| Ship type | Size [DWT] | Minimum Overall Length [m] | Maximum Overall Length [m] |
|---|---|---|---|
| **Chemical tanker** | 0-4,999 | - | - |
| | 5,000-9,999 | 117 | 127 |
| | 10,000-19,999 | 127 | 162 |
| | 20,000-39,999 | 141 | 200 |
| | 40,000+ | 175 | 250 |
| **Oil tanker** | 0-4,999 | 104 | 330 |
| | 5,000-9,999 | - | - |
| | 10,000-19,999 | - | - |
| | 20,000-59,999 | 171 | 224 |
| | 60,000-79,999 | 183 | 236 |
| | 80,000-119,999 | 227 | 256 |
| | 120,000-199,999 | 250 | 292 |
| | 200,000+ | 300 | 340 |
| **Length range** | | **104** | **340** |

[17] Lloyd's List database

Using Marathon Long Beach Berth 121 marine terminal as an example, the terminal could accommodate VLCC of as long as 340m [1100 feet]. An example is shown in Figure 6-9. Comparing with the Alaskan Navigator (LOA 290m [950 feet]), which is equipped with shore power (shown overlayed), a VLCC can be about 50m [150 feet] longer. The existing cable management system may not be able to cover the required horizontal reach for various sized tankers visiting the terminal (i.e. to reach a shipboard connection point on the far side of the ship), which might prevent the largest of tankers from utilizing the connection.

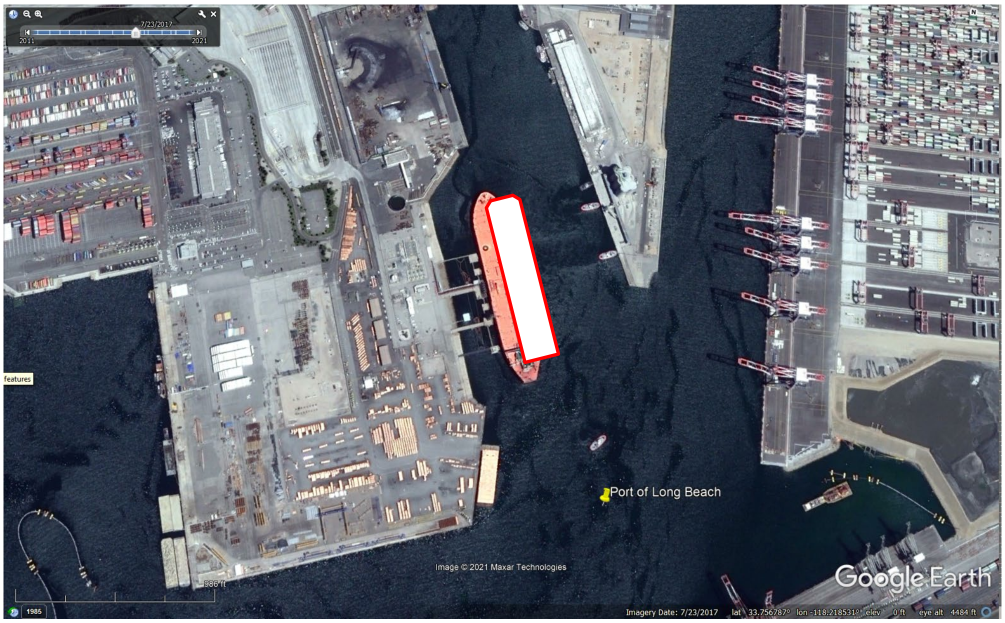



**Figure 6-9 Satellite photo of a VLCC (IMO No.: 9302968) calling Marathon Long Beach Berth 121 on 23-July-2017**

In addition, for some terminals, the tanker may have the possibility of berthing either along the portside or the starboard side. This depends on the channel's navigation condition, weather condition, where the loading/offloading connections on the vessel are located etc. An example of Marathon Long Beach Berth 78 is shown in the figures below. For the scenarios of a VLCC or Suezmax berthing on the port side and a VLCC or Suezmax berthing on the starboard side, it may induce a range of around 500 ~ 600 m [1600 feet – 2000 feet] to be covered by the shore power cable management system. This range of length may pose challenges and may require special considerations for shore side connection to the cable management system while considering the need to account for tidal and draft variations.

Similar technical challenge applies to the container vessels. At Port of Long Beach, to maximize shore power connection at the container terminals, the Port staff established design criteria, which requires shore power outlets every 200 feet [61m], combined with a 100-foot [30m] movable supply point. This type of arrangement may not be feasible considering the restrictions for hazardous zones applicable for tankers and oil terminals. Further, space constraints as discussed in Section 6.3.1.11 may not facilitate this arrangement. In this context the IEC/IEEE 80005 standard doesn't permit the use of extension cables, due to possible safety risks associated with the additional connecting plugs, cable design, and maintenance.

Based on the above discussions, the wide range of the length of the tankers visiting the California oil terminals, the two scenarios of vessel orientations at the terminals and hazardous zones are identified as significant challenges to the implementation of shore power to tankers. These issues may impose risks on shore power connection compatibility between the tanker, the cable management system, and the onshore installation on the terminal.

An industry standardized solution on the installation location of the shore power connection is recommended. If the connection location is agreed to be arranged in the non-hazardous area, e.g., stern of the tanker, a cost-effective cable management system that is complying with the standards to accommodate the existing portfolio of tankers is recommended to be developed. The solutions or design changes will need to be reviewed for compliance with the existing technical standards to avoid introducing additional safety and operational risks as noted in the above paragraph.

Before an industry standardized solution is available, the shore power connection locations will need to be investigated closely for each terminal based on the terminal configuration and the portfolio of visiting tankers.


**Figure 6-10 Satellite photo of a tanker berthing on the port side at Marathon Long Beach Berth 78**

**Figure 6-11 Satellite photo of a tanker berthing on the starboard side at Marathon Long Beach Berth 78**

#### 6.3.1.3 FMECA 5.1 – Fire or explosion risk from ignition sources during transfer of hazardous cargo

Potential sources of ignition from electrical equipment include:

- Electric sparks
- Arcs and flashes
- Electrostatic discharges
- Electromagnetic waves
- Hot surfaces
- Flames and hot gases
- Mechanically generated sparks
- Chemical reaction[18]

For electrical systems, there are hazardous areas defined for both tankers and marine oil terminals.

- For tankers, it generally follows the Classification rules which are normally aligned with IEC standard 60092-502:1999.
- For marine oil terminals, MOTEMS provides minimum standards for electrical systems. According to MOTEMS, hazardous area classifications shall be determined in accordance with API RP 500[19], API RP 540[20] and Articles 500, 501, 504, 505 and 515 of the California Electrical Code.

[18] International Safety Guide for Oil Tankers and Terminals (ISGOTT 6) 6th Edition, 2020

The International Convention for the Safety of Life at Sea (SOLAS) is an international maritime treaty which sets minimum safety standards in the construction, equipment and operation of merchant ships. In SOLAS, it prescribes that for tankers **electrical equipment, cables and wiring shall not be installed in hazardous locations unless it conforms with standards not inferior to those acceptable to the Organization**.[21] This is also stated in the International Electrotechnical Commission standard, IEC 60092-502:1999 Electrical installations in ships – Tankers.

According to DNV Rules for Classification: Ships, Part 5 Chapter 5 Oil tankers and Chapter 6 Chemical tankers, **electrical equipment and wiring shall in general not be installed in hazardous areas**. Where essential for operational purposes, the arrangement of electrical installations in hazardous areas shall comply with DNV Rules for Classification Part 4 Chapter 8 Section 11. This principle is aligned with the other International Association of Classification Societies (IACS) members.

Hazardous areas are described in SOLAS Chapter II-1, Part D, Regulation 45. The hazardous areas are divided into three zones. The typical hazardous areas for each zone and equipment installation alternatives according to DNV Rules for Classification: Ships are given in Table 6-7. The typical hazardous area arrangement for a tanker is shown in Figure 6-12 and Figure 6-13. The detailed definition of hazardous areas and requirements shall refer to SOLAS and class rules.

In summary, based on SOLAS, IEC standards, and Classification Rules, electrical equipment and wiring shall in general not be installed in hazardous areas. If the shore power connection has to be installed within the hazardous zone, the electrical equipment generally has to be explosion-proof (ex rated). However, currently, there is not yet a marine use socket complying with the explosion-proof requirement. Further evaluation would be necessary to determine the feasibility of developing an explosion-proof socket suitable for marine use within the CARB at-berth regulation timeframe, the lack of which would restrict the number of tankers able to utilize infrastructure.

**Table 6-10 Typical hazardous areas for a tanker and Ex protection requirements according to zones in DNV Rules Pt.5, Ch.5, Sec.8**

| Zone | Typical areas | Ex protection requirements according to zones in DNV Rules[22] |
|---|---|---|
| **Zone 0** | - Cargo tanks, slop tanks<br>- Pipes and equipment containing cargo or developing flammable gas | a) Electrical equipment installed in zone 0 shall normally be certified safe for intrinsic safety Ex ia, or certified safe with EPL Ga.<br>b) For zone 0 systems, the associated apparatus (e.g. power supply) and safety barriers shall be certified safe for Ex ia application.<br>c) Equipment specially certified for use in zone 0. |
| **Zone 1** | - Space adjacent to Zone 0, e.g. void spaces, cofferdams, pump rooms, trunks, fore peak tanks etc.<br>- Some areas on the open deck, or semi-enclosed spaces on deck, e.g.:<br>○ Areas on open deck, or semi-enclosed spaces on deck, within 3 m of any cargo tanks outlet, gas or vapor outlet, cargo manifold valve, cargo valve, cargo pipe flange, cargo pump-room ventilation outlets and cargo tank openings for pressure release provided to permit | a) Certified safe for zone 0 application, or certified safe with EPL Ga.<br>b) Certified safe for zone 1 application, or certified safe with EPL Gb.<br>c) Normally, Ex o (oil filled) and Ex q (sand filled) are not accepted. However, small sand filled components as i.e. capacitors for Ex e light fixtures are accepted. |

[19] American Petroleum Institute (API), API Recommended Practice 500 (API RP 500), "Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2," 3rd edition, December 2012

[20] American Petroleum Institute (API), API Recommended Practice 540 (R2004) (API RP 540), "Electrical Installations in Petroleum Processing Plants," 4th edition, 1999

[21] The International Convention for the Safety of Life at Sea (SOLAS) Chapter II-1, Part D, Regulation 45.11

[22] DNV Rules for Classification: Ships, Part 4 Chapter 8 Section 11, July 2021

| | | |
|---|---|---|
| | the flow of small volumes of gas or vapor mixtures caused by thermal variation.<br>○ Areas on open deck, or semi-enclosed spaces on open deck above and in the vicinity of any cargo gas outlet designed for the passage of large volumes of gas or vapor mixture during cargo loading and ballasting or during discharging, within a vertical cylinder of unlimited height and 6 m radius centered upon the center of the outlet, and within a hemisphere of 6 m radius below the outlet.<br>○ Areas on open deck over all cargo tanks (including ballast tanks within the cargo tank area) where structures are restricting the natural ventilation and to the full breadth of the ship plus 3 m fore and aft of the forward-most and the aft-most cargo tank bulkhead, up to a height of 2.4 m above the deck. | |
| **Zone 2** | - 1.5 meters from Zone 1 in open and semi-enclosed spaces<br>- 4 meters from Zone 1 surrounding high-volume Zone 0 outlet<br>Fore peak tank connected to main ballast system in case separated from cargo tanks by a cofferdam<br>- On the top of the deckhouse it may have a small hazardous zone for the battery room, paint store, chemical room | a) Certified safe for zone 0 application, or certified safe with EPL Ga.<br>b) Certified safe for zone 1 application, or certified safe with EPL Gb.<br>c) Certified safe for zone 2 application, or certified safe with EPL Gc.<br>d) Have a manufacturer conformity declaration stating that it is made in accordance with an Ex n standard.<br>e) Documented by the manufacturer to be suitable for zone 2 installation. This documentation shall state compliance with a minimum enclosure protection as per IEC 60079-15, maximum temperature for internal or external surfaces according to the temperature class for the area and that the equipment contains no ignition sources during normal operation. |

Examples of one crude oil tanker and one product tanker's hazardous areas are given below.

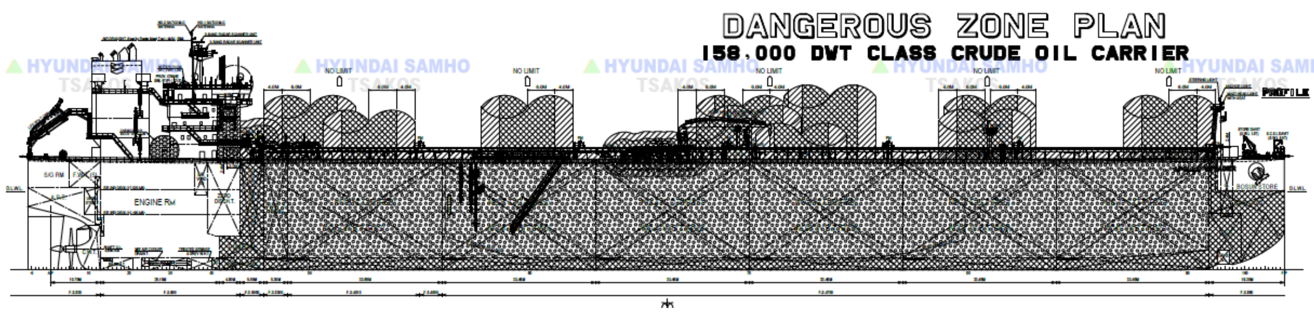



**Figure 6-12 Example of one crude oil tanker's hazardous areas**

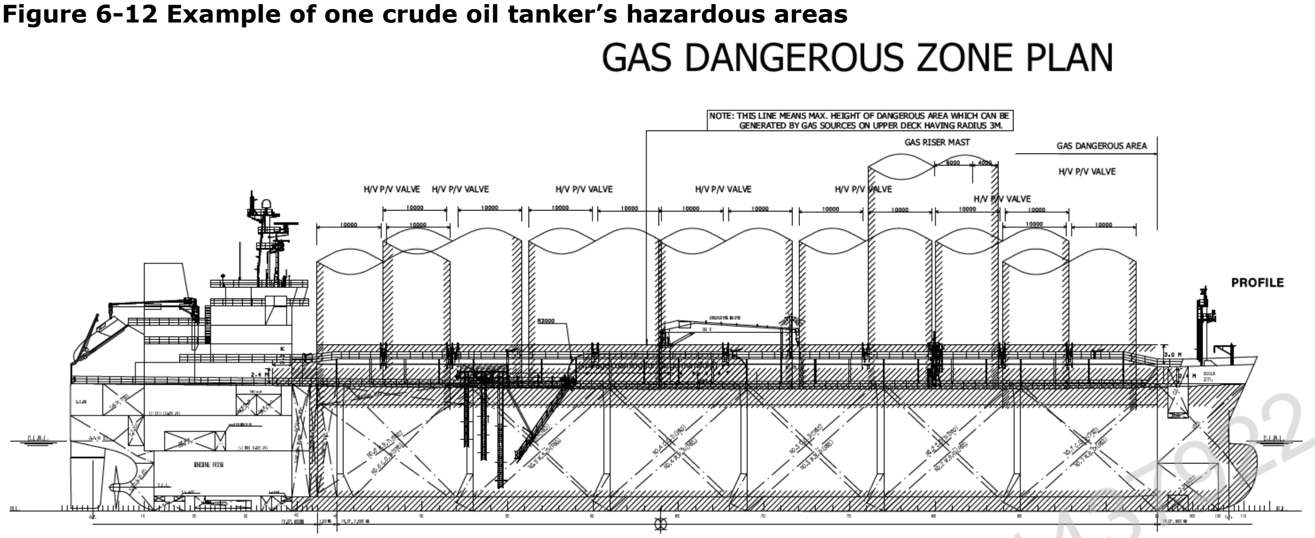


**Figure 6-13 Example of one product tanker's hazardous areas**

As mentioned earlier, the marine oil terminals also have their definition of hazardous area. According to API-RP-500[23], the hazardous (classified) location at marine terminals handling flammable liquids is shown in Figure 6-14. The marine terminals regulations around minimum standards for electrical systems, hazardous area classifications & other requirements should be complied with similar to requirements around hazardous zone for tankers.

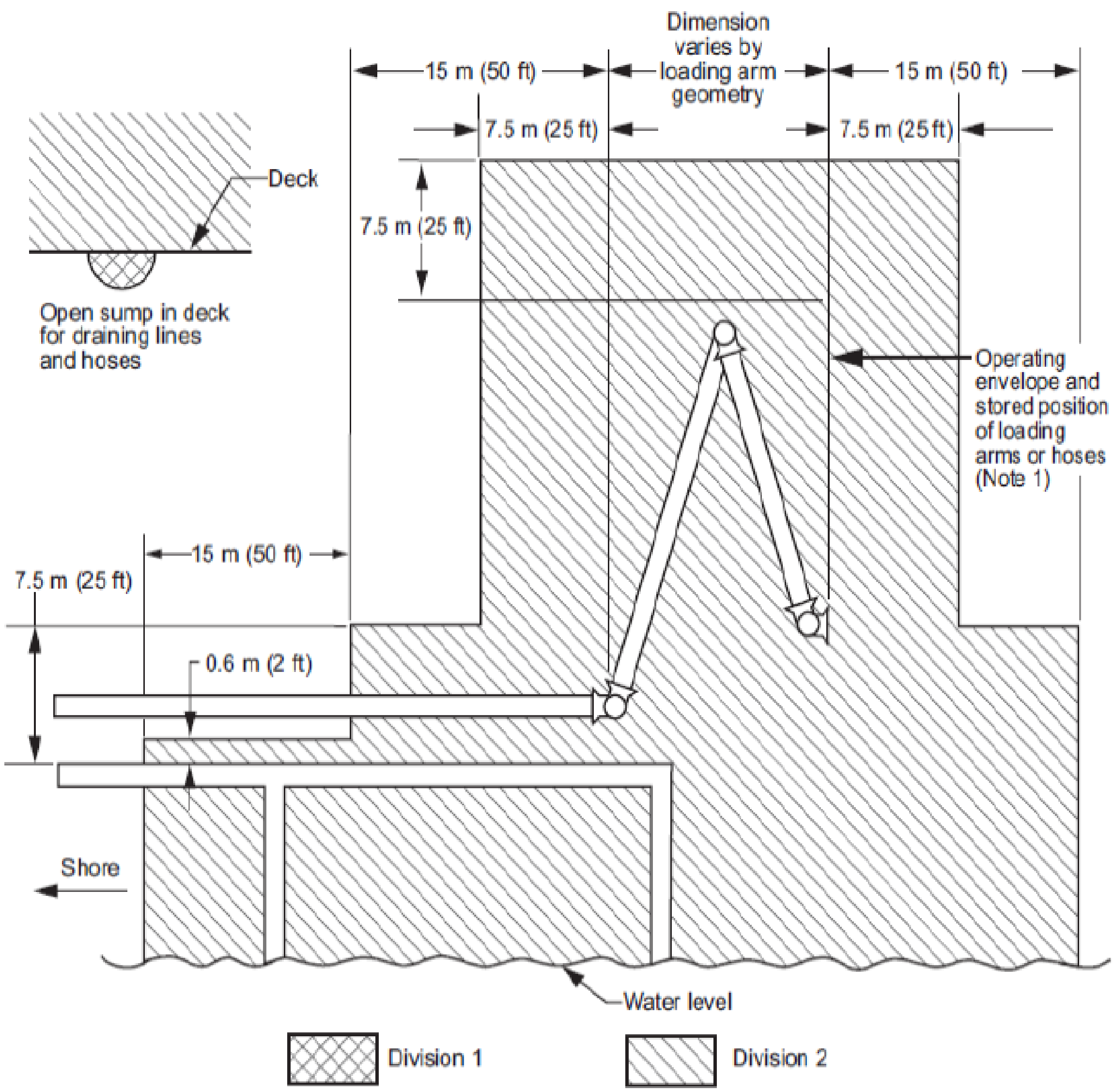



**Figure 6-14 The hazardous (classified) location at marine terminals handling flammable liquids***

[23] American Petroleum Institute (API), API Recommended Practice 500 (API RP 500), "Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2," 3rd edition, December 2012

* Note 1: The operating envelope and stored position of the outboard flange connection of the loading arm (or hose) should be considered the "source of release".
* Note 2: The berth area adjacent to tanker and barge cargo tanks is to be Division 2 to the following extent:

  a. 7.5 meters (25 feet) horizontally in all directions on the pier side from that portion of the hull containing cargo tanks.

  b. From the water level to 7.5 meters (25) feet above the cargo tanks at the highest position.

* Note 3: Additional locations may have to be classified as required by the presence of other sources of flammable liquids on the berth, or by the requirements of the Coast Guard or other authorities having jurisdiction.

During the study, a few other alternatives have also been discussed from a shipboard perspective and are given below.

- **Installing the connection point at the stern which is out of hazardous zones**

  This approach is adopted by Alaskan Navigator which is the first tanker equipped with shore power. However, for terminals that need to accommodate different sized tankers, it is challenging to manage the horizontal length difference as discussed in Section 6.3.1.2.

- **Installing the connection point at the foreship which is out of hazardous zones (Also refer FMECA 5.3)**

  This approach could avoid the challenge of currently unavailable explosion-proof marine use sockets. For terminals that accommodate different sized tankers, the cable management system may have the challenge to manage the horizontal length difference, similar to the discussion in Section 6.3.1.2.

  In addition, there is a long distance between the main switchboard which is normally located at the stern. The long cabling may increase the cost and maintenance efforts. The system will also need to be protected from green water. This scenario also brings in the potential need for a material handling system ashore to lift the cable up on the forecastle. This may pose challenges in terms of accounting for tidal and draft variations during the discharge operations at the terminal. Further, If the shore power connection point is arranged at the bow out of hazardous zone, the installation connection may enter the berth hazardous zone during slipped mooring.

- **Installing the connection point above the hazardous zone at the midship (Also refer FMECA 5.4 & FMECA 5.5)**

  Installing the shore power connection point at the midship on open deck could facilitate handling of all sizes of tankers calling the terminal, since the location of the manifold is relatively fixed.

  The risk for this option is that there may not be an available non-hazardous area at the midship for installing the connection point. The midship area has the following main hazardous zone arranged:

  - Hazardous zone 1: areas on the open deck over cargo tanks (including ballast tanks within the cargo tank area) where structures are restricting the natural ventilation and to the full breadth of the ship plus 3 m fore and aft of the forward-most and the aft-most cargo tank bulkhead, **up to a height of 2.4 m above the deck**. Therefore, in general, a platform will be needed to lift the connection point above the hazardous zone at the midship.

  - Hazardous zone 1: Areas on open deck, or semi- enclosed spaces on deck, within 3 m of any cargo tanks outlet, gas or vapour outlet, cargo manifold valve, cargo valve and/or cargo pipe flanges.

- Hazardous zone 1: areas on the open deck, or semi-enclosed spaces on the open deck above and in the vicinity of any cargo gas outlet designed for the passage of large volumes of gas or vapor mixture during cargo loading and ballasting or during discharging, **within a vertical cylinder of unlimited height and 6 m radius centered upon the center of the outlet, and within a hemisphere of 6 m radius below the outlet**.
- Hazardous zone 2: 1.5m above zone 1 on open deck within the cargo area (i.e., 2.4m + 1.5m) and 4 m beyond the cylinder caused by the large cargo vapor outlet defined in the above bullet (i.e., 6m + 4m).

Further, the midship area may fall into the hazardous locations as defined by the marine oil terminal which will require electrical equipment to be certified accordingly.

The specific hazardous area arrangement of the visiting tankers and marine oil terminals must be studied for each terminal. In addition, if a platform is installed for arranging the shore power connection point, assessment on visibility from bridge and potential stability issues need to be considered.

- **Installing the connection point in a pressurized electrical house at the midship (Also refer to FMECA 5.6)**

A pressurized electrical house with adequate positive-pressure ventilation may be used to reduce or eliminate hazardous areas. The concept is based on the principle that positive pressurization and purging can be established with clean air at sufficient continuous flow and positive pressure to reduce the original concentration of flammable gas or vapor to a safe level and to maintain this level in an enclosure or room located in a hazardous location.

The non-explosion-proof electrical instruments may then be used inside the pressurized electrical house. Detailed engineering must be performed to analyze the feasibility of pressurization in the hazardous zone together with relevant safeguards to mitigate any fire or explosion hazards. Necessary operational safeguards to avoid opening the room when the shore power system is energized should be considered in addition.

However, with the concept of arranging a pressurized electrical house on the main deck, a high-voltage cable will still need to be arranged in the hazardous area.  All cable installed in hazardous areas onboard the ships need to comply with Classification Societies installation requirement, e.g., all cables installed in hazardous areas shall have an outer non-metallic impervious sheath. Impervious Sheathed Cable is a cable constructed with an impervious metallic or nonmetallic overall covering that prevents the entrance of gases, moisture or vapors into the insulated conductor or cable. This applies to the fixed cable installation as well as for the flexible shore-to-ship cable. Research is needed to determine whether HV cable (fixed installation onboard and flexible shore-to-ship connection cable) which meet these requirements are available on the market. In addition, the cable penetration into the deck house might result in loss of positive pressure in the pressurized space.

Further, the current classification rules generally deem the enclosed space immediately above cargo tanks as hazardous area zone 1 unless the special protection has been reviewed and accepted by the appropriate authority. For access and openings to non-hazardous spaces other than accommodation and service spaces, the following provisions in the DNV classification rules apply:

— entrances shall not be arranged from hazardous spaces

— **entrances from hazardous areas on open deck shall normally not be arranged**. If air locks are arranged such entrances may, however, be approved following the below requirements:

- Entrance through air locks to non-hazardous spaces shall be arranged at a horizontal distance of at least 3 m from any opening to a cargo tank or hazardous space containing gas sources, such as valves, hose connections or pumps used with the cargo.
- Air locks shall comply with the requirements regarding gas-tightness, height, geometrical form, and ventilation.

A thorough examination and potential updates of the existing regulations and industry standards (e.g., SOLAS, IBC code, Class rules, ISGOTT, PIANC standards) for the pressurized electrical house concept are needed to ensure compliance.

To summarize this section, the tanker segment brings its set of unique challenges related to the hazardous cargo while implementing shore power technology. The industry level development on explosion proof equipment, a more adaptable cable management systems, feasibility of pressurized electrical house on the main deck at midship etc. are some of the key issues to be considered before a large-scale implementation of the shore power technology in the tanker segment.

#### 6.3.1.4 FMECA 0.2 – Uncertainties on power demand that accounts for different peak factors across different ship type

When calculating the power demand based on the historical fuel (energy) consumption, the result will be an averaged value. This is the case when using the auxiliary engine power output given in Table 6-7. This may not be sufficient for momentary or short-term peak consumption.

Each ship type will have a different peak factor which should be considered when designing shore-power infrastructure. During the design stage, the decision is recommended to be taken together with tanker operators whether to design for average power demand, peak power demand, or any design point in between.

Future changes in the size and portfolio of the visiting fleet would also need to be considered, so that design decisions based on the current fleet would not render infrastructure un-suitable for future tanker calls.

#### 6.3.1.5 FMECA 2.1 - Insufficient pier strength due to additional loads by way of added equipment for shore power technology

In addition to the space availability of the terminal, its strength, especially for the wharf-typed terminals, may not be sufficient for installing shore power equipment including cable, winch, switchboard, and potentially crane.

A structural evaluation, including seismic analysis, shall be performed following MOTEMS to evaluate if upgrades of the structural system of the causeway and terminal is needed.

During the workshop, the stakeholders also informed that upgrading the causeway and terminal is costly and time-consuming. It may impact the compliance timeframe.

#### 6.3.1.6 FMECA 5.2 - Lack of unified standards for shore power limiting its use on tankers, known to have a worldwide operational profile

This risk is more relevant to the cost-effectiveness of the installation of shore power technology onboard a tanker. It is listed here as it has been discussed during the workshop as a relatively unique situation for tankers considering their worldwide operation profile.

IEC/IEEE 80005-1:2019 Utility connections in port - High voltage shore connection systems have been established for shore power. This standard has provided some provisions regarding ship-to-shore connection and interface equipment. However, it mainly focuses on safety, e.g., the requirements regarding grounding lines and safety circuits. There are also requirements for standardized plug and sockets but none of them consider 'ex' certification requirements which could be of importance here.

Tankers typically have a worldwide operation profile and the majority do not call the same port frequently. Based on the analysis of AIS data between 2017 January 1st and 2019 December 31st, Figure 6-15 to Figure 6-17 are generated to show the count of ships distribution versus the count of port calls at the same port. It shows that around 96% of the tankers calling California between 2017 January 1st and 2019 December 31st call the same port (Port of Los Angeles, Port of Long Beach, or Port of Richmond) less than 10 times in the 3 years.

To mitigate this risk, standardization of the shore power design for tankers including a unified design of safety and physical design of the plugs and sockets through e.g., IEC/IEEE 80005-1:20199 Annex F is suggested. Additional requirements for tankers with contribution from the industry stakeholders is recommended. Before this standardization is in place, it is recommended to confirm the compatibility of the shore power system with the terminal. prior to the tankers' arrival in port.

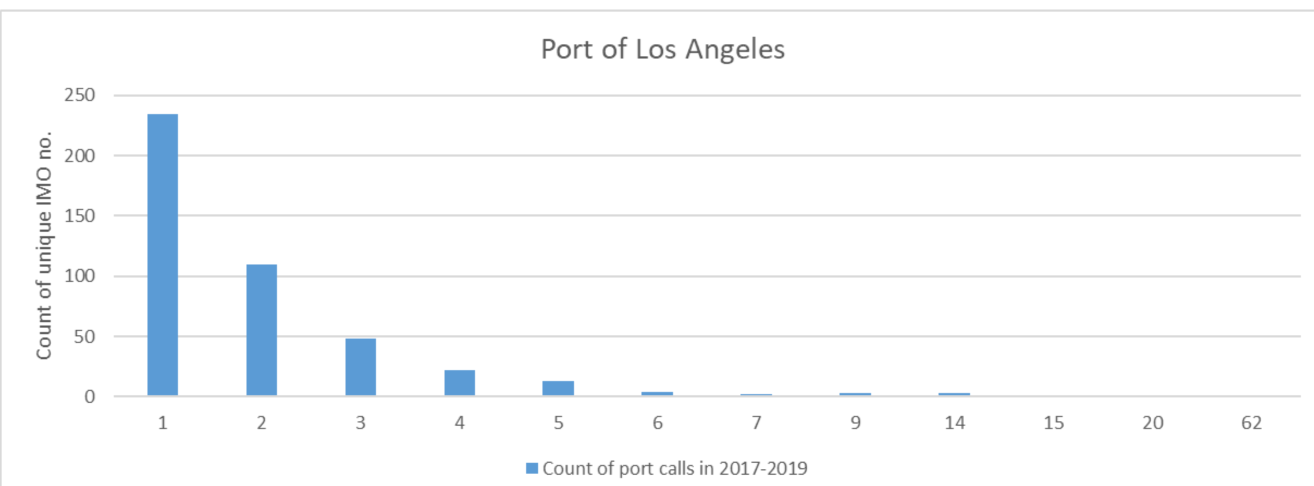



**Figure 6-15 Port of Los Angeles - The distribution of tankers' count of port calls in 2017 – 2019**

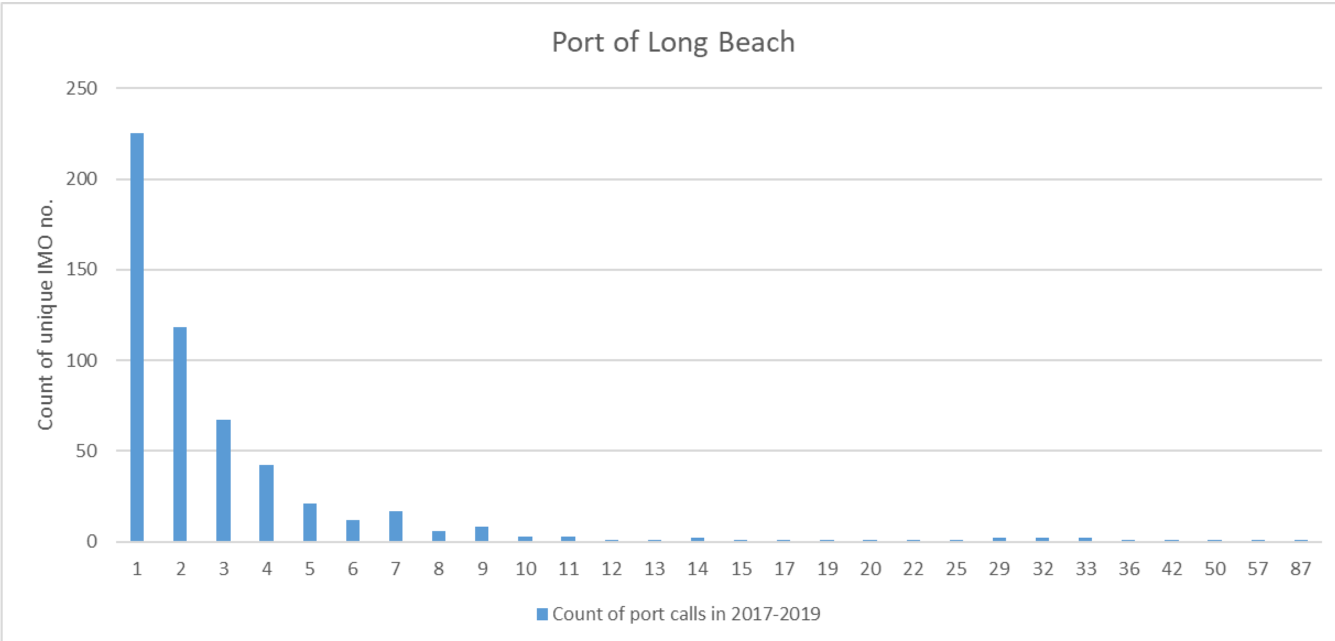



**Figure 6-16 Port of Long Beach - The distribution of tankers' count of port calls in 2017 – 2019**

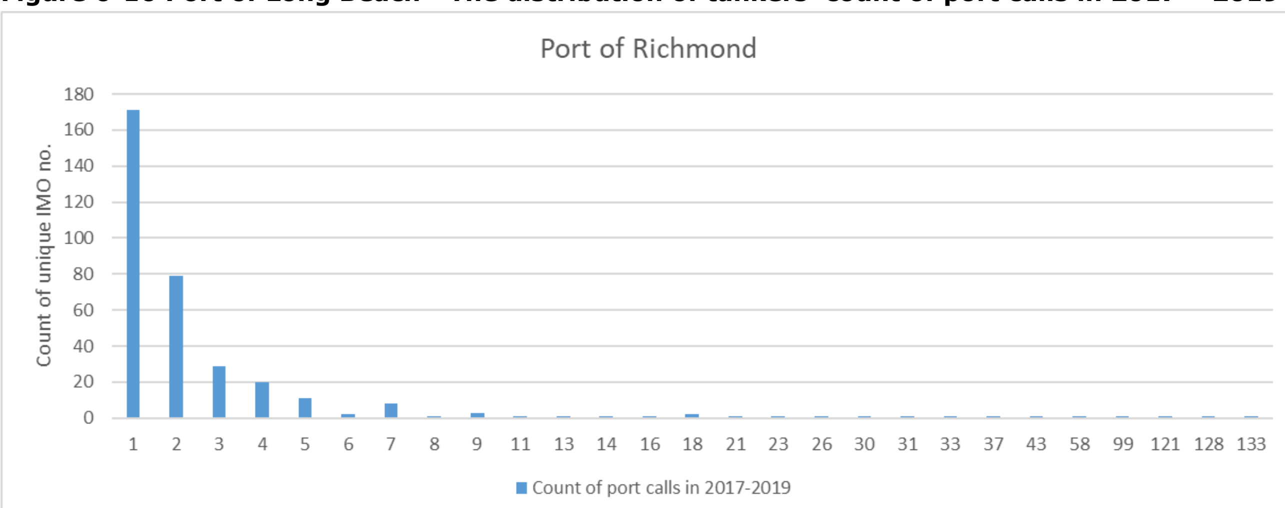



**Figure 6-17 Port of Richmond - The distribution of tankers' count of port calls in 2017 – 2019**

#### 6.3.1.7 FMECA 1.1 – Voltage and frequency incompatibility between shipboard power and shore power

Based on IEC/ IEEE 80005-1:2019, the connections for tankers should be made at a nominal voltage of 6.6 kV. For tankers, the nominal voltage level is normally 440 V AC. Some tankers may use 6.6 kV / 11.0 kV AC. To mitigate this risk, a voltage step-down transformer may be needed onboard the tankers for transforming the voltage to be compatible with the ships' needs.

The majority of tankers use 60Hz electricity. This is beneficial for visiting the USA where 60Hz electricity is used in the electrical grid. However, tankers generally have a worldwide operating profile. When ships visit areas using 50Hz electricity, e.g., some European and Asian countries, the incompatibility on the power supply's frequency would have to be resolved by the installation of a frequency converter, adding to the size and complexity of the shipboard installation required to make use of the shoreside infrastructure.

During the workshop, the installation location of the frequency converter, i.e., on the berth or on the ship, has also been discussed briefly. The cost, space availability and safety considerations are understood to drive such decisions. While a container (with a footprint of 30m$^2$) could house a transformer together with the switchgear, power conversion or frequency converter and associated switchgear might need larger space. This poses space constraints on vessels of smaller size and might entail shore-based location considerations.

#### 6.3.1.8 FMECA 0.3 – System voltage dip and subsequent faults caused by high inrush current during startup of high-capacity machinery

If there is a load restriction from the power source, the high inrush current may be induced by starting a high-capacity consumer, e.g., electrical driven cargo oil pumps. The inrush current may cause a system voltage dip. If the electrical system is designed with a low fault level, the voltage dip may exceed the allowance.

It is recommended to:

- size the transformer according to the terminal's traffic and potential peak load from the visiting tankers
- establish a communication procedure beforehand between the ship and terminal about if there are load restrictions from the shore power system and the ship's required average and peak load
- performing the start-up of electrical machinery onboard the tankers in a manner that will limit the peak currents, e.g., using a soft start or frequency-controlled motor

#### 6.3.1.9 FMECA 4.2 - Personnel injuries during handling of heavy shore power connections

For the high voltage shore connection system, the weight of the power cable is around 10 kg/meter. It may be too heavy for personnel to handle manually. A suitable material handling equipment is required for the operation to avoid potential injuries induced by handling heavy cables.

Normally, tankers have hose handling cranes installed in the midship and provision cranes at the accommodation area. Some tankers may also have a store and/or searchlight davit at the foreship. Some tankers may have trolley rails that could reach both the portside and starboard side of the ship.

The hose handling crane normally has the longest reach at around 20m. The provision crane's capacity is typically at 2 ~ 6 tons while the crane reach is typically around 4 ~ 7m. An additional crane onboard may be required to be installed at the place of shore power connection. The location of existing crane onboard the vessels, may not be installed suitably in a location facilitating handling of the shore power connection and the crane reach may be insufficient to cover the horizontal distance between the pier and the ship side.

A new crane may be needed onboard the ship. Otherwise, a crane on the terminal side could be used. In that case, the space availability and the strength of the terminal and the wharf will need to be evaluated.

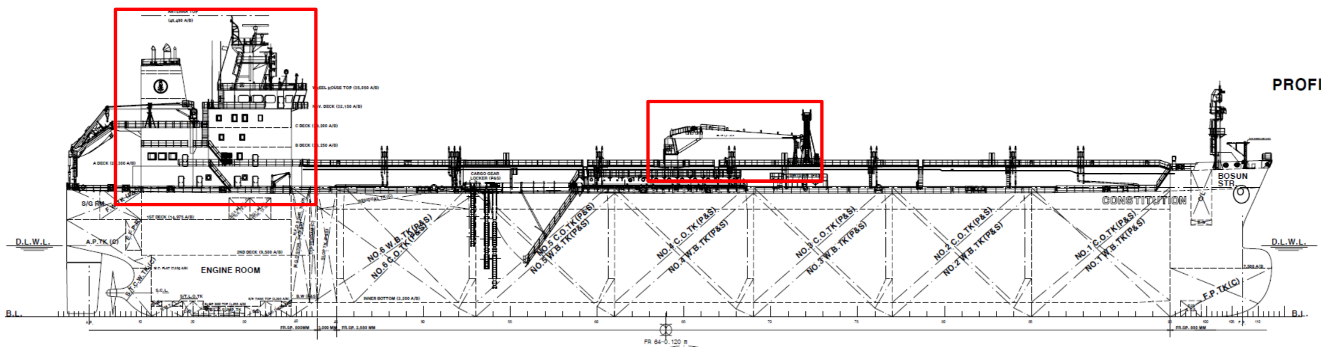



**Figure 6-18 The typical cranes' location onboard a tanker**

### 6.3.1.10 FMECA 4.3 - Personnel injuries from exposure to electrical equipment/operations

Handling high voltage equipment may involve risk to personnel safety. The personnel should not be exposed to live plug-in accordance with relevant standards, e.g., IEC standards and Class society standards.

Normally, the shipboard crew will be responsible for connecting the shore power to the ship's system. According to Oil Companies International Marine Forum (OCIMF) Vessel Inspection Questionnaires 5.1, for handling electrical equipment that is above 1 kV, a specific certification for the electrician is needed.

The qualification and safety training of the shore side and shipboard crew, e.g., high voltage operation and dedicated training on using shore power technology with appropriate working procedures (including potential LOTO training) and PPE, will be needed.

### 6.3.1.11 FMECA 3.4 - Potential upgrade of terminals to account for space constraints for installation of shore power technology

The Marine Oil Terminal Engineering and Maintenance Standards (MOTEMS) establish minimum engineering, inspection, and maintenance criteria for all marine oil terminals in California, to prevent oil spills and protect public health, safety, and the environment. The MOTEMS was first published on August 10, 2005 and became effective on February 6, 2006.

Following implementation of MOTEMS requirements, a majority of the oil terminals' new designs use the design with a pier that goes into the water. This leaves limited space for additional land-side infrastructure. There is a risk that the terminal may not have sufficient space for the shore power technology given the new designs. It is not a risk relevant to safety and reliability but imposes risk on cost and compliance timeframe as a new dedicated pier(s) may need to be constructed. Hence, this risk has not been ranked but noted for further consideration.

The Marathon Long Beach Berth 121 marine terminal which is the first and only shore power facility for tankers also needed a dedicated platform located south of the gangway tower to be constructed specifically for providing shore power.

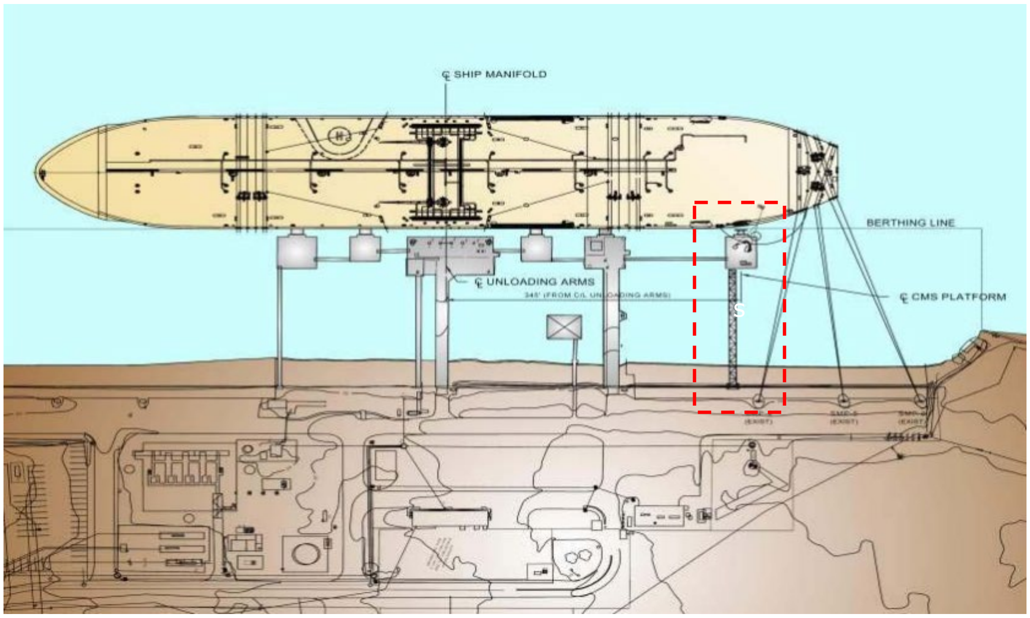



**Figure 6-19 Dedicated pier for shore power facility at Marathon Long Beach Berth 121 marine terminal**[24]

[24] The Port of Long Beach, Port of Long Beach Pier T Berth T121 BP Cold Ironing Project For Alaska Class Tankers

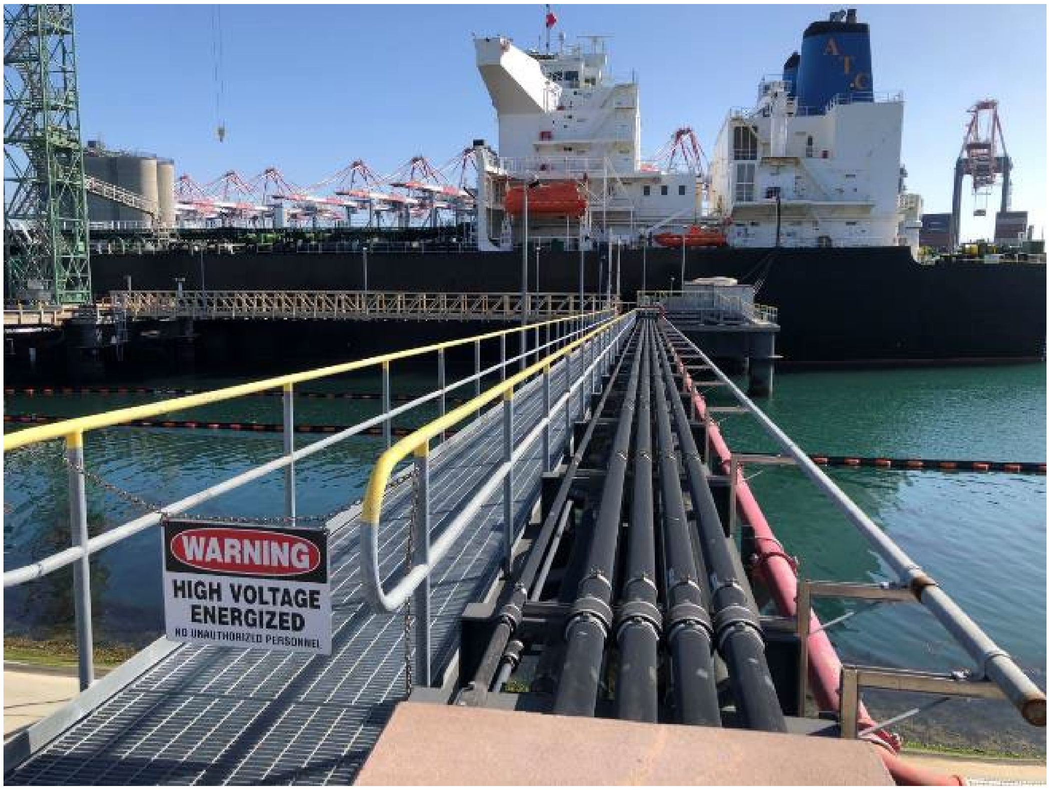



**Figure 6-20 Dedicated pier for shore power facility at Marathon Long Beach Berth 121 marine terminal**

### 6.3.2 HAZOP

The HAZOP workshops identified a total of 13 risks with one of the risks unranked. Out of the 13 risks, 6 risks were seen to be more relevant for tankers. There were 4 x risks that were medium risks and 1 x risk that was a low risk and one risk unranked. All the risks relevant for tankers are highlighted in this section. The risk matrix is as indicated in Figure 6-21 below with risk ids denoted with a # followed by number that relates to type of risk considered. Also refer to Appendix 6.

| | PROBABILITY | | | | |
|---|---|---|---|---|---|
| CONSEQUENCE | | | | | |
| | | | | | |
| | #10 | #2 | #8 | | |
| | #13 | | | | |
| | #1 | | | | |

**Figure 6-21 Risk matrix for HAZOP**

#### 6.3.2.1 HAZOP 1 – Current shore power design may not meet specified evacuation time in the event of an emergency

California Code of Regulations 2 CCR 2340 (c)(28) requires a vessel's boilers, main engines, steering machinery and other equipment essential for maneuvering to be maintained in a condition that a vessel has the capability to move away from the berth **within 30 minutes** under its own power. Where a vessel does not have such a capability, appropriate tug assistance is available so that the vessel can be moved away from the berth within 30 minutes.

For a ship using shore power, in an emergency, the disconnection process is normally as follows:

- An emergency alarm is sounded.
- A crew pushes the stop button on the shore power control panel in the engine control room to deactivate the shore power connection. This may induce a momentary blackout of the ship before the shipboard emergency generator and auxiliary engines are started to provide power.
- The shore power connection would require a manual disconnection. (Otherwise, the connector may be broken by forcing it. The shore power cable may be broken unwillingly and drops into the water.)

Based on the expert's input, the above operation may cause around 10-15 minutes delay in the evacuation of a tanker.

To avoid unnecessary delays from disconnecting shore power, the following mitigation actions have been identified during the risk assessment workshop:

- Ensure the emergency response button for disconnecting the power is implemented in the design and installation phase at reasonable locations, e.g., engine control room, local control cabinet at the connection room, shore side control room, etc.
- Implement a breaking signal system and auto-ejection mechanism
- Implement a quick-release / weak-link arrangement using an in-line breakable coupler on the cable. Once the breaking signal system sends the signal for quick release, the coupler will be unlatched and allow for disconnection
- Implement scheme and devices for handling the loose cables from both shore side and ship side;
- Develop an emergency response procedure including handling the shore power connection with a clear definition of responsibility, safety precautions, and necessary operations for the involved parties including the ship crew, the terminal and port operators
- Evaluate the time required for emergency response when connecting to shore power (disconnect shore power, turn on engine power, maneuver away from the berth) and ensure that it is within 30 minutes.

#### 6.3.2.2 HAZOP 2 - Safety of cargo operations compromised in case of a sudden loss of power when using shore power

When tankers use auxiliary engines for generating power while at berth, the ships normally have at least two auxiliary engines running with one auxiliary engine running as a redundant measure. If one auxiliary engine fails, the remaining auxiliary engine(s) will be still capable of supplying power. If all auxiliary engines fail, the emergency electrical power supply systems will start automatically.

When the ship is using shore power, in the event of shore power having a sudden loss of electrical power supply induced by e.g., electrical storm, rolling blackout, fault in the grid, etc., it will result in a momentary blackout before the emergency electrical power supply system starts.

According to DNV classification rules[25], power to all required emergency services shall be automatically available within 45 seconds when power is automatically restored after a black-out, including those supplied from main distribution systems. (These consumers may be supplied from main switchboards or sub-distribution boards). Emergency services are those services essential for safety in an emergency condition, e.g., emergency lights, navigation equipment, safety communication equipment, fire pumps, firefighting systems, steering gear, watertight doors and hatches, alarm systems, lifeboats, etc. The cargo operation is not necessarily deemed as an emergency service. Some cargo operations, e.g., ventilating fans for gas dangerous spaces and for gas safe spaces in the cargo area on tankers, inert gas systems, are deemed important (secondary essential) which need not necessarily be in continuous operation for maintaining the vessel's maneuverability but are necessary for maintaining the vessels functions. To investigate the potential impact of blackout when using shore power, the following bow tie is generated. A bow tie diagram is a form of risk assessment or a visualization of the path a hazard may take where a visual summary of all plausible accident scenarios that could exist around a certain Hazard is identified followed by identification of control measures the Bowtie displays to control those scenarios. The safety risk of a sudden loss of electrical power in the shore power system is deemed similar to the sudden failure of auxiliary engines. See Figure 6-22 & Figure 6-23 below.

[25] DNV Rules for Classification: Ships, Part 4 Chapter 8, July 2021

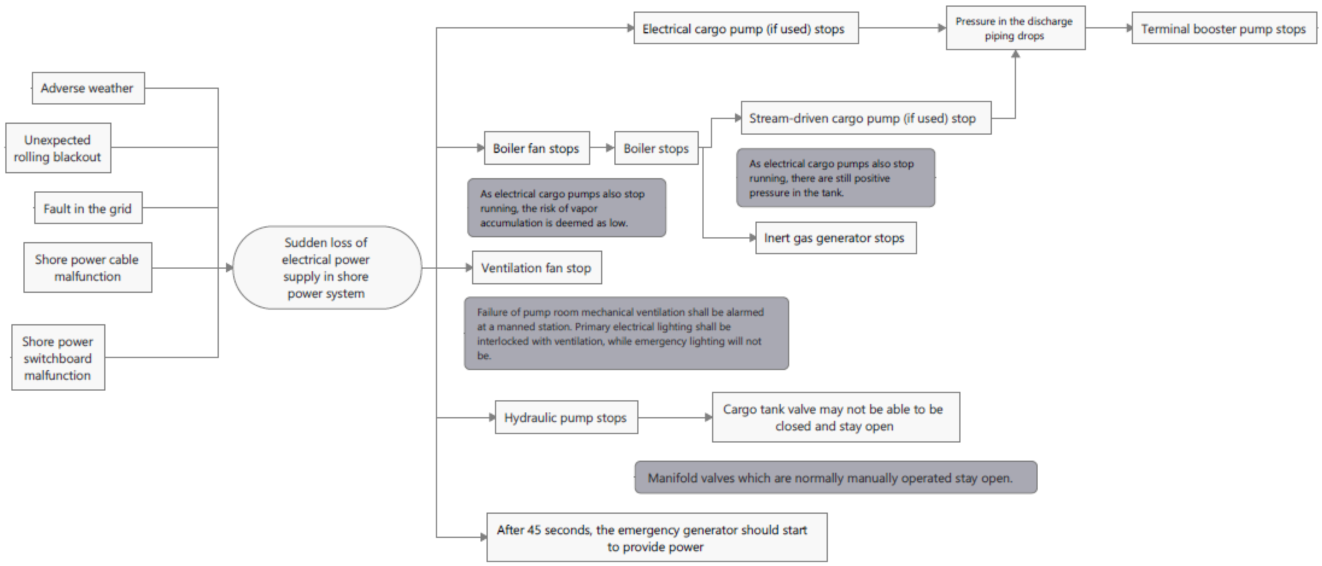



**Figure 6-22 Bow tie analysis of a sudden loss of electrical power supply in shore power system during cargo discharging**

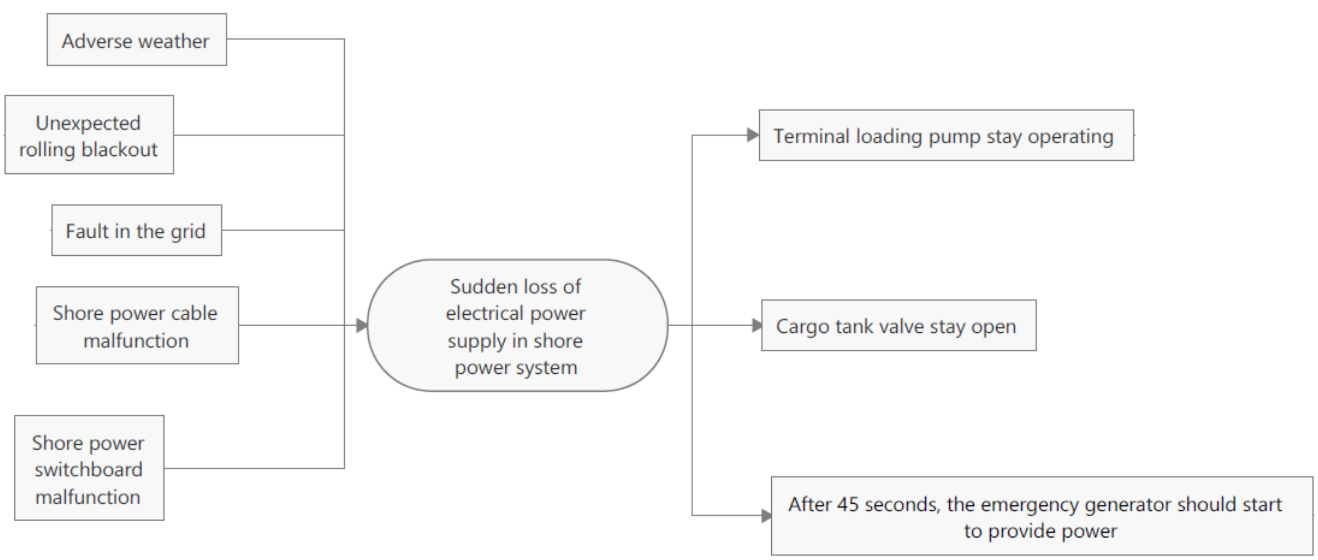



**Figure 6-23 Bow tie analysis of a sudden loss of electrical power supply in shore power system during cargo loading**

#### 6.3.2.3 HAZOP 8 - Cybersecurity may impact the safe operation of hazardous cargo

Currently IEC standard does not require data communication for tanker shore power installation. The current standard requires a monitoring function, but not a control function. The risk of unexpected blackout induced by human error, system vulnerabilities, cyberattacks is relevant when the data communication function is incorporated into the system.

If the shore power system is equipped with data communication capability, it is recommended to identifying the vulnerable subsystems (e.g., service interface of switchgear, service interface of cable management system), performing cybersecurity assessment, and ensure air gap is in place.

#### 6.3.2.4 HAZOP 13 – Lack of compliance with CARB at-berth regulation towards diesel driven power packs' emissions

According to CARB at-berth regulation, "auxiliary engine" means an engine on an ocean-going vessel designed primarily to provide power for uses other than propulsion, except that all diesel-electric engines shall be considered "auxiliary engines".

It is understood that some chemical tankers may have diesel-driven hydraulic power packs, e.g. FRAMO system. The hydraulic power pack prime movers can be electric motors or diesel engines.[26] According to Framo, a combination of electric motor and diesel engine prime movers allows the ship's generators to be designed for the relatively low power requirement in sea-going mode rather than the considerably higher requirement during cargo unloading. The ship's auxiliary engines can therefore operate with an economic load while at sea where the majority of running hours will be. The diesel hydraulic power packs will provide any additional power needed for a high capacity/high head cargo discharge. The potential configurations are shown below.

If diesel engines are used as the prime mover, they are deemed as "auxiliary engines" by CARB. As such, the emission must be controlled according to CARB at-berth regulation. For the tankers using such a configuration, the potential actions to mitigate the risk of out-of-compliances are:

- Convert the hydraulic power pack to use electric motors which draw power from the main switchboard, i.e., from the ship's service diesel generators
- Alternatively, the exhaust from the hydraulic power pack diesel engine(s) must be treated with the capture and control technology which may be too costly for such a relatively small emission source.
- .

[26] Framo, Cargo pumping system brochure

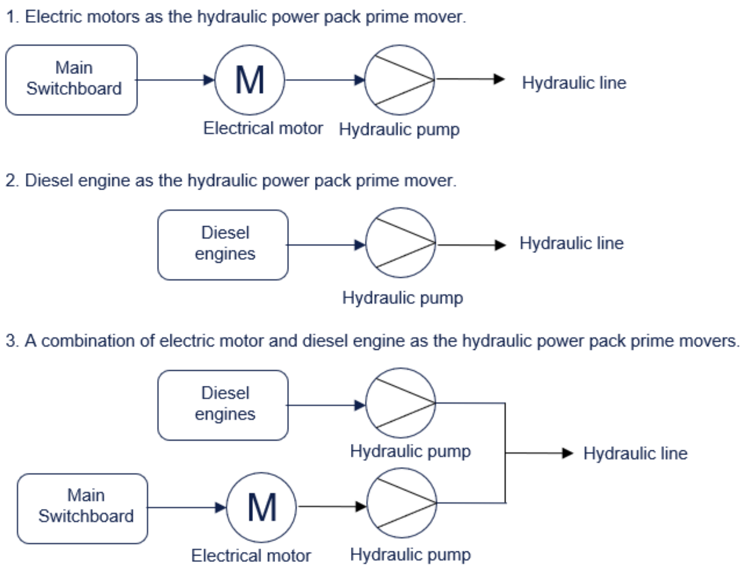



**Figure 6-24 Potential configurations of the hydraulic power pack**

#### 6.3.2.5 HAZOP 10 – Potential fire or explosion from high voltage connection ignited by vapor dispersion in the event of an oil spill

For tankers, oil spillage is a very relevant hazard. It may be caused by leakage from piping or tank, broken couples, unexpected disconnected/damaged loading arm. The vapor dispersion may result in an area having a higher risk of ignition.

It is recommended to:

- Developing the ship shore power emergency response procedure including emergency shutdown with the consideration of the cargo type, potential spillage location, and amount;
- Incorporating the operation of shore power into the terminal's spillage response procedure.

#### 6.3.2.6 HAZOP 12 – Lack of compliance with CARB at-berth regulation towards boiler emissions

During the stakeholder engagement, some stakeholders have expressed concerns that steam-driven cargo pumps' emissions may be out of compliance.

According to the CARB at-berth regulation, "for tanker vessels with steam-driven pumps, **unless the tanker is using shore power to reduce emissions from auxiliary engines**, a person must demonstrate that the CAECS achieves emission rates less than 0.4 g/kW-hr for NOx, 0.03 g/kW-hr for PM 2.5, and 0.02 g/kW-hr for ROG for tanker auxiliary boilers. Default emission rates of tanker auxiliary boilers on ocean-going vessels are 2.0 g/kW-hr for NOx, 0.17 g/kW-hr for PM 2.5, and 0.11 g/kW-hr for ROG."

Therefore, if shore power is used, the emissions from steam-driven cargo pumps will not be regulated. This understanding has been confirmed by CARB during the stakeholder engagement. Therefore, this risk is deemed irrelevant.

# 7 TECHNOLOGY ASSESSMENT OF CAPTURE AND CONTROL (C&C) TECHNOLOGY

## 7.1 Qualification basis

### 7.1.1 Technology Description

According to CARB, **barge-based capture and control systems** involve a capture and control device on a movable barge that is maneuvered alongside or aft of a vessel at berth, to reduce emissions from the vessel while it continues to operate its auxiliary engines and boilers. The current generation of barge-based technologies is designed to control emissions from the vessel's auxiliary engines. Current barge-based technologies are dependent on an external tugboat to move the barge alongside the vessel. Although there is the potential for self-propelled barges to eliminate the need for a tugboat, this technology has not yet been implemented. Once berthed beside or aft of the vessel, a capture boom on the barge lifts a duct/hood up to the top of the vessel's exhaust stack. The current stack hood is being optimized by CAEM and will feature a quick release, failsafe capture system. Then a large fan on the barge extracts the vessel exhaust and excess ambient air through the duct and route it down to the emissions "control" unit on the barge. Existing barge-based systems utilize diesel generators to power both the placement arm and emissions control systems. These systems are dispatched to reduce emissions from specific vessels, typically operated by a third-party system provider. The third-party system provider typically has its own staff on the barge to support this operation. Terminals with wider channels may readily accommodate a barge alongside a vessel at berth, but terminals with narrow channels may not be able to physically fit a barge without blocking navigation in the channel.[27] If the barge is located aft of the vessel, it may not block the navigation in the channel.

According to CARB, **Land-based capture and control systems** are essentially land-based versions of the barge-based systems described above. For a land-based system, the emissions control unit will be built in place near a terminal's wharf or can be mounted on a mobile chassis where the system will be moved along the wharf with a heavy-duty truck. Once the unit is in place on the dock, the system's capture device places the ducting over the vessel stack. The system captures and routes the vessel exhaust emissions from auxiliary engines to the landside control technology.

The boundary of the technology starts at the barge or the shore side installation and stops at the ships' funnel. The process flow is illustrated in the following figure.

[27] CARB, 2019-2020 GRANT SOLICITATION, September 2, 2020

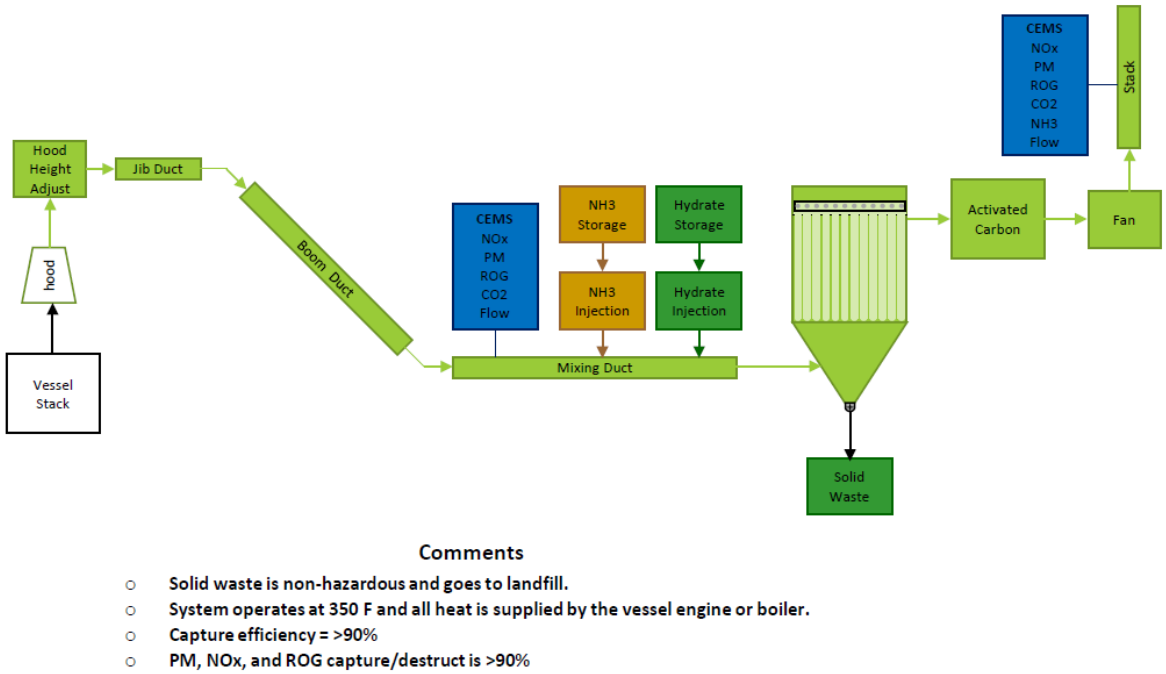



**Figure 7-1 Process flow diagram of CAEM's emission capture and control technology**

**Figure 7-2 Spud barge example**


**Figure 7-3 Jack-up barge example**

### 7.1.2 Performance Expectations

This section lists the performance expectation on capture and control technology. The details for the same are included under Appendix 7.1.

**Safety for personnel and property**

The technology should provide sufficient safety and security during normal operations and emergencies.

- The technology should be able to operate at defined weather window (tides, wind, currents, waves).
- The technology should be able to operate 24/7 (day and night) during all temperature ranges applicable for the terminal.
- The technology should not increase the risk of fire and explosion.
- The technology should not hinder the tanker requirements of safe evacuation from the berth within 30 minutes.
- The technology shall ensure safe operating environment for working personnel (connection, operations, disconnection, maintenance etc.) both during normal operations as well as emergency scenarios.
- The technology shall not adversely affect the vessel, its machinery or operations. (overloading the stacks, mooring entanglement etc.)

The design and construction of the technology shall ensure a safe environment for the personnel connecting, operating, and maintaining the technology. Further, the safety aspects of the technology shall consider relevant safeguards in terms of operational procedures and training.

**Suitable for tanker and oil terminals**

The technology should be able to be deployed and operated for the visiting tankers considering the factors including:

- The technology should be compatible with different sizes of tankers and their berthing configuration relative to the terminal.
- The technology should be compatible with different stack configurations including number, shape, and height.
- The technology shall ensure reachability towards stack in good time.
- The technology should be able to handle and treat the expected maximum exhaust gas flowrate from multiple sources when a tanker is at-berth
- The technology should be able to withstand the variable temperature from exhaust gas sources
- The technology should be compatible with the variation of tankers' draft and tide.
- The technology should comply with the relevant hazardous zones' requirement for tankers where applicable.

The technology should be able to be deployed and operated for the marine oil terminals considering the factors including:

- The technology should comply with the relevant hazardous zones' requirement of the marine oil terminals where applicable.
- Wharves should be able to carry the weight of the shore-based capture and control technology.
- The wharves should have sufficient space for the installation, operation and maintenance of the barge-based capture and control technology.
- The technology shall limit operational interference such as interference with mooring, cargo or other operations
- The barge-based capture and control technology shall enable safe stowage when not in use.

**Reliability & performance**

- The technology shall perform with acceptable failure rates ensuring little downtime over its lifetime
- The technology shall enable safe inspection, testing and maintenance regime
- The barge-based capture and control technology shall enable sufficient maneuverability in the terminals' environment.

### 7.1.3 Applicable Regulations and Standards

The capture and control technology should comply with and not impact the compliance of the existing relevant rules, regulations, industry standards and guidelines that are applicable to tankers and marine oil terminals.

The following regulations and standards are relevant to tankers and marine oil terminals.

**Table 7-1 Relevant regulations and standards**

| Category | Tanker and Terminal Regulations, Rules, Standards, and Guidelines |
|---|---|
| **Safety: Design and operation** | **IMO Regulation**<br>Safety of Life at Seas (SOLAS) Chapter II-1, Part D |
| | **California State Lands Commission Regulation**<br>Marine Oil Terminal Engineering & Maintenance Standards (MOTEMS) |
| | **Classification Society Rules** |
| | **Maritime Industry Guidelines**<br>OCIMF's Marine Terminal Operator Competence and Training Guide<br>International Safety Guide for Oil Tankers and Terminals<br>The World Association for Waterborne Transport Infrastructure (PIANC) - Safety Aspects of Berthing Operations of Oil and Gas Tankers |
| **Safety: Personnel** | Standards of Training, Certification, and Watchkeeping (STCW) |
| **Environmental protection** | **IMO Regulation**<br>IMO MARPOL Annex VI |
| | US Environmental Protection Agency - ECA requirements (SOX, NOX, PM) |
| | California Air Resources Board's (CARB) ocean-going vessels at berth regulation |

**Figure 7-4 Regulation and standards for tanker and terminals**

In addition to the above, the following CARB requirements are seen to be relevant:

CARB - Control Measure For Ocean-Going Vessel At Berth
Section: 93130.7 (e)(1): At least seven calendar days before arrival, the vessel operator shall communicate in writing with the terminal operator and operator of the CAECS to coordinate the use of a CAECS, and shall do all of the following:

(A) Request use of a CAECS; and

(B) Supply the terminal operator and the operator of the CAECS with information about the compatibility of the vessel with the intended CAECS.

### 7.1.4 Critical Parameters

During the technology assessment workshop on June 24, 2021, the following critical parameters have been identified for the capture and control technology. The dimensioning loads and operational parameters are to be included in a list to be used to check that these have been considered and addressed in the qualification tests, and that any change to these parameters is reflected in the qualification activities. The details of the same are included under Appendix 7.1.

**Table 7-2 Critical parameters for using capture and control technology on tankers [28]**

| |
|---|
| **Fuel composition limitations**<br>**Marine distillate fuel with ≤ 0.1% sulfur content** |
| **Maximum SCR (Selective Catalyst Reduction) inlet temperature**<br>450 °C |
| **Static pressure**<br>Minimum of -2 mm $H_20$ at the hood |
| **Connection** |

[28] https://www.arb.ca.gov/sites/default/files/2020-04/coverletter-ab-15-02_ADA.pdf

| |
|---|
| Direct connect system with seal per specifications |
| **Auxiliary Engine load (kW)**<br>typically, VLCC = 2 x 1,200kW aframax = 2 x 750kW |
| **Allowable operation range**<br>500-1700 kW, current allowable range of the CAEM METS-1 system, could be scaled up |
| **Exhaust flow rate that can be treated (standard cubic feet per minute (scfm))**<br>1400 to 6500 scfm of engine exhaust; The CAEM METS-1 system is currently capable of treating up to 6500 scfm of exhaust, might be scaled for tanker applications, upto two engines may be simultaneously controlled |
| **Ammonia slip emission**<br>Not to exceed 5 ppmdv, averaged over 60 minutes |
| **Vertical and horizontal stack position**<br>Vertical stack position shall consider draft and tidal variations while horizontal position shall consider both starboard and portside mooring. |
| **Time for connection**<br>A maximum and minimum time interval for connection to stack shall be defined. |
| **Treatment capacity**<br>The technology shall be able to treat exhausts from auxiliary engine, boilers as well as combined exhaust quantities. Minimum and maximum quantities to be specified. |
| **Temperature of exhaust gas**<br>The technology shall be able to accommodate a range of temperature of exhaust gas. Minimum and maximum to be specified. |
| **Operational impact**<br>The technology shall limit interference of the normal operations such as mooring, cargo operations, traffic etc. |
| **Other relevant parameters as described under performance expectations**<br>The critical parameters shall be developed from the performance expectations as seen relevant. |

## 7.2 Technology assessment

The purpose of technology assessment is to determine which elements require technology qualification and identify their key challenges and uncertainties. The technology qualification basis forms the input to the technology assessment. The output is an inventory of the novel technology elements, and their main challenges and uncertainties. The technology assessment shall include the following steps:

— Technology composition analysis

— Assessing the technology elements with respect to novelty

To fully understand the novel elements of compound technology, as well as provide common understanding and terminology between people from different technical disciplines, the technology composition shall be analyzed. This is a top-down assessment that starts with the system-level functions and proceeds with decomposing the technology into elements including interfaces.

The emissions capture and control technology supplier Clean Air Engineering-Maritime, Inc.[29] (CAEM) has been developing and operating systems that are capable of capturing and controlling emissions from the auxiliary engines and boilers of ocean-going vessels while at berth or anchor. CAEM currently holds a CARB-approved emissions capture and control technology used for compliance with the airborne toxic control measure for auxiliary diesel engines operated on ocean-going vessels at-berth in a California port: Marine Exhaust Treatment System-1 (METS-1).[30]

The technology assessment is performed largely based on the design concept that CAEM is currently developing for tankers.

The technology composition analysis was conducted together with other industry stakeholders and subject matter experts during the workshop on June 24, 2021. The result is given in the table below.

**Table 7-3 Emissions capture and control technology composition analysis**

| ID | Subsystem | Major Components | Main Function |
|---|---|---|---|
| 1 | Emission capture unit | Crane / placement boom | Bring the flexible duct to the vessel stack |
| | | Stack adaptor / hood | Work as the interface between relevant exhaust stack and flexible duct |
| | | Flexible duct | Transport the exhaust from the stack to the treatment unit |
| 2 | Emission control unit | Inlet | Connection of flexible duct to the treatment system |
| | | Treatment system | Perform treatment of the exhaust |
| | | Exhaust fan | Create vacuum for exhaust flow |
| | | Power supply | Provide power to the treatment system and exhaust fan |
| | | Control panel | Control the treatment system |
| | | Outlet | Release the treated exhaust into the atmosphere |
| 4 | Basis | Land-based (Mobile chassis/stationary)<br>Barge-based | Transport and store the emission capture unit and or the emission control unit |

[29] https://caemaritime.com/

[30] State of California Air Resources Board, Executive Order AB-15-01, June 2015

Novel technologies typically evolve from existing proven technologies. Normally, only some elements of the technology are novel. Uncertainty is associated mainly with novel elements. In order to focus on where uncertainty is greatest, the novelty categorization shown in Table 7-4 can be used. Both the novelty of the technology itself and its application area affect the uncertainty associated with the technology.

Elements categorized as novel (category 2, 3 and 4) shall be taken forward to the next step for further assessment.

Only knowledge and experience that is documented, traceable and accessible to the qualification team should be used to reduce the degree of novelty.

**Table 7-4 Categorization according to DNV Recommended Practice**

| Application area | Degree of the novelty of the technology | | |
|---|---|---|---|
| | Proven | Limited field history | New or unproven |
| **Known** | 1 | 2 | 3 |
| **Limited knowledge** | 2 | 3 | 4 |
| **New** | 3 | 4 | 4 |

This categorization indicates the following:

- **Category 1:** No new technical uncertainties (proven technology).
- **Category 2:** New technical uncertainties.
- **Category 3:** New technical challenges.
- **Category 4:** Demanding new technical challenges.

Technology in Category 1 is proven technology where proven methods for qualification, tests, load and structural analysis can be used to document margins to failure. It is assumed that acceptable margins to failure for these items are achieved through the regular project activities in order to ensure a reliable qualification process for the components in this technology category.

Technology defined as Category 2, 3, or 4 is defined as new technology and requires qualification. Components assigned to these categories will later be subject to the threat assessment, i.e., FMECA and HAZOP. For sub-components that fall into Category 2, 3, or 4, further subdivision of these components may be necessary based on the risk ranking and complexity of the sub-components.

The components and functions were assessed with the industry stakeholders and subject matter experts during the workshop. DNV has reviewed the response from the workshop participants and developed the novelty categorization as below. Some high-level challenges/uncertainties which are relevant to using the components onto tanker and oil terminals discussed during the workshop are also listed in the table below. Detailed risk assessments have been performed and presented in Section 6.3 and also under Appendix 7.2.

**Table 7-5 Components and categories**

| System | Category | Challenge/uncertainty |
|---|---|---|
| Emission capture unit | 4 | - The placement boom cannot cover the wide range of tanker sizes.<br>- The stack adaptor cannot accommodate the different stack configurations of tankers.<br>- The duct is not able to transfer volume and heat of emission over a wide range of emission flow rates |
| Emission control unit | 3 | - The treatment system does not have enough capacity to treat the amount of emission from tankers. |
| Basis | 4 | - The location of the basis interferences with the normal operation of the tankers.<br>- Disconnecting the technology increases the evacuation time of the tankers. |

## 7.3 Threat assessment

A group workshop with the participants as included under Appendix 7 has been facilitated by DNV on June 24, 2021 and July 09, 2021 virtually via Microsoft Teams. The critical risks which are **unique** for the technology's application onto tankers are discussed in this section. The detailed results of FMECA and HAZOP are given in the Appendix 7.3 & 7.4 respectively.

The risk assessment has been focusing on analyzing:

- the applicability/difference of the identified risks of shore-based emissions capture and control
- the additional or difference in risks from using a barge based capture and control technology

### 7.3.1 FMECA

The FMECA focused on potential failure modes and their effects for the operation of the land-based & shore-based capture and control systems. During the workshop, failure modes from perspective of applicability towards all vessel types were considered and later categorized/filtered to identify the failure modes that would be more relevant specifically for tankers. Ranking of the failure modes are captured in the Figure 7-5 below with risk ids denoted with a # followed by number that relates to type of failure mode considered. Also refer to Appendix 7.

| | PROBABILITY | | | | |
|---|---|---|---|---|---|
| CONSEQUENCE | | | | | |
| | | #3.2, #3.5, #3.14 | #1.17, #1.20<br>#2.4 | #1.15, #1.21 | |
| | | | #2.5<br>#3.6, #3.12,<br>#3.16, #3.19 | #3.17 | |
| | | #3.13 | | #1.6<br>#3.10, #3.11 | |
| | | | #1.22<br>#3.9, #3.15 | | |

**Figure 7-5 Risk ranking for FMECA**

The overall risk ranking indicted 55 risks in total. Out of the 55 risks identified, 21 of them were found more relevant for tankers. These are indicated in the risk ranking figure above. Out of the 21 risks identified, 6 x risks were high risks, 12 x risks were medium risks, and 3 x risks were low risks. This section describes the details of all the risks relevant for tankers when it comes to utilizing the land-based & shore-based capture and control systems. The details for the same are provided under Appendix 7.3.

#### 7.3.1.1 FMECA 1.6 - Potential operation of 'hazardous zone' non-compliant displacement boom within hazardous zone

As mentioned in 6.3.1.3, the tankers and marine oil terminals have hazardous zones defined. Electrical equipment working inside these areas must comply with the relevant standards, rules, and codes' requirements. As informed by CAEM, during the transportation, the placement boom will be in the stowed position. In the normal operation, the placement boom should approach the stack at the stern of the tankers which is out of the main hazardous zone around the cargo hold areas and the manifold. However, it may still run into the localized hazardous zone around the battery room, paint store, chemical room, etc.

To mitigate this risk, the following recommendations have been identified during the workshop:

- Collect the hazardous zone arrangement from the terminal and also visiting tankers via pre-arrival questionnaire
- Define the route of placement boom operation accordingly to avoid the operation in the hazardous zones
- All vessels might not mitigate this risk the same way so mitigation will be vessel specific

CAEM uses a Vessel Mooring Treatment Plan (VMTP) to collect vessel information and prepare for C&C operations, this document will be updated for tanker use.

#### 7.3.1.2 FMECA 3.10 – Lack of sufficient station keeping in the event of strong surge/swell or passing vessel traffic

The current design of barge-based capture and control technology is planned to operate with 2 spuds with the option to install 4 spuds in 6 different locations. In the event of waves generated from swell or surges or passing traffic, there is a risk with regards to loss of station keeping that may impact the operations.

The following recommendations are identified during the workshop to mitigate this risk:

- Evaluate the spud station keeping capacity against the local climatology and implement appropriate changes in the design.

It is noted that a Jack-up barge capable of operating in 30m (98') water depth could be considered as an alternative.

#### 7.3.1.3 FMECA 3.11 – Potential risk of collision between tanker and barge induced due to channel motions from passing vessel traffic

When using the barge-based capture and control technology, the passing vessel in the channel may cause movement of the tanker. If there is not sufficient clearance between the barge and the tanker, it may induce hull collision.

According to Marine Oil Terminal Engineering & Maintenance Standards (MOTEMS)[31], in general, vessels shall remain in contact with the breasting or fendering system. Vessel motion (sway) of up to 2 feet off the breasting structure may be allowed under the most severe environmental loads, unless greater movement can be justified by an appropriate mooring analysis that accounts for potential dynamic effects. The

[31] Marine Oil Terminal Engineering & Maintenance Standards (MOTEMS) 3105 F.2 Mooring analyses

allowable movement shall be consistent with mooring analysis results, indicating that forces in the mooring lines and their supports are within the allowable safety factors. Also, a check shall be made as to whether the movement is within the limitations of the cargo transfer equipment.

The following recommendations are identified during the workshop to mitigate this risk:

- The safe operating envelope of the barge should be defined with enough clearance between the tanker and the barge-based system will be identified in the mooring and passing vessel analysis for each terminal.
- The maximum clearance that the capture and control technology could provide should be evaluated and compared with the required clearance.
- The barge may also be equipped with a fender system.

#### 7.3.1.4 FMECA 1.22 – Potential electrical short circuit upon contact of stack adaptor to stacks

The capture and control technology is designed to operate the stack adaptor in the non-hazardous zone. However, the metal-to-metal contact between stack adaptor and tanker's stacks may induce electrical short circuits. It may result in unfavorable sparks, ignition, or fire.

It is recommended to review Marine Oil Terminal Engineering & Maintenance Standards (MOTEMS) to identify the requirements and potentially considering bonding and grounding and ensure compliance.

#### 7.3.1.5 FMECA 3.9 – Potential damage to underground pipelines or cables at port from spud-based solution proposed for barge-based technology

For barge-based capture and control technology, it is planned to use spudding for station keeping. Some terminals have underground pipelines or cables arranged. The spudding activity may cause damage to underground pipelines or cables.

The following recommendations are identified during the workshop to mitigate this risk:

- collect the information about any underground pipelines from the terminal guide and arrange the spudding operation based on the specific terminal arrangement.

It is understood that CAEM has a Vessel Mooring and Treating Plan (VMTP) in place and is assisting terminals with underground evaluations for pipeline and other interferences

#### 7.3.1.6 FMECA 3.15 - The tanker requirements of safe evacuation from the berth within 30 minutes not met in the event of technology being deployed

California Code of Regulations 2 CCR 2340 (c)(28) requires the tank vessel's boilers, main engines, steering machinery and other equipment essential for manoeuvring are maintained in a condition so that the tank vessel has the capability to move away from the berth **within 30 minutes** under its own power. Where the tank vessel does not have such a capability, appropriate tug assistance is available so that the tank vessel can be moved away from the berth within 30 minutes.

To disconnect the capture and control technology from the tanker, it involves the following process:

- lifting the stack adaptor/hood

- stowing the placement boom
- if using the barge-based system, the following activities are additional:
  - lifting the spud
  - starting the engines/propulsion and barge move away from the evacuation route of the tanker

According to CAEM, the process will not need additional support from the tankers' crew. The above process may prolong the evacuation time of the tanker. However, it is understood, based on discussions with port pilots, that this is unlikely.

The following recommendations are identified during the workshop to mitigate this risk:

- Develop an emergency response procedure for such emergency scenarios
- Ensure proper training of the crew including performing scenario drills to evaluate the impact in the event of a real case scenario.

#### 7.3.1.7 FEMCA 3.17 – Potential interference of the technology with normal tanker operations

During the workshop, the possibility of arranging the base unit (fixed or floating platform or barge) at the stern of the tanker on the pier side, as illustrated in Figure 7-6, is also discussed. This will reduce the impact on the passing traffic. However, it will likely interfere with the mooring arrangement of the tankers at the stern as shown in Figure 7-7 and Figure 7-8. This location is generally not recommended for arranging the base unit.

In addition, the tanker will perform deballasting during loading at the berth. If the barge is too close to the deballast discharge point, it may have water onto the system and impact the operation.

To mitigate this risk, it is recommended to:

- Consider the location arrangement of the base unit in terms of normal operation of the tankers to ensure no interference to and from normal operation of tankers


**Figure 7-6 Base unit at the stern of the tanker on the pier side**

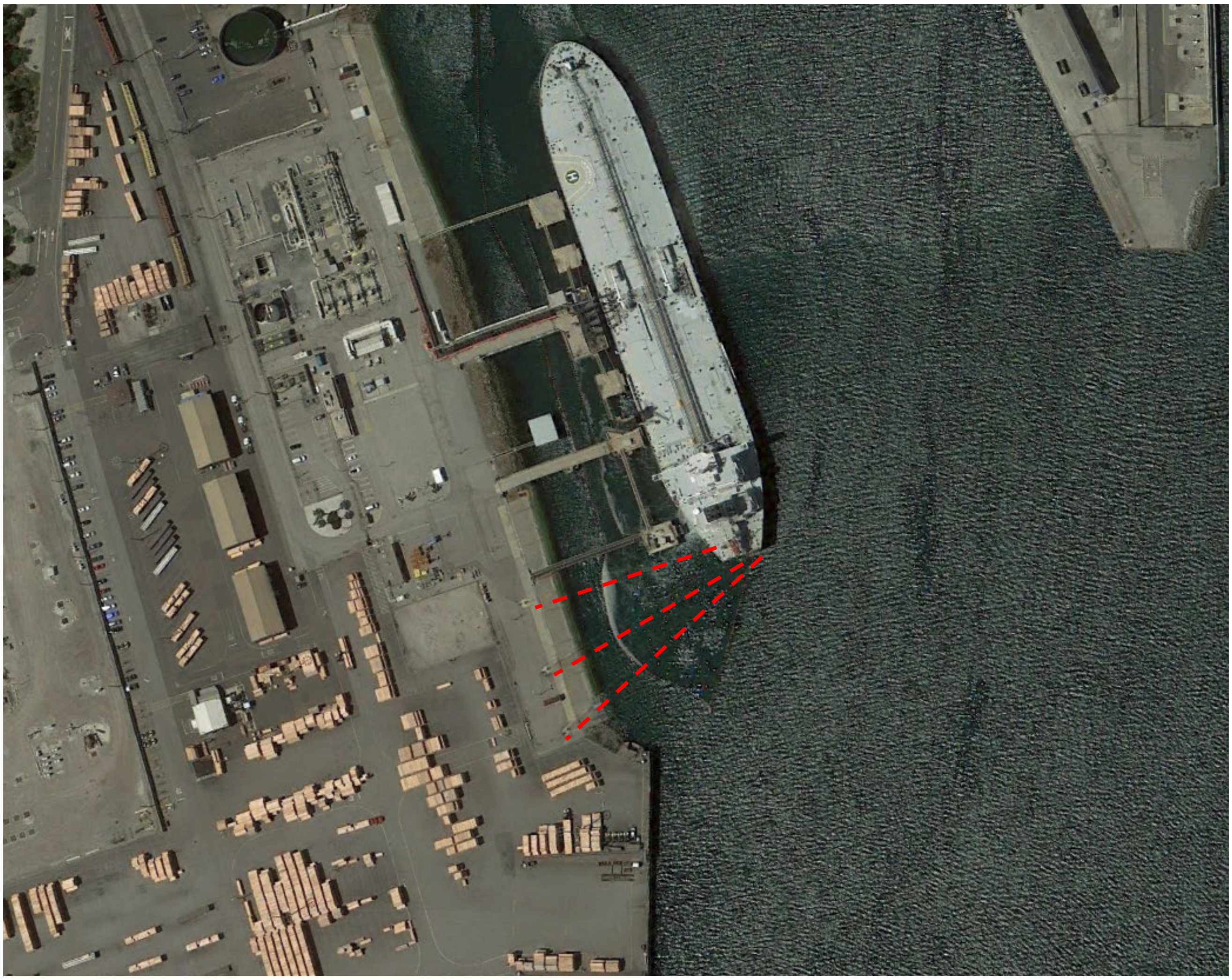


**Figure 7-7 Illustration of mooring lines at the stern of the tanker**

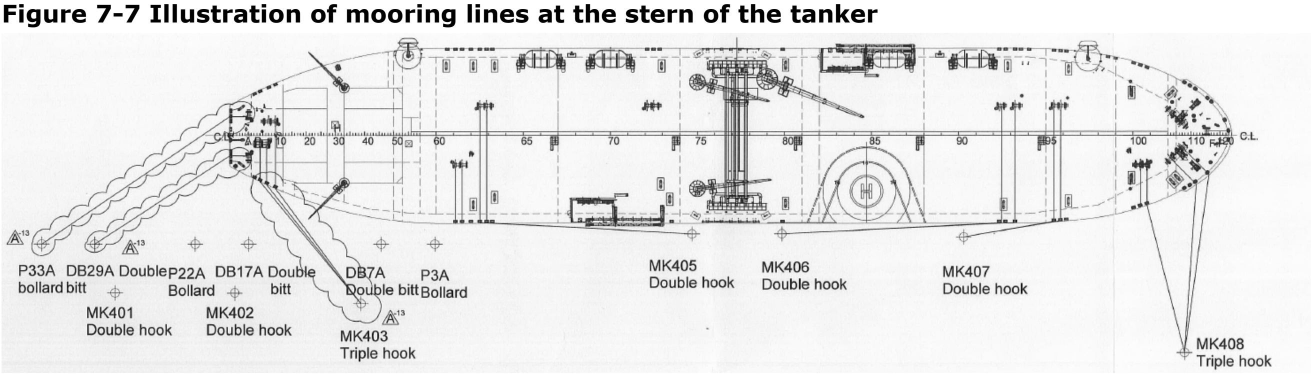



**Figure 7-8 An example of mooring layout of a Suezmax tanker**

#### 7.3.1.8 FMECA 2.5 – Potential operational disruption to boilers/auxiliary engines due to malfunction of technology

The capture and control technology will be equipped with an exhaust fan which provides a minimum of -2 mm $H_20$ at the hood. The fan may malfunction, e.g., overspeed, underspeed, sudden stop due to loss of power. This may cause backpressure buildup or high negative pressure within the tanker's exhaust system. It may cause the boiler fan to stop and incomplete combustion. It may also impact inert gas generation.

The current design concept includes a pressure monitoring system. The stack adaptor is attached to the tanker's stack with openings. If the backpressure is built up, the exhaust gas will escape through the opening. The infrared thermal camera will be capable of recognizing it and sending alarms to the operator.

To further mitigate the risk, the following recommendations are identified during the workshop:

- The capture and control technology supplier will:
    - implement an alarm window of pressure monitoring including both upper and lower limit
    - consider implementing pre-warning alarm regarding differential pressure for crew onboard the tanker to respond ahead
    - ensure fan speed is controlled according to the pressure in the duct
    - evaluate the reliability of the pressure sensor and develop redundancy accordingly
- Establish communication procedure between capture and control supplier, tanker's crew, and terminal operator, including:
    - providing instruction/checklist for tanker's crew to understand the pre-transfer processes, confirmation to proceed, capture and control technology's alarms, emergency procedures etc.
    - capture and control technology service supplier to attend the pre-transfer conference
    - establish VHF communication channel and protocol including pre-warning alarm that alerts the barge crew who can advise the tanker crew via established communications method. Action required by the tanker crew will be included in the instructional description and information package provided prior to connecting.

#### 7.3.1.9 FMECA 3.6 - Incompetent crew impacting the system's reliability and safety of the operation.

The complex navigation condition and operation of the capture and control system requires experience and sufficient qualification of the crew to ensure a safe operation. If the crew onboard the barge is inexperienced or unqualified, it may impact the system's reliability and safety of the operation.

The following recommendations are identified during the workshop to mitigate this risk:

- ensure the crew of the barge is trained properly considering the complexity of the capture and control operation, traffic congestion, etc.
- ensure the crew operating the capture and control technology is familiar with the terminal facility and the local navigation system
- develop operation procedures involving port, terminal, and the capture and control service provider.

#### 7.3.1.10 FMECA 3.12 – Potential non-compliance of the terminal with MOTEMS requirements while using capture and control technology

The Marine Oil Terminal Engineering and Maintenance Standards (MOTEMS) establish minimum engineering, inspection, and maintenance criteria for all marine oil terminals in California, to prevent oil spills and protect public health, safety, and the environment.[32]

The usage of capture and control technology may induce changes in the operation and result in incompliance with MOTEMS requirements. To mitigate this risk, the following recommendations are identified during the workshop:

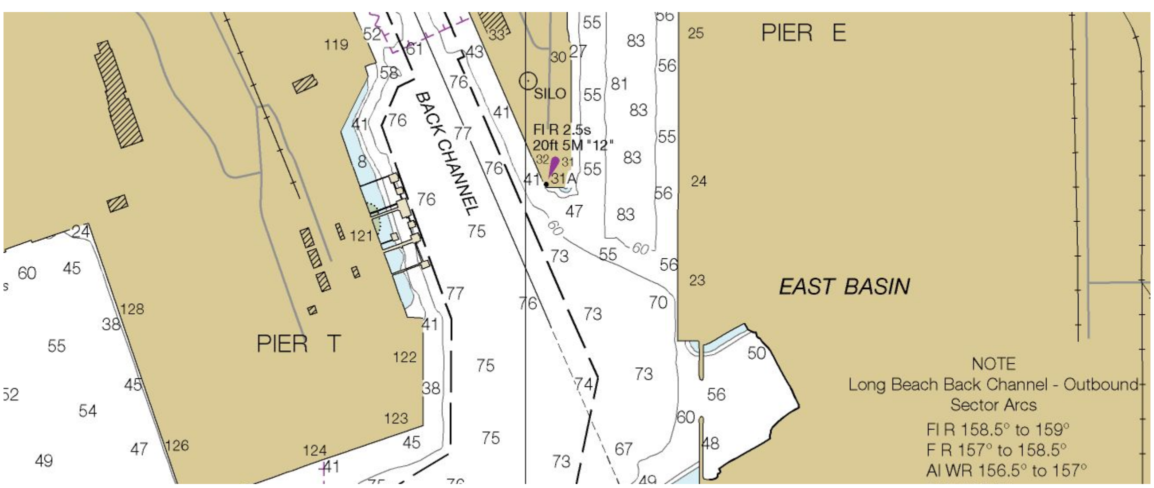
- consider performing Management of Change review before implementation
- monitor marine terminal regulation updates and ensure compliance.

#### 7.3.1.11 FMECA 3.16 – Terminal depth (in some cases) not accounted for in the design of the spud for the barge-based capture and control technology.

During the workshop, it is discussed that double banking and mooring involve additional safety risks and is not a preferred way to ensure the station keeping of the barge. Using spuds could potentially be an alternative to provide station-keeping. This is used in CAEM’s current design concept for barge-based capture and control technology for tankers. The length spud is currently considered at 75 feet.

If the terminal has relatively deep water, the length of spud may be too short. An example is Port of Long Beach Berth 121 may have the water depth around 76 ~ 77 feet. It is noted that a Jack-up barge capable of operating in 30m (98’) water depth could be considered as an alternative. Further, some company’s engineering standards do not allow spuds at this great of depth due to safety, reliability and other operational concerns.

It is recommended to review the water depth and perform underground utilities survey for spudded barge applications during the design stage of the barge and adjust the spud length according to the terminal arrangement. A Geotech survey might also be required.

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[32] California State Lands Commission

**Figure 7-9 Water depth at Port of Long Beach Berth 121**

#### 7.3.1.12 FMECA 3.19 – The environmental condition may be too harsh for the barge design.

According to CAEM, the barge-based capture and control technology for tankers will be designed with self-propulsion capability. The maximum speed of the barge will be around 5 knots for operating in Port of Los Angeles and Port of Long Beach. As mentioned earlier, these two ports have enclosed water. The environmental condition (current, wind, wave, tide, etc.) is normally much more benign compared with the Northern California ports. The barge design that is suitable for Port of Los Angeles and Port of Long Beach may not be able to operate safely in the Northern California ports. The propulsion power, stability performance, station keeping capacity of the spuds, etc. may need to be improved accordingly.

It is recommended to:

- Design the barge according to the environmental conditions for the planned operation areas.

#### 7.3.1.13 FMECA 1.15 – Inability of stack adaptor to connect to all emission sources due to compact stack configuration

Some tankers have a compact design of the funnel. In this situation, the limited space may prevent the connection of the stack adaptors to all working stacks. Therefore, some exhaust streams cannot be processed by emission capture and control technology.

To mitigate this risk, the following recommendations are identified during the workshop:

- C&C service supplier to develop pre-arrival communication procedure and understand the stack configuration, the number, and location of operating stacks for the visiting tankers. A bespoken stack adaptor connection method will be developed. The connection method should allow enough room for the necessary adjustment of the location without damaging the vessel’s stacks.

If it is found that the stack configuration is too compact for connecting stack adaptors, Vessel Incident Events (VIE) and Terminal Incident Events (TIE) may be used. However, it is to be noted that there is a limit in its usage and is listed here as an observation.

#### 7.3.1.14 FMECA 1.21 – Inability of the technology to process all exhaust streams when shifting from one stack to another

While at berth, a tanker may need to shift the usage of auxiliary engines or boilers. In this case, different stacks will need to be connected. As CAEM’s current concept of emission capture and control technology for tankers uses only 4 stack adaptors. The emission capture and control technology cannot process all exhaust streams when shifting stack adaptor from one stack to another.

For this risk, the following recommendations are identified during the workshop:

- C&C service supplier to develop pre-arrival communication procedure and communicate the possibility of limiting the shifting of auxiliary engines and boilers while at berth.

If it is found that a tanker needs to shift auxiliary engines or boilers, Vessel Incident Events (VIE) and Terminal Incident Events (TIE) may be used. However, it is to be noted that there is a limit in its usage and is listed here as an observation.

### 7.3.1.15 FMECA 1.17 – Insufficient reach of the placement boom to all emission streams simultaneously due to height and large span of the funnel

The tanker vessel exhaust stacks may be as high as 50 meters above the wharf. The tankers may have two scenarios of berthing orientation, i.e., at the port side or starboard side. The barge-based capture and control technology seems to have a better performance on the flexibility.

In addition, for some tankers, the funnel may have a large span. An example is given by a stakeholder whose ship is using a special double engine room arrangement. Exhaust streams may exist from both the port and starboard sides.

To mitigate this risk, the following recommendations are identified:

- For the shore-based capture and control technology, it should evaluate if it is capable of covering the tankers visiting the terminal considering the size, height of the stack, and berthing orientations.
- For the barge-based capture and control technology, the service supplier shall develop a pre-arrival communication procedure and understand the stack height, configuration, number, and location of operating stacks for the visiting tankers. A bespoken stack adaptor connection method will be developed.

If it is found that the funnel is too wide for the placement boom to reach, Vessel Incident Events (VIE) and Terminal Incident Events (TIE) may be used. However, it is to be noted that there is a limit in its usage and is listed here as an observation.

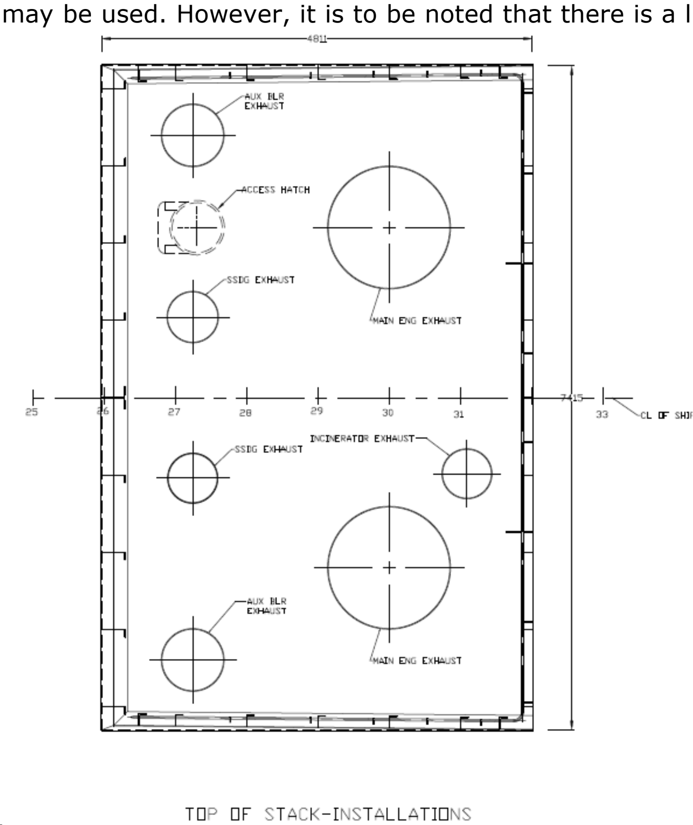



**Figure 7-10 An example of top of stack installation**

#### 7.3.1.16 FMECA 1.20 – Inability of the technology to process all exhaust streams due to higher number of emission sources

Normally, tankers have at least 2 auxiliary engines operating at berth. If the ship has an increased power demand, it is also possible to run 3 auxiliary engines. In addition, commonly 2 boilers may be running at the same time. With the reduced cargo discharge rate at 10 out of 11 berths in LB/LA, it is noted that the common practice is to run 1 generator and 1 boiler.

As a clarification, according to CARB, tankers' inert gas generator emissions are not regulated in the at-berth regulation.

Therefore, there could be up to 4 emission sources to be processed. The total number may also be higher. This is higher than the container vessels which have already been using the emissions capture and control technology.

According to CAEM, the concept for tankers considers using 2 placement booms and each boom has 2 stack adaptors. Therefore, 4 emission streams may be processed at the same time.

The following recommendations were identified during the workshop:

- C&C service supplier to develop pre-arrival communication procedure and understand the number of operating stacks for the visiting tankers.

If it is found that a tanker needs to run more than 4 emission streams, Vessel Incident Events (VIE) and Terminal Incident Events (TIE) may be used. However, it is to be noted that there is a limit in its usage and is listed here as an observation.

#### 7.3.1.17 FMECA 2.4 – Inability of the technology to process all exhaust streams due to high exhaust rate from tankers

The currently CARB-approved Marine Exhaust Treatment System-1 (METS-1) system is approved for container vessels with only one auxiliary engine operating at berth. The approved operating conditions are shown in Table 7-2. This system would be too small for tankers considering the total number of exhaust streams from both auxiliary engines and boilers as well as the potential higher power output of auxiliary engines.

During the workshop, CAEM informed that for the design concept to be used on tankers the exhaust flow rate will be increased. It is recommended to review the range of exhaust gas flow rate of the tankers visiting California and increase the treatment capacity of the capture and control system accordingly.

**Table 7-6 Marine Exhaust Treatment System-1 (METS-1) system approved operating conditions[33]**

| Parameter | Value |
|---|---|
| Ocean-going Vessel Type | Container Vessels |
| Ocean-going Vessel Engine Type | One auxiliary engine |
| Fuel composition limitations | Marine distillate fuel with ≤ 0.1% sulfur content |
| Maximum engine MCR [kW] for each engine type | 2500 kW |
| Allowable operating range [kW] | 600 – 1500 kW;<br>Only one auxiliary engine may be controlled per METS-1 system |
| Exhaust flow rate that can be treated [standard cubic | 1020 to 5100 scfm of engine exhaust |

[33] State of California Air Resources Board, Executive Order AB-15-01

feet per minute (sfcm)]

#### 7.3.1.18 FMECA 3.13 – If the navigation channel is narrow, the usage of barge-based capture and control technology may block the traffic.

The size of the barge that CAEM currently developing is around 31 meters (102 feet) x 18 meters (60 feet). In addition, clearance is also needed between the tanker and the barge as discussed in Section 7.3.1.3. The water channel close by the terminals can be narrow. According to the engaged experienced pilots, typically 46 meters (150 feet) maneuvering room is needed. If the barge is arranged alongside the tanker, it may block the traffic due to the limited width of the channel. A few illustrations are given below.

Figure 7-11 illustrates that if the barge is berthing alongside an Aframax tanker at Berth 78, it will likely prevent the tanker or bunker barge from passing the channel to leave or call Berth 77 and 76. According to the stakeholder, Berth 77 often has Panamax tankers visiting and Berth 76 frequently has bunker barge visiting. Around Berth 86, there is a turning basin. A detailed evaluation has to be performed to investigate whether the traffic will be impacted if the barge is berthing alongside the tanker.

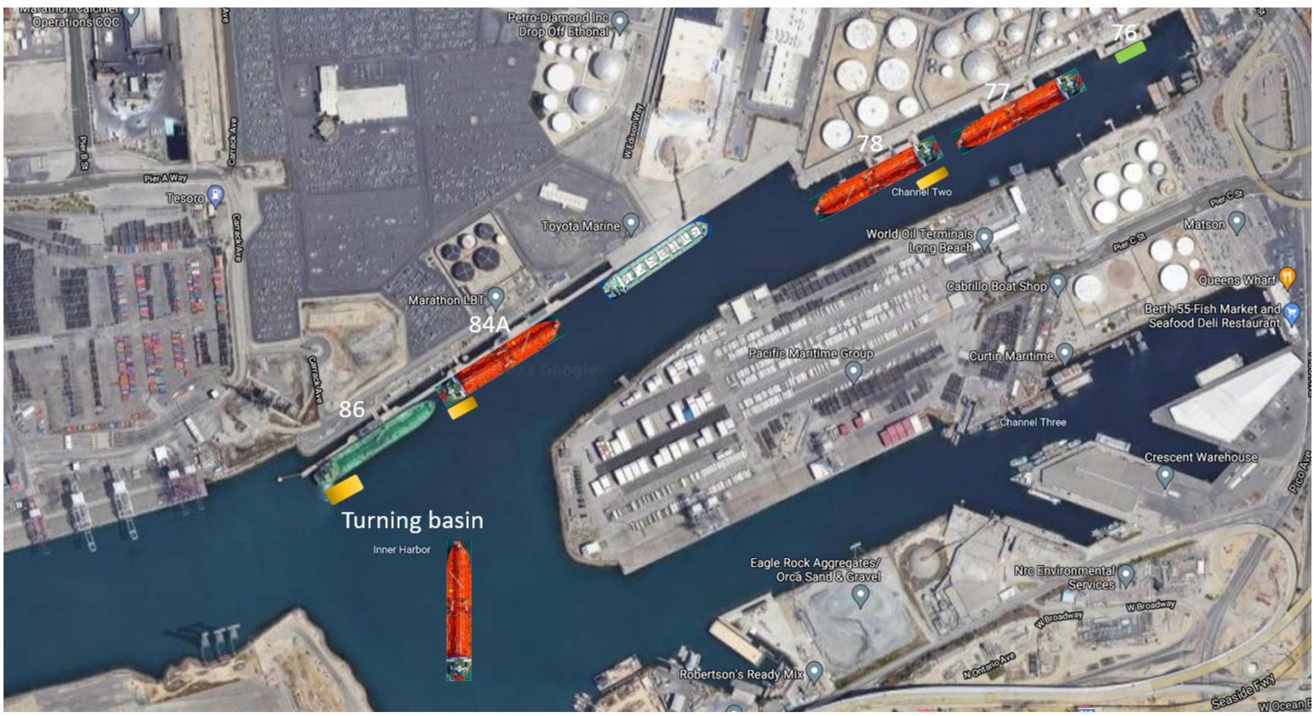



**Figure 7-11 Illustration of the potential impact on the traffic around Port of Long Beach Berth 76 ~ 78, 84A and 86 from the usage of barge-based capture and control technology (The figure is used only for illustration purposes. The measurement is not accurate.)**

On the Carquinez Strait, there are several bridges. The ships must follow a certain route to pass through the bridge. Figure 7-12 illustrates that if the barge is berthing alongside a tanker at marine oil terminals close by the Benicia-Martinez Bridge it may impact the passing traffic on their eastbound way to pass the bridge.


**Figure 7-12 Illustration of the potential impact on the traffic at Carquinez Strait from the usage of barge-based capture and control technology (The figure is used only for illustration purposes. The measurement is not accurate.)**

To mitigate this risk, the following recommendations were identified during the workshop:

- assess the berthing location of barge based on the local traffic and channel navigation system to avoid adverse impact to the passing traffic;
- ensure that the barge is not berthing inside the regulated navigation area;
- consider moving the barge temporary to allow passing traffic following the provision from CARB at-berth regulation regarding removing the capture and control technology temporarily;
- develop real-time communication platform btw all parties (pilot, terminal, capture and control service provider) and install communication and navigation equipment (VHF, GPS, Satellite compass) onboard the barge;
- consider equipping the barge with an automatic identification system (AIS).

#### 7.3.1.19 FMECA 3.2 – Insufficient space at the terminals for installation of shore-based capture and control technology

According to CAEM, the footprint of the technology is around 5.5 meters (18 feet) x 9.1 ~ 15.2 meters (30~50 feet). The height is around 9.8 meters (32 feet).

Similar to the discussion in Section 6.3.1.11, terminals may not have sufficient space for the installation of shore-based capture and control technology. The barge-based capture and control technology could be used as an alternative. Otherwise, a dedicated floating or fixed platform may be needed.

#### 7.3.1.20 FMECA 3.5 – Safety and reliability of operation compromised by improper design and construction of barge

The design and construction of the barge-based capture and control technology needs to consider the different operational profile of the barge given the large variety of terminals it is intended to be deployed. It should also consider the different ship sizes and complexities associated with the potentially complex operations. In case of improper design and construction, this will have an impact on safety and reliability of operations.

If the barge is not operated self-propelled between ports or in open water, but only inside the enclosed area in a port, it may not need to be classed or inspected by US Coast Guard. There are also no industry vetting standards for these barges according to DNV's knowledge.

To mitigate this risk, the following recommendations are identified during the workshop:

- class the barge with a classification society and implement a periodical inspection and maintenance plan
- determine the operating area and clarify with US Coast Guard on the regulatory requirements

#### 7.3.1.21 FMECA 3.14 – Potential encroachment of neighboring property during deployment of capture and control technology

Regarding the potential berthing location of the barge, one possibility is at the stern of the tanker. However, it may involve the risk of encroachment on other's property. An example is given below. It shows that if a tanker is berthing on the port side at Shell Oil Products US Mormon Island Marine Terminal LA Berth, there will be too limited room for berthing the barge in Shell's property. This will involve encroachment on Tinto Minerals' property and impact the ship calling their terminal.

Combining the discussion in Section 7.3.1.18, another possibility is berthing the barge alongside the tanker. It may block the traffic from entering or leaving the channel especially when there is a vessel berthing at Berth 153.

The following recommendations are identified during the workshop to mitigate this risk:

- To review the possibility of berthing the barge at the stern of the tanker, the footprint of the barge should be assessed. Discussion with the neighboring property owner(s) regarding the possibility of using their property may be needed. This should be performed together with the assessment of the local traffic and channel navigation system to identify the feasibility and most preferable berthing location.


**Figure 7-13 Illustration of the property boundary line of terminals (The figure is used only for illustration purposes. The measurement is not accurate.)**

## 7.3.2 HAZOP

The HAZOP workshops identified a total of 12 risks. Out of the 12 risks, 2 risks were seen to be more relevant for tankers. Both the risks identified were medium risks. All the risks relevant for tankers are highlighted in this section and the details can be found under Appendix 7.4. The risk matrix is as indicated in Figure 7-14 below with risk ids denoted with a # followed by number that relates to type of risk considered. Also refer to Appendix 7.

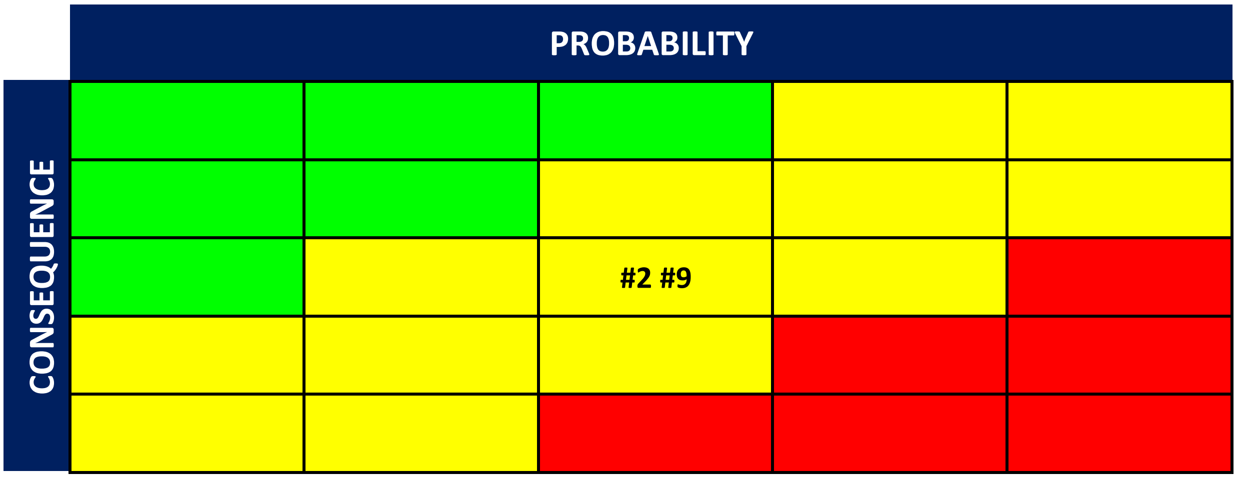



**Figure 7-14 Risk matrix for HAZOP**

#### 7.3.2.1 HAZOP 2 - Safety risk due to human fatigue from long and complex operation of tankers

While at berth, tankers have a relatively complex and long operation. A VLCC may stay in a port for discharging for 3 days. It may cause human fatigue and increase the safety risk.

It is recommended to:

- develop proper training and operation procedures for the whole process including:
  - normal operations such as connection, startup, disconnection, and maintenance
  - emergency response including safety plans
- provide accommodation and ensure proper working conditions for the crew
- develop proper working schedule and shifts for the crew and ensure the proper rest.

#### 7.3.2.2 HAZOP 9 – Potential fire or explosion from the technology in the event of an oil spill

Oil spillage is a highly relevant hazard for tankers. In the event of oil spillage, potential sources of ignition should be eliminated.

It is recommended to:

- Develop a safety/emergency response plan with terminals and ports for oil spill scenarios. The barge will likely need to shut down power and provide shelter (accommodation) for the crew onboard.
- Provide proper procedure and equipment for communication between the emergency response team, tanker, terminal, port, and capture and control service provider.
- Provide necessary PPE during such incidents

# 8 TIMELINE AND COST ESTIMATION

This section will discuss the timelines and costs for the design, permitting, and construction of the technologies assessed to meet the CARB At-Berth regulation as well as an update on the timing of applicable design and operational standards. Estimates are based on available information and input provided by the stakeholders in this project. DNV also used experience and data on the cost and timeline from other projects when considered relevant to this study (e.g., on the shipboard installation and shoreside capital costs). The timeline is a high-level estimation broken down into major milestones at the year/half year granularity. The purpose will be to evaluate a minimum but realistic timeline to implement the technology and comparing it with the timeframe of 2020 At-berth Regulation shown in Table 2-2. A similar approach is used to estimate the capital cost which may include vessel and terminal modifications, procurement of the technologies, etc. The operational cost was analyzed based on the categorized tanker and terminal versions.

DNV recognizes that the technologies reviewed in this report are also evolving. As an example of this, we acknowledge that CARB has granted the South Coast Air Quality Management District (SCAQMD) $10 million dollars to develop a barge-based C&C system. As a result of the work associated with the grant, the hurdles identified in this report may be addressed and result in earlier adoption than determined here. The timelines provided in this section represent DNV’s best assessment of the technologies based on their current status. Section 9 also provides a view into the broader energy and fuel transition happening in the maritime industry including the use of environmentally friendly fuels and energy sources to achieve emissions reductions greater than those provided by the technical design and operational measures alone.

## 8.1 Shore Power

The following subsection provides details on the timing of applicable design and operational standards, the timing of permitting, design and construction, and the costs associated with shore power technology.

### 8.1.1 Timing of Applicable Design and Operational Standards

In DNV’s opinion, for wide, large-scale implementation of shore power technology, further development of industry standards, regulations, and classification societies rules is required. The gaps in the standards, regulations, or absence of industry guidelines for shore power are likely to delay implementation, increase safety risks, or lead to confusion over technology deployment and investment.

This is especially a concern regarding use of shore power for tankers at berth because the cargo operations involve hazardous products and interfaces with hazardous zones on the terminals and onboard the ship. The explosion and fire risks, as well as personnel risk must be mitigated to be as low as reasonable possible. The global trading pattern of oil and product tankers, the differences in the vessel designs, power needs, and sizes, as well as the lack of standardizations of terminal configurations and shore power cable managements system for tankers needs to be considered. Oil terminal and tanker operations also require specialized crews with relevant training and certifications required during cargo operations. The monitoring, operation, and maintenance of the system and components used when connecting and using shore power will also require planning, training, drills and documentations.

That these concerns are shared were evident from the stakeholders engaged in this technology assessment and risk workshops for this study. To address those concerns, a common framework anchored in industry regulations or guidelines should be developed, but there is currently no timeline for addressing these gaps, and it is unclear who is responsible for initiating these efforts.

DNV

In Section 6.1.3, relevant agencies, industry associations, existing regulatory framework, and standards relevant to shore power use for tankers at berth were listed.  Of these, DNV, during this technology assessment, has identified standards, agencies, and industry groups that would have a more significant role on the safe implementation of shore power for tankers in California ports and worldwide. Table 8-1 lists the regulations, rules, standards, and guidelines identified from Section 6.

**Table 8-1. Status of regulations, rules, standards, and guidelines**

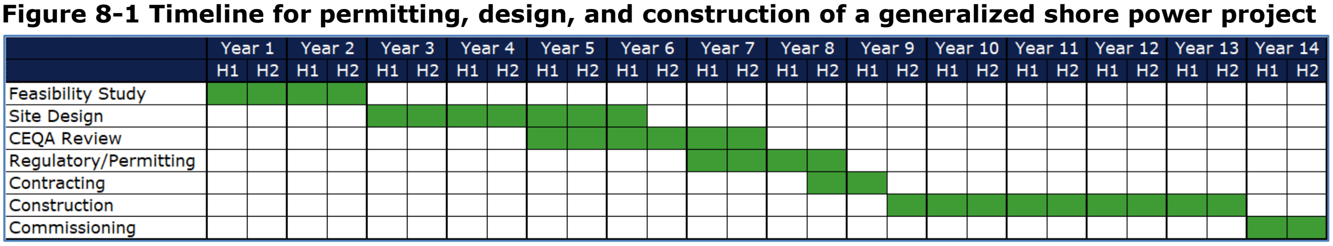
| **Regulations, Rules, Standards, and Guidelines** | **Need** | **Timeline** | **Status** |
|---|---|---|---|
| **IMO Regulation**<br>Interim Guidelines on safe operation of on-shore power supply (OPS) | Interim guidelines need technical modifications and eventually approved at MSC 105. Focus will be on operational requirement and this is was the comment from the IMO Correspondence group following the draft guideline submitted by China | Interim guideline could be approved at MSC105, May 2022. | Interim guideline refer to IEC/IEEE 80005-1 for design requirements |
| **IACS/ Classification Society Rules** | IACS:  recommended practice<br>Class:  Tanker specific shore power rules/class notation | 1-2 year | Under discussion |
| **International Standards regarding Interoperability**<br>– IEC / IEEE 80005-1:2019, High voltage shore connection | Lack of<br>IEC/IEEE joint WG need participation from industry to develop tanker specific requirement | 2-3 years | Under discussion |
| **Maritime Industry Guidelines**<br>International Safety Guide for Oil Tankers and Terminals (ISGOTT) | A new edition to include use of shore power during cargo operations | 2 -3 years | Not aware of any ongoing work on updates of these guidelines with a focus on shore power |

### 8.1.2 Timeline for Permitting, Design, and Construction

While each terminal has its own set of unique characteristics that will impact the timeline, a typical shore power project is likely to take around 14 years years making it very unlikely that any ports will be able to comply with the 2020 At-berth Regulation timeline. For larger and more complex terminals, additional time will be required to complete each step due to the larger scale of the engineering, design, and construction effort. This timeline also assumes that the necessary design and operational standards exist, which is discussed in the previous subsection. This section presents generalized durations for the various components of a project: feasibility study, site design, California Environmental Quality Act (CEQA) review, permitting, contracting, construction, and commissioning. Actual timelines may vary depending on the unique challenges associated with each terminal.

Figure 8-1 presents the generalized timeline for a shore power technology installation. These tasks, and their uncertainty, are explained below. Some of these major tasks can be undertaken concurrently to minimize total project timeline; however, some tasks must be completed before the next task can commence.

**Figure 8-1 Timeline for permitting, design, and construction of a generalized shore power project**



**Feasibility study**

The first step for each terminal is to conduct a feasibility study to determine the appropriate, cost-effective technology that can be installed and operated safely. This will inform the site design and ensure a correct layout and structural design to support the necessary equipment. Any feasibility study needs to consider the availability and applicability of internationally accepted standards for interfacing and design. This feasibility study also needs to consider the reliability of power supply given California's recent power generation and transmission issues due to natural disasters. This stage would likely take at least two years to complete in order to properly assess the solution and its alternatives. As part of this stage, the local electricity provider will also need to conduct an assessment of how additional electrical demand will impact the grid, which can take up to a year to complete in conjunction with the site feasibility study. If there are multiple projects in a utility service area, this assessment needs to consider the cumulative impacts of the increased demand.

**Site Design**

The site design cannot commence until a feasibility study is completed to determine the appropriate technology and layout. This site design includes the preliminary and final design and engineering, assessments on utility infrastructure, and siting for egress and safety. The site design may take up to 3.5 years to complete, and depending on the complexity of the site design, could take as long as 5.5 years.

**CEQA Review**

Since any potential project is likely to have a significant effect on the environment, a CEQA review is required. To provide an accurate and stable project description, this review cannot begin until around 60% of the design is completed. This review could require preparation of an Environmental Impact Report (EIR), public comment periods, hearings, and review of the EIR until a final adopted EIR results with specific mitigations for impacts. Based on a review of recent marine projects in California, this is likely to take approximately 3 years. Additional permitting cannot begin until the CEQA review is completed.

**Regulatory/Permitting**

After completing the CEQA environmental review process, projects need to receive permits or regulatory approvals from:

- Local: The local air quality control/management district, local Regional Water Quality Control Board, and building permits and/or coastal development permits from the local city/county
- State: California State Lands Commission, California Department of Fish and Wildlife, and coastal development permits from the California Coastal Commission (if not delegated to the local city/county)
- Regional: San Francisco Bay Conservation and Development Commission (for northern Californian terminals)
- Federal: United States Army Corps of Engineers, U.S. Fish and Wildlife Service (if protected species are affected), National Marine Fisheries Service (where marine mammals may be present), and the United States Coast Guard

Because of the time required to prepare applications across agencies and jurisdictions, time for review and addressing comments, and the potential that requested changes may results in site re-design, this is likely to take about 2 years and potentially longer.

**Contracting**

While the project team is pursuing the appropriate permits, contracting for engineering, contractors, and suppliers can bid. This process includes a bidding (multiple RFPs), selection, and procurement. This can take up to a year or longer to complete.

**Construction**

The shoreside construction phase is largely dependent on the complexity of the site design. This can include crane construction/installation, deck modifications, pilings, new power infrastructure/substation upgrades, cable installation/new ducting, and seismic retrofit. We estimate that this is likely to take about 4.5 years but could range to more than 7 years.

**Commissioning**

After construction is complete, commissioning is required to verify CARB compliance and other federal and state requirements, implement operator training and oversight, and modifications to ensure proper operation to achieve compliance. Newer technologies require longer commissioning durations.  We estimate this is likely to take about 1 year to complete.

### 8.1.3 Costs for Vessel Modifications

The installation for shore power technology on tankers will typically be incurred by the vessel owner and will vary depending on a variety of factors.  The installation costs are lower for new vessels compared to retrofitting existing vessels.

Depending on the number and location of the connection points, the additional costs, including the equipment costs, for shore power technology on new vessels are estimated to be between $350k and $700k. The capital cost for the equipment is the largest share of the cost, but since the equipment cost and installation expenses are most often included in the total newbuilding cost given by shipyard to the owner, there is a wide range and some uncertainty in the range. However, since the number of the tanker calls at California will be dominated by vessels already in service without the technology installed at the newbuilding phase, the rest of this section will focus on retrofitting existing vessels.

For existing vessels, the cost is dependent on the vessel type, size, vintage, and the need for an onboard transformer. The typical cost for a tanker ranges from about $150,000 to around $1M. For smaller vessels, costs range from about $70,000 to $500,000, and for larger vessels, the costs range from about $500,000 to $1M. If shore power connections are added to both sides of the vessel, costs can be higher. Similarly, if vessels require new electrical cargo pumps/variable frequency drives (VFDs), the cost estimates for vessel modifications can increase to $2-3M.

The key components driving the cost include the distribution system, control panel and junction boxes, cable winch (can also be found on the berth side) and connection unit, and any frequency converters. Table 8-2 shows the typical cost ranges for different size vessels assuming an onboard switchboard connection point and high voltage switchboard updates/additions with the connection point aft of the hazardous zones (no use of safe house midship close to the manifold) .[34] The table illustrates that there are large uncertainties in the cost estimates, and because the technology is still relatively new in the tanker segment and the risk mitigation is even more critical, costs may be higher than what is presented. Additionally, how the retrofit is done, e.g. incremental in steps or during a single shipyard stay can also impact costs significantly (and are not represented in this table). [35]

**Table 8-2. Cost ranges for tanker vessels retrofits**

| | 1,000 – 4,999 GT | 5,000 – 9,999 GT | 10,000-24,999 GT | 25,000 GT - 49,000 GT | 50,000 – 99,000 GT | >=100,000 GT |
|---|---|---|---|---|---|---|
| **Crude Tankers** | $70,000 - $420,000 | $140,000 - $550,000 | $140,000 - $550,000 | $140,000 - $550,000 | $420,000 - $1,040,000 | $420,000 - $1,040,000 |
| **Chemical/product tankers** | $70,000 - $420,000 | $140,000 - $550,000 | $420,000 - $1,040,000 | $420,000 - $1,040,000 | | |
| **Gas tankers** | $70,000 - $420,000 | $420,000 - $1,040,000 | $420,000 - $1,040,000 | $420,000 - $1,040,000 | $420,000 - $1,040,000 | $420,000 - $1,040,000 |

These price ranges are consistent with a 2004 shore power cost effectiveness study commissioned by the POLB. The study included an analysis of twelve vessels, including several tankers, and concluded that the average cost to retrofit vessels with shore power technology was $725k (adjusted for 2021 USD).[36]

The above vessel modification costs assume that the shore power connections will be behind the accommodation area and outside the hazardous zones on deck so there is more flexibility to how it will be arranged. In order to connect at the cargo manifold area, connections within the hazardous zone requiring the design and construction of a specialized pressurized and inerted deckhouse (safe room) with an airlock to house the connection point for the shore power is foreseen.  The cost of this arrangement would be significantly higher than the retrofit costs in the above table. The deckhouse option also has a safety design challenge since the cable will have to enter the room itself and then the space would have an opening to a hazardous zone.

In May 2019, the California Air Resources Board (CARB) Staff estimated costs for vessel retrofits for the Standardized Regulatory Impact Assessment. Based on a June 2018 survey, CARB assumed an average cost per vessel was $2,256,278 based on a range of $1,612,556 to $2,900,000.[37] Some of the cost estimates include shore power on the second side of the vessel; however, these values are higher than the DNV estimates provided above.

[34] Cost values developed as part of a 2015 study conducted by DNV examining shore power at Norwegian ports. Numbers have been converted to 2021 USD using an average annual inflation rate of 2.42% (US Bureau of Labor Statistics).

[35] Esimated costs for shorepower conversions for tankers around 10 mUSD for vessel with steam driven cargo pumps has been reported, and more than twice that for tanker vessels with electric driven cargo pumps

[36] https://sustainableworldports.org/wp-content/uploads/Long-Beach.pdf

[37] https://ww2.arb.ca.gov/sites/default/files/2020-04/costassumptions_may19_ADA.pdf

### 8.1.4 Costs for Shoreside Modifications

The costs for shoreside modifications vary greatly depending on the unique challenges of each terminal. This results in wide range of costs depending on the space constraints and required distance of electrical runs. Each terminal will require a feasibility study to determine the optimal arrangement and expected costs for modifications. These feasibility studies are not transferable to other terminals because of the unique terminal arrangements and the vessels that they serve. For a typical shoreside modification with limited complexities, the installation of shore power costs between $2.5M – $14M per berth, including interconnections to the grid. Depending on the number of berths, outlets per berth, and supporting infrastructure needs, costs can exceed $20M per terminal. Facilities with multiple berth facilities may have lower capital costs per berth due to economies in design, permitting, and costs of share infrastructure.

The one tanker terminal with existing shore power connections in California is the Marathon Oil Terminal on Pier T (Berth 121) in POLB. The project was completed in 2009 and included a shoreside switchgear and transformer, which was located next to the port substation, and a cable management system platform (crane on ship).  The shore power connection was built to serve the Alaska Tanker Company's four oil tankers, and these ships are diesel electric and uses electric driven cargo pumps.

The costs presented in this section provide a typical capital cost range for the main components of the shoreside infrastructure. These modifications typically include costs for main substation, shoreside substation, and berth components. In estimating the capital costs for a specific OPS installation, the costs of extending power from the port's substation to the shoreside substation and, potentially, the costs of increasing the capacity of the substation must be accounted for. These costs only represent the CAPEX costs and do not include O&M or energy costs. Table 8-2 outlines the cost ranges for the main shoreside components. Actual costs may be higher depending on specific berth arrangements. If a terminal does not have sufficient space to accommodate the shoreside infrastructure, there will likely be additional costs associated with expanding the terminal footprint.

**Table 8-3. Shoreside component cost estimates**

| Component | Costs | Notes |
|---|---|---|
| **Substation Upgrade** | $100K - $7M | Includes upgrades to main substation and cabling to shoreside substation. Costs will vary depending on status of main substation and distance to shoreside substation. |
| **Shoreside Substation** | $1M - $3M | Includes shoreside switch gear for feed and isolation of each SPO. |
| **Berth Components** | $500K - $3M | Includes shore power outlet, cable vault, and cable extender. Total cost of berth components dependent on number SPOs and arrangement of cable vault. |

As part of the May 2019 Standardized Regulatory Impact Assessment, CARB staff estimated the cost for shore side modifications using June 2018 survey values at $21,983,333 per tanker berth. These costs ranged from $2,250,000 to $40,000,000 per berth. Costs from container terminal OPS installations also offer insights into expected costs for tanker terminal OPS installations; however, there are some significant differences in the terminal configurations and complexities with tanker interfacing that make OPS more challenging and more expensive. The POLA and POLB developed cost estimates for tanker terminals based on previous shore power construction projects and cost estimates for future shore power work. Using and average cost per SPO of $2,272,609 and $500,000 for a 100-foot cable reel management system, assuming 2 SPOs per berth, the average costs per berth was about $5 million, not including any potential upgrades or connections in the main substation or expansion of the terminal footprint.

## 8.2 Capture and Control Technology

The following subsection provides details on the timing of applicable design and operational standards, the timing of permitting, design and construction, and the costs associated with capture and control technology.

### 8.2.1 Timing of Applicable Design and Operational Standards

To ensure the safe operations of a barge-based or shore-based control system during the transfer of hazardous cargo, there should be international standards and guidelines to accommodate all vessels and vessel interfaces safely. While there are standards for barge construction and operations,[38] there are currently no standards for exhaust capture operations while transferring hazardous cargo at a terminal. The gaps in the standards, regulations, or absence of industry guidelines are likely to delay implementation, increase safety risks, or lead to confusion over technology deployment and investment. Similar to shore power, a common framework anchored in industry regulations or guidelines should be developed, but there is currently no timeline for addressing these gaps, and it is unclear who is responsible for initiating these efforts.

Manufacturers have not yet designed or built capture and control systems that would qualify under the 2020 At-berth Regulation. However, while there is currently no ready to use capture and control technology deployable for tankers, a barge-based system that is currently being designed would likely qualify under the 2020 At-berth Regulation and could be ready for operation by 2025. Shore-based capture and control technology has never been implemented on tankers and needs to be proven that it can be deployed before wide-scale implementation.

### 8.2.2 Timeline for Permitting, Design, and Construction

Based on the infrastructure needs and permitting process, the timeline for a land-based capture and control project will be similar to the that of a shore power project – 14 years. Based on that timeline, a land-based system is currently not a viable option to meet the regulatory deadlines. The earliest that a land-based system can be implemented is 2034. Because of the similarity with shore power infrastructure requirements and the uncertainty around the technology, the rest of this section presents a timeline for a barge-based capture and control project.

The timeline for implementing a barge-based capture and control technology is about 5 years.[39] This timeline also assumes that the necessary design and operational standards exist, which is discussed in the previous subsection. If there is a proven, off-the-shelf technology that was safe for use on tankers and boilers, many of the early steps could be bypassed or the timeline shortened. Figure 8-2 shows a generalized timeline for a barge-based capture and control project. The timeline estimates for preliminary and detailed engineering, construction, and commissioning are based estimates provided by an engineering

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[38] Example: ABS Rules for Building and Classing Steel Barges (2021)

[39] This timeline assumes that there is no need to conduct a CEQA review or any other environmental permitting. If an environmental review of the barge operation is required, this could extend the project timeline 1-2 years.

firm that has already completed a feasibility study and engineering for a Maritime Emissions Treatment System (METS) barge that is expected to available for use by 2025 at Long Beach/Los Angeles terminal. Details of the capacity and specifications of the METS barge for tankers are work in progress.

**Figure 8-2. Timeline for permitting, design, and construction of a generalized barge-based capture and control project**


The starting point for a terminal looking at a barge-based capture and control system is the preliminary feasibility study. A feasibility study is needed for each terminal to determine the feasibility of the technology for each terminal. This should include environmental conditions, navigation and ship access, vessel activity, and space restrictions. Barge-based capture and control systems may not be available for all berths such as those in area-restricted ports and within bays that are subject to severe waves and tides. Any feasibility study must be terminal specific and cannot be used by other terminals; however, terminal feasibility studies need to also consider the cumulative impacts (e.g., limited wharf availability) of multiple barge-based systems at port. Many of the terminal compliance documents for CARB may contain much of this work reducing the total timeline.

At least one vendor has completed the preliminary engineering and has nearly completed the detailed engineering for a barge-based system that is expected to meet CARB requirements, so the key remaining elements in the timeline are a terminal-specific HAZOP and construction. As part of the initial construction phase, the barge must be lofted, and production-level drawings developed. This process can be expedited for simple barges, but it is probably 3 months in total duration. After that is completed the typical construction timeline for self-propelled barge of this nature is likely another 8-14 months. The final step in the timeline is the commissioning phase which concludes with an operating permit from CARB.

### 8.2.3 Costs for Capture and Control Technology

Since no capture and control systems are currently deployed on tankers, there are is still a lot of uncertainty the costs estimate. For land-based systems, CARB estimated costs, as part of the Standardized Regulatory Impact Assessment,[40] at about $16.5 million per berth in capital expenses. This includes $4.5 million for piping infrastructure from the berth to the land-side emission control system, $5 million for the emission controls system, and $7 million for each loading crane. These costs are highly variable based on the existing berth arrangement and available wharf space, but the values are a reasonable estimate for the total capital costs.

For barge-based systems, the capital costs make up a smaller portion of the total costs due to higher operating and administrative costs. However, there are other advantages to barge-based systems including

[40] https://ww2.arb.ca.gov/sites/default/files/2020-04/costassumptions_may19_ADA.pdf

their ability to move and support multiple berths. The CARB estimates of $4.9 million for the barge construction[41] understate to total capital costs required. Costs will be even higher for terminals further north due complications around wind and currents. Any system should be designed in a way that does not require vessel modifications, so all of the capital costs will be on the terminal side. In addition to the capital costs, there will also be leasing/port fees, fuel costs, labor costs, and maintenance costs.

[41] https://ww2.arb.ca.gov/sites/default/files/2020-04/costassumptions_may19_ADA.pdf

# 9 ENERGY AND FUEL TRANSITION IN SHIPPING

Globally, there is increasing demand for solutions to reduce emissions from the maritime industry with the use of cleaner energy sources. More stringent emission regulations have driven the demand for more use of environmentally friendly fuels and energy sources to achieve emissions reductions greater than those provided by the technical design and operational measures alone. This trend is being accelerated as the IMO implements its strategy for the reduction in greenhouse gas emissions from international shipping and shipowners face the prospect of stricter requirements on the carbon intensity of their operations, moving towards the eventual goal of eliminating shipping greenhouse gas emissions in this century.

This development, driven both by global and regional regulations and policies, as well as other maritime stakeholders, e.g., the finance institutions, shippers, and cargo owners, will drive a transition from the traditional fuels and energy sources currently used by ocean-going vessels. Additionally, energy efficiency improvements and innovative technologies will also need further development to achieve the targets set by the maritime industry.

This transition is already underway with rapid growth in the newbuilding orderbook of new ships, especially during the last year, including tankers, are being ordered with alternative fuels, like LNG, LPG, methanol, biofuels as well as early designs based on ammonia as a fuel. The new fleet and fuel mix of the future will also affect the air emissions when at berth, and there might be less need or different needs for reducing the at-berth emissions.

## 9.1 Regulatory Drivers

The International Maritime Organization (IMO) is the main regulatory body for commercial ships trading in international waters. Its policies drive important environmental and safety standards that push the implementation of measures for reduction of emissions in the industry. In 2018, the IMO adopted a resolution on an Initial Strategy to reduce GHG emissions, with ambitions for reducing total emissions from shipping at least by 50% in 2050, and to reduce the average carbon intensity by 40% in 2030, compared to 2008.

The IMO has not yet decided on specific pathways for GHG emission reductions but has committed in its initial strategy to implement an escalating series of measures. Short-term measures focused on improving the energy efficiency (EEXI) and carbon intensity (Carbon Intensity Index or CII) of the existing fleet are to enter into force in 2023 as decided at the Marine Environmental Protection Committee Meeting (MEPC 76) in June 2021. The IMO is also scheduled to review the Initial Strategy in 2023, at which point the focus is expected to shift to mid-term measures which may include requirements to implement alternative fuels, global $CO_2$ pricing measures, or a carbon content limit on fuels permitted for use by international shipping, alongside tightening of existing design and operational measures.

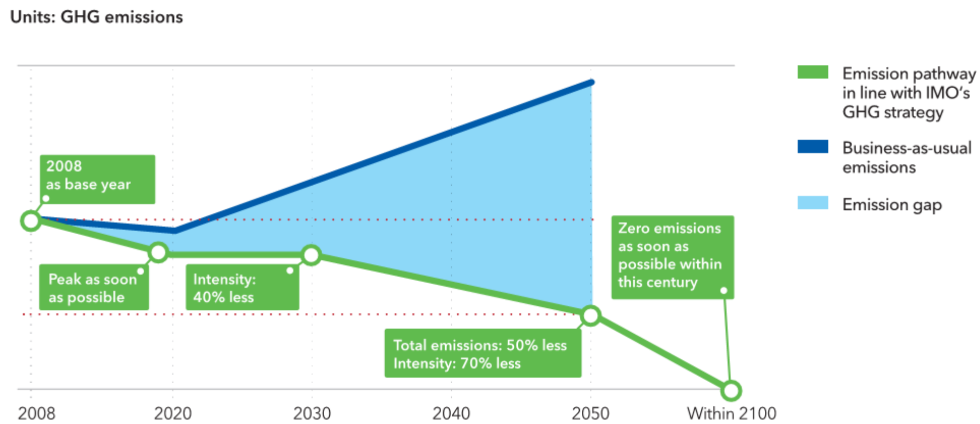



**Figure 9-1 Indicative world fleet GHG emissions pathway to meet IMO ambitions**

While the IMO vision and strategy has been submitted to the United Nations Climate Change Conference process and is widely seen as compatible with Paris Agreement goals, it is of course possible that a growing international sense of urgency may force a significant acceleration of the IMO's plan. Taking for example a scenario where deep decarbonization (e.g. significantly more than 50% reduction by 2040) became a goal then earlier adoption of carbon-neutral fuels would be required, in addition to stricter design, operational, and market-based measures.

## 9.2 Decarbonization of shipping

DNV has since 2017 produced an Energy Transition Outlook (ETO) report to help energy stakeholders and decision-makers responding to a changing energy landscape. The maritime part of the ETO is called the "Maritime Forecast to 2050" (MF2050). MF2050 provides an independent outlook on the maritime energy future, including marine vessel fuel use. The 2019 version of MF2050 focused on the challenges facing the maritime industry in meeting the IMO GHG reduction targets, and the potential implications for maritime stakeholders. It concluded that new fuels, alongside energy efficiency, will play a key role in meeting the IMO GHG targets for 2030 and 2050.

MF2050 includes a model of the different scenarios to reduce the GHG emission from shipping that will meet or even exceed the IMO stated ambitions. Figure 9-2 Uptake of Alternative Fuels – Forecast scenario to meet IMO ambitions with focus on design requirements is taken from the 2019 MF2050 and shows one forecast scenario for energy use and projected fuel mix 2018–2050, assuming a regulatory environment in line with current IMO ambitions and with most measures focused on design requirements for new ships.

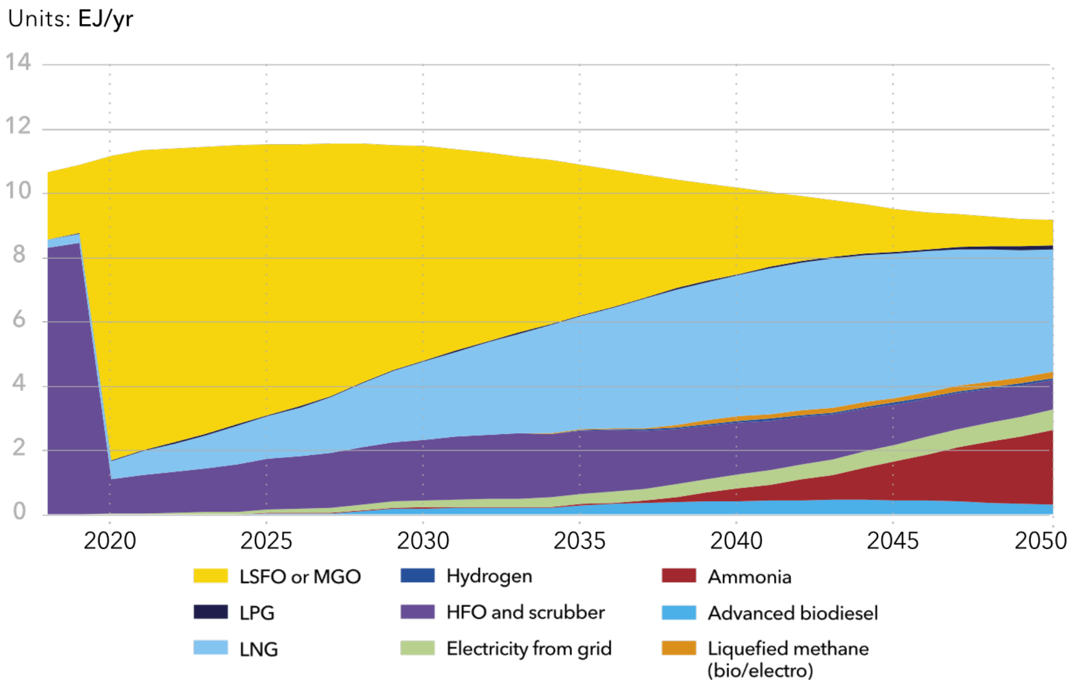
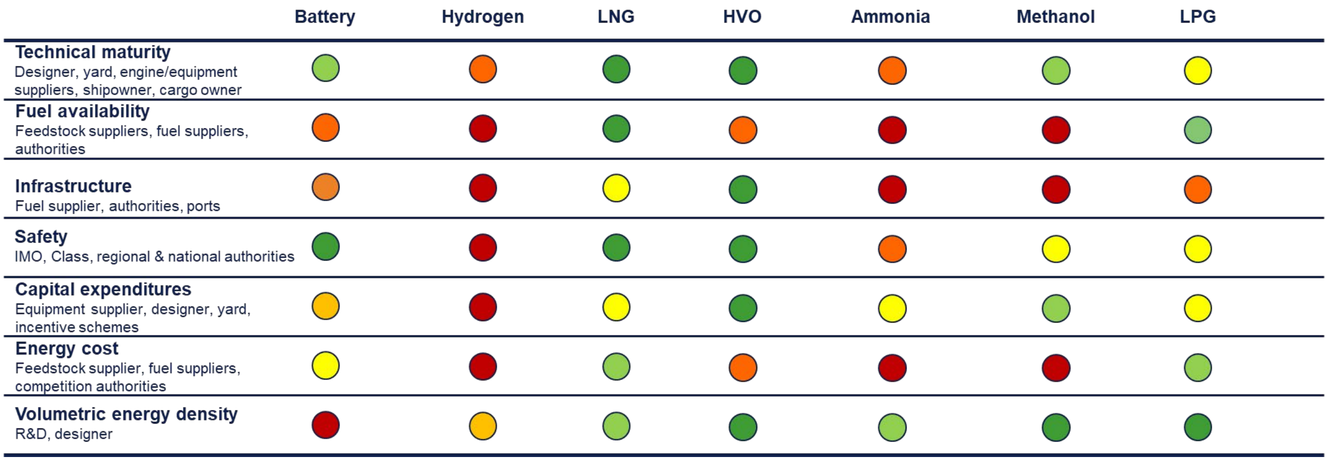



**Figure 9-2 Uptake of Alternative Fuels – Forecast scenario to meet IMO ambitions with focus on design requirements**

It is noted that the actual fuel mix in the future will depend on many factors.

The use of shore power or Onshore Power Supply (OPS) while a ship is in port, rather than the use of the ship's auxiliary engines is also considered as a measure to reduce the environmental impact of shipping and to improve the air quality in the ports. Major ports in Europe, the North-East and West coasts of North America, and now increasingly in Asia have installed OPS facilities. There are shore power facilities for ocean-going vessels in at least 13 North American ports, with several others currently under development. An important consideration for a feasibility assessment is to focus on the operational, economic, and business aspects of shore power. Several jurisdictions, beyond California, have implemented or are considering regulatory requirements or incentives for the use of OPS for ships during port stays.

As the pressure for reducing emissions even further, owners are also looking for other fuels that could help to achieve these targets. Currently, many fuels are being considered as a possible solution for tackling emissions in the maritime industry, with different sources and levels of maturity, but with common issues: availability, cost of production, safe storage, and others.




Technical maturity – refers to technical maturity level for engine technology and systems
Fuel availability – refers to today's availability of the fuel, future production plants, and long-term availability.
Infrastructure – refers to available infrastructure for bunkering
Safety – refers to rules and guidelines related to the design and safety requirements for the ship and onboard systems.
Capital expenditures – cost above baseline (conventional fuel-oil system) for LNG and carbon-neutral fuels, i.e. engine and fuel-system cost.
Energy cost – reflects fuel competitiveness compared with MGO, taking into account conversion efficiency.
Volumetric energy density – refers to the amount of energy stored per volume unit compared with MGO, taking into account the volume of the storage solution.

**Figure 9-3 Alternative Fuels - Barriers in 2020 (source: MF2050)**

A brief description of some alternatives is given here:

**Energy Storage Systems** – Energy is stored onboard in battery cells used to provide power for hotel loads, specific consumers, and/or propulsion. While the technology is consolidated and available globally. These batteries can be charged when the vessel is at port or while sailing through other renewable sources onboard. While the technology is consolidated and available globally, the biggest challenge is the very low energy density, which allows for use only in smaller vessels sailing short routes. New technologies are under development for increasing storage capacity.

**LNG -** The must technical mature and viable alternative fuel currently, natural gas from LNG is the cleanest fossil fuel available today. There are no SOX emissions related to it, particle emissions are very low, the $NO_X$ emissions are lower than those of MGO or HFO, and other emissions such as HC, CO or formaldehyde from gas engines are low and can be mitigated by exhaust gas after-treatment if necessary. Nevertheless, methane releases must be considered when evaluating the CHG reduction potential of LNG as ship fuel, as well as the overall well-to wake GHG emissions. The use of Bio-LNG and e-LNG, as well as renewable diesel fuels are options to reduce the GHG emissions from dual fuel engines.

**Hydrogen** – With an energy density 2.6 times greater than LNG (140MJ/kg versus 53MJ/kg), hydrogen is seen as a good candidate, but it also brings safety concerns for storage at port and onboard. Burning Hydrogen does not produce GHG gasses, but the generation of clean hydrogen with no carbon footprint requires higher amounts of energy and comes at higher costs. Due to its low specific gravity, it's only feasible if stored in compressed ($CGH_2$) or liquid forms ($LH_2$). While the latter has the highest volumetric energy density (10 MJ/l), it must be stored at very low temperatures (-252ºC) leading to additional challenges for transportation and storage onboard.

**HVO** – Hydrogenation-derived renewable diesel (HVO / HDRD) is the product of fats or vegetable oils - alone or blended with petroleum - refined by a hydrotreating process known as fatty acids-to-hydrocarbon hydrotreatment. Diesel produced using this process is called renewable diesel to differentiate it from biodiesel, for example, FAME. $CO_2$ emissions are significantly lower with this fuel and replace diesel without significant changes onboard. Main challenges are the high cost of production and limited availability globally.

**Methanol:** The main upside for methanol is the relatively good performance on applicability, being able to utilize existing engine and low tank costs, which further translates into low capital costs. On the other side, a major downside to methanol as an alternative fuel is its environmental performance if produced from fossil sources. Fossil based Methanol is priced close to, or higher than MGO in today's market. Bio-methanol and e-methanol can offer very low GHG emissions on a lifecycle basis but with higher cost, but availability and infrastructure is very limited currently.

**Ammonia** – Like Hydrogen, the combustion of Ammonia as a fuel does not result in any direct carbon emission. Both gases present similar challenges for use onboard, but Ammonia has a slight advantage as it does not requires extremely low temperatures and has volumetric energy density slightly higher than hydrogen and about half as that of MGO. The main concern for ammonia is safety, as exposure can happen not only through inhalation but also through contact, causing severe health effects.

**LPG -** Low energy cost (close to LNG) and low capital costs make a compelling economic case for LPG. However, operational experience is limited, thus the maturity level is medium. In addition, the lack of bunkering infrastructure is a barrier for using LPG as an alternative marine fuel. Moreover, a major downside to LPG as an alternative fuel is its environmental performance when produced from fossil sources.

# APPENDICES
## Appendix 1 – List of Engaged Stakeholders

| Category | Role | Entity |
|---|---|---|
| **Regulator** | State | CARB |
| **Regulator** | Federal | USCG |
| **Regulator** | Local | South Coast AQMD |
| **Regulator** | Local | Bay area AQMD |
| **Regulator** | International | EMSA |
| **Technology supplier** | Capture and control | Clean Air Engineering-Maritime (CAEM) |
| **Technology supplier** | Capture and control | STAX Engineering |
| **Technology supplier** | Shore power | ABB |
| **Technology supplier** | Shore power | Cavotec |
| **Associations** | Associations | WSPA |
| **Associations** | Associations-Ship | OCIMF |
| **Associations** | Associations-Ship | INTERTANKO |
| **Associations** | Associations-Pilot | Pilot Associations |
| **Terminal** | Terminal-SFO, LB/LA | Chevron |
| **Terminal** | Terminal-LA | Shell |
| **Terminal** | Terminal-SFO, LB/LA | Valero |
| **Terminal** | Terminal-LA | PBF Energy |
| **Terminal** | Terminal-LA | Marathon |
| **Terminal** | Terminal-SFO, LB/LA | Phillips 66 Company |
| **Terminal** | Terminal-LB/LA | PBF |
| **Port** | Port | Port of LB |
| **Port** | Port | Port of LA |
| **Tanker owner/ operator** | Tanker owner/ operator | Chevron shipping |
| **Tanker owner/ operator** | Tanker owner/ operator | Polar tanker/ConocoPhillips |
| **Subject matter expert** | SME-Tankers in general | DNV |
| **Subject matter expert** | SME-Electrification | DNV |
| **Subject matter expert** | Risk assessment | DNV |
| **Subject matter expert** | SME-Engine manufacture | Wartsila |
| **Others** | Construction | AECOM |

DNV

# Appendix 2 - List of Workshop Participants May 20 2021

## Shore Power Workshop #1- Technology composition analysis

| Full Name | Company |
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| **Ronald Jansen** | ABB |
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| **Powers, Katy K** | SHELL |
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| **Tia Youk (Guest)** | |
| **Steve Brett (Guest)** | PBF Energy (Torrance Logistics LLC) |
| **Taryn Wier (Guest)** | |

# Appendix 3 – List of Workshop Participants June 7-8 2021

## Shore Power Workshop #2 - Risk assessment

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| **Caris, Eric** | POLA |
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| **Sanjeet _Valero** | VALERO |
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# Appendix 4 – List of Workshop Participants June 24 2021

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| **Payne, Lee** | CONOCOPHILLIPS |
| **Wright, John K.** | CONOCOPHILLIPS |

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| **Wang, Yanran** | DNV |
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| **GilYong Han** | INTERTANKO |
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| **Ndiangang, Magnus** | KINDERMORGAN |
| **Ririe, John** | KINDERMORGAN |
| **Smith, Cinnamon** | KINDERMORGAN |
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| **Pisano, Teresa** | PORTLA |
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| **Bill Johns** | |
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# Appendix 5 – List of Workshop Participants July 9 2021

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| **Fields, Laura** | CHEVRON |
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| **Gibson, Joe F** | CONOCOPHILLIPS |
| **Hayes, Robert M** | CONOCOPHILLIPS |
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| **Andersen, Jan Hagen** | DNV |
| **Wang, Yanran** | DNV |
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| **Vahik Haddadian** | H3SOLUTIONS |
| **GilYong Han** | INTERTANKO |

| Full Name | Company |
|---|---|
| **Garcia, Carmen** | KINDERMORGAN |
| **Ndiangang, Magnus** | KINDERMORGAN |
| **Tomlinson, Jim** | MARATHONPETROLEUM |
| **Panos Deligiannis** | NEDAMARITIME |
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| **Mathur, Roy** | PBFENERGY |
| **Stone, William** | POLB |
| **Williams, Jennifer** | POLB |
| **Baird, Scott** | PORTLA |
| **Coluso, Amber** | PORTLA |
| **Flinn, David** | PORTLA |
| **Cameron Kiani** | PRECISIONPARTNERS |
| **Anne McIntyre** | SFBARPILOTS |
| **Flanagan, Christopher** | SHELL |
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# Appendix 6 – Threat Assessment - Shore Power

## 5.1 FMECA Results – Shore power

| Id | System | Failure mode | Failure Cause | Effect of failure | Existing Safeguards | Cons. | Prob. | Risk | Comment | Recommendations | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.1 | Power source | Electrical failure - power shortage | The electrical grid is not be able to provide sufficient power supply. | The shipboard instrument will not receive stable power source. | | 5 | 3 | H | | -The energy agencies, ports, and their electrical utility companies (such as Southern California Edison, Pacific Gas and Electric Company, etc.) will need to be involved to review the feasibility and planning of providing the additional power load with the consideration of hot weather when significant demand and strain have been put on California's energy grid. | Described |
| 0.2 | Power source | Quality of electricity (voltage variation, voltage and current transient, harmonic distortion) | During starting of the cargo pumps, voltage may decrease momentarily. When calculating power demand based on fuel (energy) consumption the result will be an averaged based power figure. This may not be sufficient to cope with | | | 5 | 2 | M | | Each ship type will have a different peak factor which should be considered when designing shore-power infrastructure. During the design stage, the decision is recommended to be taken together with tanker operators whether to design for average power demand, peak power demand, or any design point in between. | Described |

| Id | System | Failure mode | Failure Cause | Effect of failure | Existing Safeguards | Cons. | Prob. | Risk | Comment | Recommendations | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | momentary or short-termed peak consumption. | | | | | | | | |
| 0.3 | Power source | Electrical failure - high inrush current | High inrush current may happen when starting a high capacity consumer, e.g. electrical driven cargo oil pumps | Voltage dip | | 3 | 2 | M | | It is recommended to:<br>- sizing the transformer according to the terminal's traffic and potential peak load from the visiting tankers;<br>- establishing a communication procedure beforehand between the ship and terminal about if there are load restrictions from the shore power system and the ship's required average and peak load;<br>- performing the start-up of electrical machinery onboard the tankers in a manner that will limit the peak currents, e.g. using a soft start or frequency-controlled motor. | Described |
| 0.4 | Power source | Electrical failure | Lighting strike | Damage of the consumers onboard the ship | | 4 | 1 | M | | Insulation has to be in place for overvoltage protection. Ensure the design and installation of shore power system are following the relevant local standards and codes. | Not unique to tankers |

| Id | System | Failure mode | Failure Cause | Effect of failure | Existing Safeguards | Cons. | Prob. | Risk | Comment | Recommendations | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.1 | Main incoming station | Electrical failure | Shipboard electrical frequency and voltage may not be compatible with the shore power. | | | 4 | 2 | M | | -Voltage step down transformers and frequency converter to be installed when needed | Described |
| 1.2 | Main incoming station | Electrical failure - overheatin g | The extreme environmental temperature may induce overheating of the main incoming station. | | | 3 | 2 | M | | Consider implementing climate control for the main incoming station | Not unique to tankers |
| 1.3 | Main incoming station | Electrical failure - fail to start | Fault in the control system. | Unable to supply power to the tankers | Ship will continue to use auxiliary engines to provide power. | 2 | 3 | M | This situation will be registered as a Vessel Incident Event (Vie) / Terminal Incident Event (Tie). | | Not unique to tankers |
| 1.4 | Main incoming station | Electrical failure - fail to stop | Fault in the control system. | Cannot disconnect the shore power when it has power on. | | 2 | 3 | M | | -Incorporate a mechanical tripping of the circuit breaker for bypassing the main incoming station control system | Not unique to tankers |

| Id | System | Failure mode | Failure Cause | Effect of failure | Existing Safeguards | Cons. | Prob. | Risk | Comment | Recommendations | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.1 | Power cable | Mechanical failure - structural failure | The strength of the pier may not be sufficient to carry the extra load from the power cable. | Structural damage of the pier | | 5 | 2 | M | | -A structural evaluation, including seismic analysis, shall be performed following MOTEMS to evaluate if upgrades of the structural system of the causeway and terminal is needed. | Described |
| 2.2 | Power cable | Mechanical failure - Rupture | Cable might be damaged from the traffic on the wharf and earthquake. | | | 3 | 2 | M | | -Perform electrical relay coordination study | Not unique to tankers |
| 2.3 | Power cable | Mechanical failure - Flooding | Flooding in the duct may damage the power cable. | | | 3 | 2 | M | | -Ensure using waterproof typed power cable | Not unique to tankers |
| 3.1 | Onshore installations (excluding CMS) | Electrical failure - Overheating | Switchgear could be overheated in the extreme weather. | | | 3 | 2 | M | | Consider implementing climate control for the switchgear | Not unique to tankers |
| 3.2 | Onshore installations (excluding CMS) | Electrical failure - Fail to start | Fault in the cable, switchgear, etc. at the onshore installation | Unable to supply power to the tankers | Ship will continue to use auxiliary engines to provide power. | 2 | 3 | M | This situation will be registered as a Vessel Incident Event (Vie) / Terminal Incident Event (Tie). | | Not unique to tankers |

| Id | System | Failure mode | Failure Cause | Effect of failure | Existing Safeguards | Cons. | Prob. | Risk | Comment | Recommendations | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.3 | Onshore installations (excluding CMS) | Electrical failure - Fail to stop | Fault in the control system. | Cannot disconnect the shore power when it has power on. | | 2 | 3 | M | | -Incorporate a mechanical tripping of the circuit breaker for bypassing the control system | Not unique to tankers |
| 3.4 | Onshore installations (excluding CMS) | Design challenge | The terminals may not have sufficient space for the shore power installation. | | | - | - | - | -Easy access and minimizing the distance between ship and pier is preferred. | -Evaluate if an upgrade of the terminal is needed for accommodating the pier side shore power equipment. | Described |
| 3.5 | Onshore installations (excluding CMS) | Mechanical damage | Wake from channel, provision loading, vehicle traffic, dropped objects may cause damage. | | | 3 | 2 | M | | -Review the traffic design to introduce safety barriers, e.g. armor, at the high risk locations | Not unique to tankers |
| 3.6 | Onshore installations (excluding CMS) | Electrical failure - Internal short circuit or arc | Internal short circuit or arc | Injury of personnel during operation. | | 3 | 4 | M | | -Perform an arc splash study and internal arc test<br>-Following the local code to identify the design requirements, e.g. use arc-proof switchgear. The code may include:<br>1. National Fire Protection Association (NFPA) 70 - National Electrical Code (NEC) and<br>2. NFPA 70E - Standards for electrical Safety in the Workplace | Not unique to tankers |

| Id | System | Failure mode | Failure Cause | Effect of failure | Existing Safeguards | Cons. | Prob. | Risk | Comment | Recommendations | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 4.1 | Cable management system | | Wide range of tankers' length and two scenarios of berthing orientations | Some tankers cannot be covered by the reach of cable management system. | | 5 | 3 | H | Scenario: installation of the connection point at the stern out of hazardous zone, which is closer to the consumers. | -An industry standardized solution on the installation location of the Shore power connection location is recommended. if the connection location is agreed to be arranged in the non-hazardous area, e.g. stern of the tanker, a cost-effective cable management system that is complying with the standards to accommodate the existing portfolio of tankers is recommended to be developed. the solutions or design changes will need to be reviewed for compliance with the existing technical standards.<br>-Before An industry standardized solution is available, the Shore power connection locations will need to be investigated closely for each terminal based on the terminal configuration and the portfolio of visiting tankers. | Described |
| 4.2 | Cable management system | | Lifting heavy materials | Injury of personnel during operation. | | 3 | 3 | M | | -Locate/ install a suitable crane for handling the cables. | Described |
| 4.3 | Cable management system | | Handling high voltage cables | Injury of personnel during operation. | | 3 | 3 | M | | -Ensure the shore power design and installation follow relevant standards, e.g. IEC standards and Class society standards.<br>-Provide high-voltage operation and shore power usage safety trainings for the relevant personnel | Described |

| Id | System | Failure mode | Failure Cause | Effect of failure | Existing Safeguards | Cons. | Prob. | Risk | Comment | Recommendations | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 4.4 | Cable management system | | Unawareness of the potential conflicts during the design and operation | Interference the normal operation of tankers and marine oil terminal, e.g. cargo discharging, provision loading, etc. | | 3 | 1 | L | | -Perform traffic study and develop an operation procedure to avoid conflictions | Not unique to tankers |
| 5.1 | Shipboard installation | Electrical failure - ignition from sparks and/or over-temperature | Electrical equipment's spark and/or over-temperature | Fire or explosion during the transfer of hazardous cargo. | | 5 | 3 | H | -Currently, there is no ex-proof certified marine use high voltage components such as cable, plug, socket<br>-Current standards do not recommend electrical installation in the hazardous areas. | -Consider the possibility of using pressurized electrical house in the hazardous area, however the possibility high voltage cable running through hazardous area still seems not feasible with the current availability of ex-proof marine use equipment and current status of industry standards.<br>-Implement measures to avoid sparks and over-temperature | Described |

| Id | System | Failure mode | Failure Cause | Effect of failure | Existing Safeguards | Cons. | Prob. | Risk | Comment | Recommendations | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5.2 | Shipboard installation | Electrical failure | In-compatibility between the connections at different ports due to the lack of developed design standards | The usage of shore power technology is limited. | | 5 | 2 | M | Currently there are no unified standards for shore power especially the plugs and sockets while tankers typically have a worldwide operation profile. | -Before the tankers' arrival, it is recommended to confirm the compatibility of the shore power system with the terminal.<br>-Standardization of the shore power design for tankers including a unified design of safety and physical design of the plugs and sockets through e.g. IEC/IEEE 80005-1:20199 Annex F Additional requirements for tankers with contribution from the industry stakeholders is recommended. | Described |
| 5.3 | Shipboard installation | Electrical failure - ignition | If the shore power connection point is arranged at the bow out of hazardous zone, the installation connection may enter the berth hazardous zone during slipped mooring. | | | 4 | 1 | M | Scenario: installation of the connection point at the foreship | -Develop procedure for de-energize the shore power system during the emergency situation of slipped mooring. | Described |

| Id | System | Failure mode | Failure Cause | Effect of failure | Existing Safeguards | Cons. | Prob. | Risk | Comment | Recommendations | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5.4 | Shipboard installation | | Install the shore power connection on an elevated platform at the midship | Blockage of visibility and impact on stability | | 3 | 1 | L | Scenario: installation of the connection point at an elevated location at midship (Benefit is that the location of manifold area is relatively fixed. It makes the terminal capable of accommodating more ship sizes.) The height of hazardous zone from deck depends on the location of PV valves and natural ventilation. | -If a platform is installed for arranging the shore power connection point, assessment is recommended to ensure it is not impacting the bridge's visibility and ship's stability. | Described |

| Id | System | Failure mode | Failure Cause | Effect of failure | Existing Safeguards | Cons. | Prob. | Risk | Comment | Recommendations | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5.5 | Shipboard installation | | Install the shore power connection on an elevated platform at the midship | The platform is still inside the hazardous zone of the tanker or berth. | | 4 | 3 | M | | -the specific hazardous area arrangement of the visiting tankers and marine oil terminals has to be studied for each terminal. | Described |
| 5.6 | Shipboard installation | Electrical failure - ignition from sparks and over-temperature | There are still openings to the electrical house. The installation may be out of compliance of the current regulations and industry standards. | | | 3 | 2 | M | Scenario: installation of the connection point in an electrical house with airlock and overpressure at the midship. Chemical tankers follow IBC code which has strict requirement on installation of electrical equipment. ISGOTT has strict requirement on electrical requireme | -A thorough examination and potential updates of the existing regulations and industry standards (e.g. SOLAS, IBC code, Class rules, ISGOTT, PIANC standards) for the pressured electrical house concept | Described |

| Id | System | Failure mode | Failure Cause | Effect of failure | Existing Safeguards | Cons. | Prob. | Risk | Comment | Recommendations | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | nt as well. PIANC has requirements on the terminal design. | | |
| 5.7 | Shipboard installation | | The condition of instruments may be unknown after a long term of unuse. | | | 3 | 1 | L | | -Develop a maintenance procedure<br>-Develop an inspection procedure before connection | Not unique to tankers |
| 5.8 | Shipboard installation | Mechanical failure - cable tear and wear | Cable tear and wear, especially with long cable run and exposure to greenwater | Personnel injury, unable to provide power, sparks in the hazardous zone | | 4 | 2 | M | | -Implement protection of the cable and the shore power equipment from tear and greenwater | Not unique to tankers |

## 5.2 HAZOP Results -Shore power

| ID# | Deviation | Cause | Consequence | Safeguard | Cons. | Prob. | Risk | Recommendations | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Emergency (earthquake, tsunami, fire) | Earthquake, tsunami, fire | Release procedure and system design may not be able to meet evacuation requirement (30min requirement from California Land Commission) | -The current terminal design is designed to be compliant with MOTEMS and meeting the requirement on earthquake. | 5 | 1 | M | -Ensure the emergency response button for disconnecting the power is implemented in the design and installation at reasonable locations, e.g. engine control room, local control cabinet at the connection room, shore side control room, etc.;<br>-Implement a breaking signal system and auto-ejection mechanism;<br>-Implement a quick-release / weak-link arrangement using an in-line breakable coupler on the cable. Once the breaking signal system sends the signal for quick releasing, the coupler will be unlatched and allow for breaking;<br>-Implement scheme and devices for handling the loose cables from both shore side and ship side;<br>-Develop an emergency response procedure including handling the shore power connection with a clear definition of responsibility, safety precautions, and necessary operations for the stakeholder including shipboard, terminal, and port teams;<br>-Evaluate the time required for | Described |

| ID# | Deviation | Cause | Consequence | Safeguard | Cons. | Prob. | Risk | Recommendations | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | emergency response when connecting to shore power (disconnect shore power, turn on engine power, maneuver away from the berth) and ensure that it is within 30 minutes. | |
| 2 | Blackout of shore power | Sudden electrical grid power loss, fault in the power transmission system | Cargo discharging will be interrupted. The cargo discharge valves and ballast valves may not be able to close due to the loss of hydraulic power. The | -The manifold valves are still operatable as these normally are manual valves.<br>-Shore side shut-down valve may control the cargo discharge/loading (if the whole terminal experiences a grid power lost, | 3 | 2 | M | -Establish a ship and terminal-specific bow tie analysis of shore power blackout and identify the difference with blackout from ship's auxiliary engines (if any), and its consequence;<br>-Develop an emergency response procedure with the consideration of the needed recovery time and establish shore power blackout response procedure;<br>-Incorporate the signal reading of shore power loss into the shore side discharge/loading valves; | Described |

| ID# | Deviation | Cause | Consequence | Safeguard | Cons. | Prob. | Risk | Recommendations | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|
| | | | inert gas generation will stop during blackout. | the Shore side discharge valve normally will be closed automatically.) | | | | -Consider increasing the redundancy into the shore power design with the balance of cost-effectiveness. | |
| 3 | Dropped object | Objects drop (depending on the location of installation, from provision crane at stern, cargo loading arm) onto flexible cable between ship and shore. | It may result in a spark. | | 3 | 2 | M | -Perform traffic analysis of potential simultaneous operations<br>-Consider installation of cable tray/trench to provide protection of flexible cable | Not unique to tankers |
| 4 | Harsh weather | Strong wind, gust, load from passing vessel | The shore power connection (cable, crane operation) may be damaged. | | 3 | 2 | M | -Provide technology supplier the weather envelope (California State Land Commission has specific requirements for weather conditions of cargo operations) and evaluate the shore power's capacity under harsh weather<br>-Develop an operation procedure which considers:<br>--the weather limits, if the weather | Not unique to tankers |

| ID# | Deviation | Cause | Consequence | Safeguard | Cons. | Prob. | Risk | Recommendations | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | is too harsh, the shore power may not be connected<br>--monitoring the condition including weather condition, vessel movement due to ballasting/de-ballasting, tidal movement | |
| 5 | Harsh weather/Human error | Connection point becomes damp during harsh weather or misoperation. | Injury of personnel<br>Damage of instrument<br>Delay of connection | | 3 | 2 | M | -Develop an operation procedure to inspect the connection and ensure that it is dry before connection | Not unique to tankers |
| 6 | Wild fire | Dust accumulated onto the electrical instruments. | | | 2 | 1 | L | -IP (ingress protection) protection to be provided | Not unique to tankers |
| 7 | Wild fire | Adverse weather condition from wild fire (haze, high PM) | Adverse effect to workers' effect and may cause delay on delaying shore power. | | 3 | 3 | M | -Provide PPE for the workers | Not unique to tankers |

| ID# | Deviation | Cause | Consequence | Safeguard | Cons. | Prob. | Risk | Recommendations | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|
| 8 | Cybersecurity | Human error, system vulnerabilities, cyberattacks | It may cause a blackout, especially during the cargo operation which is a critical operation. | Currently IEC standard does not require data communication for tanker shore power installation. The current standard requires a monitoring function, but not a control function. | 3 | 3 | M | -If the shore power system is equipped with data communication capability, it is recommended to identifying the vulnerable subsystems (e.g. service interface of switchgear, service interface of cable management system), performing cybersecurity assessment, and ensure air gap is in place. | Described |
| 9 | Ships moving out of the operating envelop | Mooring line breaks, passing traffic impact and ships drift away (as an emergency without announcement). | -Release procedure and system design may not be able to meet evacuation requirement (30min requirement from California Land Commission)<br>-Snap-back of broken | | 3 | 1 | L | -Implement a weak link mechanism<br>-Consider the implementation an active load monitoring system for the mooring line and in cooperation this signal to shore power control<br>-If the shore power installation is located at the stern, the shore power installation has to avoid the mooring installation. | Not unique to tankers |

| ID# | Deviation | Cause | Consequence | Safeguard | Cons. | Prob. | Risk | Recommendations | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|
| | | | mooring line may damage the shore power instrument. This is relevant when the shore power connection is installed at the stern. | | | | | | |
| 10 | Oil spillage | Leakage from piping or tank, broken couples, unexpected disconnected/damaged loading arm | Fire or explosion | -Terminal's existing emergency response procedure | 3 | 1 | L | -Develop the ship shore power emergency response procedure including emergency shutdown with the consideration of the cargo type, potential spillage location, and amount;<br>-Incorporate the operation of shore power into the terminal's spillage response procedure. | Described |
| 11 | Human error | Energized shore power plug became disconnected. | Personnel may be exposed to live cable. | -Shore power safety loop design<br>-Mechanical interlock opening will disconnect the power. | 3 | 1 | L | -Develop shore power operation procedure and perform training of the relevant personnel | Not unique to tankers |
| 12 | Human error | If use shore power technology, boilers' emissions may be out of compliance with | Out of compliance | | - | - | - | If shore power is used, the emissions from steam-driven cargo pumps will not be regulated. Therefore, this risk is deemed | Described |

| ID# | Deviation | Cause | Consequence | Safeguard | Cons. | Prob. | Risk | Recommendations | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|
| | | CARB at-berth regulation. | | | | | | irrelevant. | |
| 13 | Human error | If use shore power technology, diesel driven power packs' emissions may be out of compliance for CARB at-berth regulation. | Out of compliance | | 4 | 1 | M | -Convert the hydraulic power pack to use electric motors which draw power from the main switchboard, i.e. from the ship's service diesel generators<br>-Alternatively, the exhaust from the hydraulic power pack diesel engine(s) must be treated with the capture and control technology which may be too costly for such a relatively small emission source.<br>-Use the Innovative Concepts (IC) provision given in CARB at-berth regulation as a compliance option to offset the emission from the hydraulic power pack diesel engines and achieve equivalent (or greater) emissions reductions in port. | Described |

DNV

# Appendix 7 –Emissions Capture and Control

## 6.1 Performance Expectations

| Performance Expectations | Description | Requirements | Critical Parameters | Requirements/ Acceptance criteria | | Comment | Action | Current product feasibility |
|---|---|---|---|---|---|---|---|---|
| | | | | Min | Max | | | |
| **Suitability for tankers** | The technology should be able to be deployed and operated for all tankers visiting the terminal | The technology should be capable of accommodating the difference sizes of tankers | Range of tankers visiting the terminals | - Seawaymax (0-60,000 dwt)<br>-100 m Coastal Tankers at <50,000 DTW and 200 m x 32 m beam | -ULCC (315,000-520,000 dwt)<br>-350m<br>VLCC at 320,000 DTW and 340 m x 60 m beam | What is the maximum number of aux engines and boilers running on the largest vessel during discharging of cargo? | | |
| | | The technology should be able to fit the variable stack configurations | Stack dimensions | 0.4 m, single Aux engine at 600 kW | '1.2 m for a 45 MT/hr steam boiler on a VLCC<br>0.5m for auxiliary engines<br>0.5m for IG vent | Shall fit the stack for the range of visiting tankers to the terminals | | N |

| Performance Expectations | Description | Requirements | Critical Parameters | Requirements/ Acceptance criteria | | Comment | Action | Current product feasibility |
|---|---|---|---|---|---|---|---|---|
| | | | | Min | Max | | | |
| | | | Stack numbers | 4<br>Single aux engine operational while vessel is at berth and not offloading cargo or is being loaded. | 6 (2boilers, 3 aux engine, 1inert gas vent line)<br>Single aux engine providing power for vessel operations while at berth.<br>Cargo Operations<br>-Hydraulic Pumps - a second aux engine running to support cargo offloading<br>-Steam Pumps - 1 or 2 boilers operational depending on offload rate. | Typically, while at-berth typically both boilers are running. All 3 aux engines may be running at certain scenario and minimum 2 are running.<br><br>In the port of LA/LB all berths are limited to an unloading rate of less than 10,000 bbls/hour which means only a single aux engine or single boiler will be associated with unloading operations. The one exception is T121 which can offload at rates up to 80,000 bbls/hour | | N |
| | | The technology should be able to reach the stack position | Stack vertical position | 35.4m | 67 m | Ballast 55m for a VLCC, 40m for Aframax | | |
| | | | Stack horizontal position | 30m | 49m | The tanker may be moored on starboard side or | | |

| Performance Expectations | Description | Requirements | Critical Parameters | Requirements/ Acceptance criteria | | Comment | Action | Current product feasibility |
|---|---|---|---|---|---|---|---|---|
| | | | | Min | Max | | | |
| | | | | | | portside. The C&C technology needs to account for both scenarios. | | |
| | | The technology should be able to reach the stack position within a specified time period | Definition of min/max times | 20 min | 60 minutes | Best case, worst case | | |
| | | The technology should be able to treat the exhaust GAS amount from the tanker discharging cargo | Auxiliary engine kW | Single engine at 400 kW operating | typically, VLCC = 2 x 1,200kW<br>AFRA = 2 x 750kW | -7000 kW for T121 terminal | | N |
| | | | Boiler (metric ton/hr steam) | For hydraulic pumping a boiler is not used | VLCC = 2 x 45 Mt/hr steam<br>AFRA = 2 x 25 MT/hr steam | 30,000 kg steam per hour | | N |
| | | | Total exhaust from auxiliary engines and boilers (kg/hr) | Single Aux Engine at 400 kW = 3,000 kg/hr | TBD | It will be calculated based on the auxiliary engine (7.3 kg/kW for Aux Engines) and boilers' emission. 'VLCC = 2 x 10,000 kg/hr (DG) + 2 x 50,000kg/hr (A/B including IG vent)<br>AFRA = 2 x 6,250 | | |

| Performance Expectations | Description | Requirements | Critical Parameters | Requirements/ Acceptance criteria | | Comment | Action | Current product feasibility |
|---|---|---|---|---|---|---|---|---|
| | | | | Min | Max | | | |
| | | | | | | kg/hr (DG) + 2 x 35,000kg/hr (A/B including IG vent ); if independent IGG (or electrical COP) then +10,000kg/hr | | |
| | | The technology should be able to accommodate for changes in vessel draft and tidal variation during the operation | Select a vessel scenario with greatest variation in drafts (light vs loaded condition) | - | VLCC = 22.5 m laden, 11m ballast - AFT DRAFT | Changes of draft and ship movement during operation needs to be accounted for | -Current design for container vessels can accommodate draft change around 10-15feet by boom adjustment. | |
| | | The technology should be able to accommodate the variable temperature of exhaust gas from the sources including aux. engine, boiler, inert gas generator. | Temperature of exhaust gas | 150 °C | 400 °C | | | |
| | | Comply with hazardous zone requirements as relevant for accommodating tankers | - Identify the requirements and ensure compliance as relevant | n/a | Barge will operate outside hazardous zones | -The technology plans for a design without operator at funnel | | Y |

| Performance Expectations | Description | Requirements | Critical Parameters | Requirements/ Acceptance criteria | | Comment | Action | Current product feasibility |
|---|---|---|---|---|---|---|---|---|
| | | | | Min | Max | | | |
| **Suitability for oil terminals** | The technology should be able to be deployed and operated for all tankers visiting the terminal | Sufficient infrastructure and space available to install the technology (shore-based) | -Site suitability in terms of impact to neighboring infrastructure and potential logistics. | n/a | -Some terminals may require both side berth | 80x20 m footprint | | |
| | | Terminals and wharves existence and should be able to carry the weight of the installation (shore-based) | - Bathymetry/foundation related calculations to ensure site suitability | n/a | Treatment unit located on a floating pontoon moored to the shore and connected to shore power. | | | |
| | | Comply with hazardous zone requirements if relevant | - Establish if this will apply '- If so, ensure compliance | n/a | Floating pontoon to comply with hazardous zone requirement if required. | | | |
| | | Sufficient infrastructure and space available (barge-based) | Sufficient channel width and maneuvering capacity for safe maneuvering and placement of barge | - | - | CAEM Barge is approximately 32m long and breadth of 18m. Highly maneuverable with dual 360-degree rotating thruster propellers with joystick control. | | |

| Performance Expectations | Description | Requirements | Critical Parameters | Requirements/ Acceptance criteria | | Comment | Action | Current product feasibility |
|---|---|---|---|---|---|---|---|---|
| | | | | Min | Max | | | |
| | | | Tug availablility | - | Max wind conditions will be determined, and tugs used to assist where required. | For CAEM's current design for POLA and POLB, the barge will be self-propelled and has a speed around 2-3knots. | | |
| | | Limit interference of the normal operation, e.g. mooring, cargo loading/unloading, traffic | | - | For CAEM's design, the vessel will be spudded. The movement from passing traffic is assumed to be minimal. | | | |
| | | Have space available for barge-based technology storage | | - | CAEM Barge is approximately 32m long and breadth of 18m. Storage space is needed. | | | |
| **Compliance** | The technology shall be in compliance with applicable local, terminal, industry and tanker rules | Technology shall meet applicable rules, regulations, industry standards and guidelines as applicable. | -IMO Regulations | -SOLAS<br>-MARPOL | | | | |
| | | | -California State Lands Commission Regulation | MOTEMS | | | | |
| | | | -Class Society Rules | -Ship rules | | | | |
| | | | -Maritime Industry Guidelines | -OCIMFs Guidelines<br>-PIANC | | | | |

| Performance Expectations | Description | Requirements | Critical Parameters | Requirements/ Acceptance criteria | | Comment | Action | Current product feasibility |
|---|---|---|---|---|---|---|---|---|
| | | | | Min | Max | | | |
| | and regulations | | -CARB Ocean-going vessels at berth regulation | Should be approved by CARB with the emission reduction limits for the exhaust | | | | |
| **Safety** | The technology should be safe to deploy and operate during normal operations | Safety of personnel should be maintained throughout the operation (connection, operation, disconnection, maintenance) | Training, procedures, design and construction, safeguards | | CAEM's design and construction will be in accordance with ABS Rules. Procedures to include general operation and emergency procedures. Training in the procedures will be developed and performed on a continuous basis. | | -Vetting of the barge to ensure safety | |
| | | Safety of property should be maintained throughout the operation | To be evaluated as part of the HAZID/FMECA | - | - | | | |
| | | Use of the technology should not increase the risk of fire and explosion | To be evaluated as part of the HAZID/FMECA | - | - | | | |

| Performance Expectations | Description | Requirements | Critical Parameters | Requirements/ Acceptance criteria | | Comment | Action | Current product feasibility |
|---|---|---|---|---|---|---|---|---|
| | | | | Min | Max | | | |
| | | The technology should be able to operate safely at defined operational windows | Wind | | 30 knots | MEG 4 environmental criteria ie wind 60kts, current 3.5kts, swell 2.5m | | |
| | | | Current | | 0.75 knot<br>Maybe up to 6 knots for Northern California terminals | | | |
| | | | Waves | | 2.5m swell | -How is the system compensating for relative movements | | |
| | | | Temperature | | | Define operational windows | | |
| | | Should be able to operate safely 24/7 (day and night) | Visibility and illumination should be sufficient for the safe crane operations | | 24-hour operation with lighting and cameras sufficient to perform all operations. | | -Ensure illumination at port | |

| Performance Expectations | Description | Requirements | Critical Parameters | Requirements/ Acceptance criteria | | Comment | Action | Current product feasibility |
|---|---|---|---|---|---|---|---|---|
| | | | | Min | Max | | | |
| | | Protection requirments | Establish protective barriers as necessary for normal and emergency operations | | The barge will operate outside the normal hazardous area. The pontoon will be built to intrinsically safe standards as required for the zone of operation. | IP, ex-proof | -Identify the hazardous area definition from both tankers and terminals<br>-Identify the equipment of capture and control running potentially in the hazardous zone | |
| | | System not to interfere with machinery combustion parameters and safety matters | treatment system fan suction | | Extraction to be minimum possible and adjustable so as not to interfere with boiler air pressure sensors and do not alter IG oxygen level.<br>Low speed stable flow to be maintained.<br>Treatment system should not apply backpressure to the piping | | | |
| | Securing arrangement for hood on stacks | should not impose any load on the stacks | structural integrity | | | | | |
| | SIMOP - | | mooring tangling | | | Possible catastrophic failure due to | | |

| Performance Expectations | Description | Requirements | Critical Parameters | Requirements/ Acceptance criteria | | Comment | Action | Current product feasibility |
|---|---|---|---|---|---|---|---|---|
| | | | | Min | Max | | | |
| | | | | | | mooring wire break. | | |
| | The technology should provide sufficient safety during emergencies | Should not hinder the tanker requirement of safe evacuation from the berth within 30 minutes | Evacuation shall be possible within the specified 30 min limit | as soon as possible | 30 mins | -Disconnection process: boom removing -> stow boom (within 10min), spud lifted, barge sails away with its own power (around 10min) require no interaction from vessel or crew<br><br>-How is the system quickly disconnected? '-Potentially adverse loads on connection? -The plan for complying with California State Lands Commission (CSLC) ruling requiring a 30-minute vessel evacuation from berth -Tugs? Other means? | -Develop emergency disconnection procedure and training of personnel | |

| Performance Expectations | Description | Requirements | Critical Parameters | Requirements/ Acceptance criteria | | Comment | Action | Current product feasibility |
|---|---|---|---|---|---|---|---|---|
| | | | | Min | Max | | | |
| **Reliability & Emission reduction** | Performance | The capture and control technology should perform as expected with acceptable failure rates. | Failure rates/NPT | | 90% available hrs (10% time for maintenance) | -Power generation has redundancy. The rest does not have redundancy currently. | | |
| | Lifetime | The capture and control technology should perform as expected over the lifetime. | Lifetime/ design life | | 15 years before a major overhaul, 10 years operating life after the overhaul | | | |
| | Maintenance | The capture and control technology shall enable safe maintenance as required.<br>'Flexible pipe and boom should be of suitable material, easy to maintain and easy to inspect/test | Maintainability | | - | | | |
| | | Barge should be capable of maneuvering in the port and sail to different ports. | -Sailing speed | No minimum speed | 5 knots | The barge will be highly maneuverable with dual 360-degree rotating thruster propellers with joystick control. Barge should be able to maintain position and be | | |

| Performance Expectations | Description | Requirements | Critical Parameters | Requirements/ Acceptance criteria | | Comment | Action | Current product feasibility |
|---|---|---|---|---|---|---|---|---|
| | | | | Min | Max | | | |
| | | | | | | safely moored - as required. | | |
| | | | -Sailing range | n/a | Within confines of Port of LA and Port of Long Beach | Passage between other ports to be evaluated on a case-by-case basis. | | |

## 6.2 Technology Assessment

| ID | Description | Application | | | Technology | | | Techn. Class | Main function | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Known | Limited knowledge | New | Proven | Limited History | New | | | |
| 1 | **Emission capture unit** | | | 1 | | 1 | | 4 | Transport ship exhaust to the treatment system by connecting the ship exhaust stack to the emission control unit via a duct. | -Reach of crane<br>-Stack suitability<br>-Motion compensation<br>-Connection (connection time expected at around 45min to an hour for tankers, |
| 2 | **Emission control unit** | | 1 | | | 1 | | 3 | The emission control unit consists of catalytic ceramic filters (CCF) technology to treat the ship exhaust and remove diesel particulate matter (PM) and NOx. | -Any parts need Ex proofing? |
| 3 | **Shore-based** | | | 1 | | 1 | | 4 | | |
| 4 | **Barge-based** | | | 1 | | 1 | | 4 | | |

## 6.3 FMECA – Capture and control

| Id | System | Component | Failure mode(s) | Failure cause(s) | Effect of failure(s) | Existing Safeguards | Con. | Prob. | Risk | Recommendations | Comments | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.1 | Emission capture unit | Crane / displacement boom | Power outage | -Generator outage<br>-Grid power outage | Not able to lift adaptor | -Barge-based has backup for generator and hydraulic power pack.<br>-Shore-based has diesel generator as a backup power for grid power.<br>-Some terminals may have back up generators. | 2 | 3 | M | -For shore based, request the back-up power from the terminal for removing boom or equip the C&C with back-up power | -If grid has a power outage, the tanker offloading flow will be reduced. | Not unique to tankers |
| 1.2 | Emission capture unit | Crane / displacement boom | Hydraulic failure | Loss of hydraulic pressure | Not able to lift adaptor | Hood has 15m movement capability driven by electric winches. | 2 | 2 | L | | | Not unique to tankers |
| 1.3 | Emission capture unit | Crane / displacement boom | Mechanical failure | Structural damage of crane / displacement boom | Not able to lift adaptor | | 2 | 2 | L | | -Crane for bulk carrier cargo loading is used | Not unique to tankers |
| 1.4 | Emission capture unit | Crane / displacement boom | Mechanical failure | Lack of stability | Emission capture not possible/ damage to vessel(s) being serviced | | 4 | 2 | M | -Perform stability analysis and define the operation envelope of the crane. | | Not unique to tankers |

| Id | System | Component | Failure mode(s) | Failure cause(s) | Effect of failure(s) | Existing Safeguards | Con. | Prob. | Risk | Recommendations | Comments | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.5 | Emission capture unit | Crane / displacement boom | Mechanical failure | Lack of maintenance | Not able to lift adaptor | | 2 | 2 | L | -Ensure proper access for maintenance and inspection of the crane/boom<br>-Develop maintenance and inspection procedure | | Not unique to tankers |
| 1.6 | Emission capture unit | Crane / displacement boom | Inadvertent operation in hazardous zone | Human error, miscommunication | The displacement boom may accidentally work inside the hazardous zone of the tankers or terminals while it is not compliant with the requirements. | | 4 | 4 | H | -Collect the hazardous zone arrangement from the terminal and also visiting tankers via pre-arrival questionnaire<br>-Define the route of placement boom operation accordingly to avoid the operation in the hazardous zones | | Described |
| 1.7 | Emission capture unit | Crane / displacement boom | Mechanical failure | The crane tips in the high wind condition | Not able to lift adaptor | | 3 | 3 | M | -Develop the safe working criteria (the crane designed for 30knots and the operating limit is defined as 25knots)<br>-Ensure the crane has been analyzed and tested according to the defined criteria | | Not unique to tankers |

| Id | System | Component | Failure mode(s) | Failure cause(s) | Effect of failure(s) | Existing Safeguards | Con. | Prob. | Risk | Recommendations | Comments | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.8 | Emission capture unit | Flexible duct | Mechanical failure | Flexible duct teared | Emission capture compromised | Flexible duct has coil steel to hold flexible duct. | 2 | 3 | M | | | Not unique to tankers |
| 1.9 | Emission capture unit | Stack adaptor /hood | Adaptor may add on additional load to the stack and cause structural damage. | Improper load distribution | Damage to stack/stack adaptor | Adaptor is not designed to add on weight to the stack in the normal operation. The crane will take the load of the adaptor via 3 winch cables. | 3 | 2 | M | | | Not unique to tankers |
| 1.10 | Emission capture unit | Stack adaptor /hood | Adaptor may damage the spark arrestor. | Improper load distribution | Damage to stack/stack adaptor | | 2 | 2 | L | -Before vessel's arrival, the stack (spark arrestor) configuration and photos need to be understood and the centering cone to be adjusted accordingly. | | Not unique to tankers |
| 1.11 | Emission capture unit | Stack adaptor /hood | Adaptor center cone may be stuck into the stack. | Improper installation or debris on stack | Damage to stack/stack adaptor | | 2 | 2 | L | -Manual operation is needed to remove the adaptor. Safety operation procedure to be developed. | | Not unique to tankers |

| Id | System | Component | Failure mode(s) | Failure cause(s) | Effect of failure(s) | Existing Safeguards | Con. | Prob. | Risk | Recommendations | Comments | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.12 | Emission capture unit | Stack adaptor /hood | Mechanical failure | Winch cable broken<br>If the stack has an angle, e.g. 90°, the adaptor may fall with 1 winch cable broken. | Stack adaptor falls onto/into the stack. | -3 winch cables installed; the hood could be lifted by 2 winch cables.<br>-The adaptor cone is designed to be bigger than the stack diameter. | 4 | 2 | M | -Evaluate the number of winch cable and location to optimise the design | -2 aux (one running, one standing-by), can we use 1 only?<br>-shifting usage of aux. engines. | Not unique to tankers |
| 1.13 | Emission capture unit | Stack adaptor /hood | The stack adaptor cannot adapt to the variable sizes of stacks. | Stack sizes bigger than adaptor | Cannot capture exhaust, leaks, or drawing in ambient air | Pressure monitoring<br>Adaptor attached to stack with an opening and IR monitoring. Pre check of exhaust pipe size and configuration, to select the proper hood and duct to match the vessel | 2 | 4 | M | -Pre-vessel call questionnaire will collect the size, relative location, angle of the stacks. Crew of C&C service supplier will select the adaptor from the inventory accordingly. | Multiple (2) funnels, e.g. Polar Tankers with twin engine room need considerati on | Not unique to tankers |
| 1.14 | Emission capture unit | Stack adaptor /hood | The system cannot process the different exhaust gas rate from different sources. | High volume and flow rate of exhaust | Exhaust not handled appropriately | | 2 | 3 | M | -Exhaust fan is used to ensure negative pressure. IR camera used to adjust the flow rate of exhaust fans. | | Not unique to tankers |

| Id | System | Component | Failure mode(s) | Failure cause(s) | Effect of failure(s) | Existing Safeguards | Con. | Prob. | Risk | Recommendations | Comments | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.15 | Emission capture unit | Stack adaptor /hood | The stack adaptor conflicts with another when the stacks have a compact configuration. | Misfit between stack and adaptor | Some exhaust streams cannot be processed by the emission capture and control technology. | | 2 | 4 | M | -C&C service supplier to develop pre-arrival communication procedure and understand the stack configuration, the number and location of operating stacks for the visiting tankers. A bespoken stack adaptor connection method will be developed. The connection method should allow enough room for the necessary adjustment of the location without damaging the vessel's stacks.<br>-If it is found that the stack configuration is too compact for connecting stack adaptors, Vessel Incident Events (VIE) and Terminal Incident Events (TIE) may be used. | -Use of innovative concept (emission credits)<br>-Each terminal has 5% non-compliance buffer for vessel visit events per terminal, each ship owner has 5% non-compliance buffer for the fleet based on the previous years' operation. | Described |
| 1.16 | Emission capture unit | Crane / displacement boom | Physical interference from shipboard installation | Improper planning and lack of communication | Damage to radar, antennas, etc., boom and hood | | 4 | 3 | M | | | Not unique to tankers |

| Id | System | Component | Failure mode(s) | Failure cause(s) | Effect of failure(s) | Existing Safeguards | Con. | Prob. | Risk | Recommendations | Comments | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.17 | Emission capture unit | Crane / displacement boom | The boom cannot reach PS and SB stacks when the funnel has a large span, e.g. when a ship is using double engine room arrangement. | Improper planning | Functionality affected | | 2 | 3 | M | -For the shore-based capture and control technology, it should evaluate if it is capable of covering the tankers visiting the terminal considering the size, height of the stack, and berthing orientations.<br>-For the barge-based capture and control technology, the service supplier shall develop a pre-arrival communication procedure and understand the stack height, configuration, number, and location of operating stacks for the visiting tankers. A bespoken stack adaptor connection method will be developed.<br>-If it is found that the funnel is too wide for the placement boom to reach, Vessel Incident Events (VIE) and Terminal Incident Events (TIE) may be used. | | Not unique to tankers |

| Id | System | Component | Failure mode(s) | Failure cause(s) | Effect of failure(s) | Existing Safeguards | Con. | Prob. | Risk | Recommendations | Comments | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.18 | Emission capture unit | Stack adaptor /hood | Structural failure | Centering cone is stainless steel. Fatigue damage may be induced by stack vibration. | Functionality affected | | 3 | 2 | M | -Develop periodical inspection procedure (visual and NDT) of the centering cone structure | | Not unique to tankers |
| 1.19 | Emission capture unit | Stack adaptor /hood | Adaptor may be disconnecting from the tankers' stack. | Poor connection or lack of engagement of the magnet | Adaptor not engaged and functionality affected | Adaptor is attached to the stack via magnetic attachment. | 2 | 3 | M | | | Not unique to tankers |
| 1.20 | Emission capture unit | Stack adaptor /hood | Unable to process all exhaust streams (e.g. 2 auxiliary engines and 2 boilers) | Misfit between stack and adaptor | Some exhaust streams cannot be processed by the emission capture and control technology. | | 2 | 3 | M | -Ensure communication procedure btw C&C service provide and tanker operator about the number and exact stacks for procession | The CAEM's design concept for tankers currently considers 2 booms for normal operation, i.e. capable of processing 4 stacks.Normally, tankers have 2 aux. engines, 2 boilers, and 1 vent line as the emission streams. | Described |

| Id | System | Component | Failure mode(s) | Failure cause(s) | Effect of failure(s) | Existing Safeguards | Con. | Prob. | Risk | Recommendations | Comments | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.21 | Emission capture unit | Stack adaptor /hood | Unable to process the exhaust when shifting auxiliary engines/boilers | Too many stacks to handle | Not all exhaust stream processed | | 2 | 4 | M | -C&C service supplier to develop pre-arrival communication procedure and communicate the possibility of limiting the shifting of auxiliary engines and boilers while at berth.<br>-If it is found that a tanker needs to shift auxiliary engines or boilers, Vessel Incident Events (VIE) and Terminal Incident Events (TIE) may be used. | | Described |
| 1.22 | Emission capture unit | Stack adaptor /hood | Inadvertent operation in hazardous zone | Electrical short circuits | sparks, ignition, fire | The adaptor is operating in the non-hazardous zone. | 5 | 3 | H | Review MOTEMS to identify the requirements and potentially considering bonding and grounding. | | Described |
| 1.23 | Emission capture unit | Stack adaptor /hood | Fire or explosion risk | Spark and stack fire in the adaptor | Incidents causing fatalities and/or damage to vessel and terminal | Adaptor made by metal. Flexible duct withstanding temperature up to 1200F. | 4 | 2 | M | | - Technology experienced 2 stack fires and it worked ok. | Not unique to tankers |

| Id | System | Component | Failure mode(s) | Failure cause(s) | Effect of failure(s) | Existing Safeguards | Con. | Prob. | Risk | Recommendations | Comments | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.24 | Emission capture unit | Flexible duct | Damage to duct | High temperature | Functionality affected | | 3 | 2 | M | | | Not unique to tankers |
| 1.25 | Emission capture unit | Flexible duct | Leakage | Lack of extraction Structural damage | Unprocessed exhaust gas emits to air | -High-definition camera and IR monitoring at the hood<br>-Boom duct has pressure monitoring | 2 | 2 | L | -Develop procedure about monitoring the leakage, alarm and response (disconnection the C&C) | -Static pressure monitor in the hood to ensure negative pressure on the hood<br>-If fan fails, in procedure to remove adaptor<br>-Open space allowed for gas emission if back pressure built-ip<br>-IR camera monitoring gas leakage | Not unique to tankers |
| 2.1 | Emission control unit | Treatment system | Personnel safety | Leakage of the processing chemical | Human fatality/injury | Secondary containment with leak monitoring in annular space | 4 | 3 | M | -Provide proper training to the workers<br>-Install leakage alarm and develop safety procedure<br>-Ensure vapor control in place | Ammonia is stored /dissolved in water. The tank is stored in a contained area. | Not unique to tankers |

| Id | System | Component | Failure mode(s) | Failure cause(s) | Effect of failure(s) | Existing Safeguards | Con. | Prob. | Risk | Recommendations | Comments | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.2 | Emission control unit | Treatment system | Personnel safety | Handling the solid waste (soot) | Human fatality/injury | | 4 | 2 | M | -Develop the system and operating procedure to ensure the solid waste is handled properly (not in the exposed way)<br>-Provide PPE to the crew | | Not unique to tankers |
| 2.3 | Emission control unit | Treatment system | Not able to process the emission exhaust | Low temperature from the exhaust gas | Functionality affected | | 2 | 4 | M | -Reheat the exhaust gas to minimum temperature requirement | | Not unique to tankers |
| 2.4 | Emission control unit | Treatment system | Design failure | High exhaust rate of tankers | The capture and control technology is not capable of processing the exhaust streams according to the at-berth regulation requirement. | | 2 | 3 | M | -Review the range of exhaust gas flow rate of the tankers visiting California and increase the treatment capacity of the capture and control system accordingly. | | Described |

| Id | System | Component | Failure mode(s) | Failure cause(s) | Effect of failure(s) | Existing Safeguards | Con. | Prob. | Risk | Recommendations | Comments | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.5 | Emission control unit | Exhaust fan | -Mechanical failure<br>-Power failure | Overspeed of fan, underspeed of fan, sudden stop | Backpressure build-up within the tanker's exhaust system. It may cause fan failure for boilers, incomplete combustion, and inert gas generation. | -Pressure monitoring<br>-Adaptor attached to stack with an opening and IR monitoring | 3 | 3 | M | -The capture and control technology supplier will:<br>--Implement an alarm window of pressure monitoring including both upper and lower limit<br>--Consider implementing pre-warning alarm regarding differential pressure for crew onboard the tanker to respond ahead<br>--Ensure fan speed is controlled according to the pressure in the duct<br>--Evaluate the reliability of the pressure sensor and develop redundancy accordingly<br>-Establish communication procedure between capture and control supplier, tanker's crew, and terminal operator, including:<br>--Providing instruction/checklist for tanker's crew to understand the capture and control technology's alarms<br>--Capture and control technology service supplier to attend the pre-transfer conference<br>--generate VHF communication channel | | Described |

| Id | System | Component | Failure mode(s) | Failure cause(s) | Effect of failure(s) | Existing Safeguards | Con. | Prob. | Risk | Recommendations | Comments | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.6 | Emission control unit | | Sensor failure Mechanical failure | Design fault | Loss of control and monitoring | | 2 | 5 | M | Evaluate the reliability of the pressure sensor and develop redundancy accordingly | | Not unique to tankers |
| 2.7 | Emission control unit | Power supply | Component failures | Generator:<br>-Mechanical failure<br>-Electrical failure<br>-Lack of fuel<br>Grid:<br>-Electrical failure | Loss of control and monitoring | | 3 | 3 | M | | -Barge has Li-Titanium oxidized battery bank and redundant generator. Spud motor is electrical driven. Hydraulic power pack redundancy may be needed to remove the boom during failure. | Not unique to tankers |
| 2.8 | Emission control unit | Power supply | Capture and control technology's own emission is not processed. | Design/operational fault | Functionality affected | If movable shore-based technology, Tier IV generator will be used. | 2 | 2 | L | -The exhaust from the generator will also be treated by the C&C technology. | | Not unique to tankers |

| Id | System | Component | Failure mode(s) | Failure cause(s) | Effect of failure(s) | Existing Safeguards | Con. | Prob. | Risk | Recommendations | Comments | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.9 | Emission control unit | Outlet | The processed gas is discharged out of compliance. | Design/operational fault | Functionality affected | Monitoring system is installed. Non-compliance addressed by CARB executive order | 2 | 2 | L | -Following CARB testing procedure and certification<br>-Develop alarm based on the regulation requirement and the procession efficiency | All exhaust streams combined and treated together | Not unique to tankers |
| 3.1 | Base unit | Shore-based | Unable to transport onto the site during the technology installation | Narrow road on the wharf Insufficient overhead clearance (height of the unit is around 30-50feet) | Delayed installation | | 2 | 2 | L | -Perform transportation analysis<br>-Assemble onsite<br>-Use heavy lift vessel | Assembled in port, moved by barge to terminal | Not unique to tankers |
| 3.2 | Base unit | Shore-based | There is no sufficient space at the terminal for installation. | Poor planning for installation | Delayed installation | | 2 | 2 | L | -Use barge or install a floating/fixed platform as an alternative | -18feet x 30~50 feet footprint overall height 32 feet | Described |
| 3.3 | Base unit | Shore-based | The berth does not have enough strength to withstand the weight and load of the capture and control technology. | Insufficient planning/home work | Damage to berth and functionality affected | -Use barge or install a platform purposely as an alternative | 4 | 1 | M | -Compare the weight limit of the pier with the unit<br>-Utilize engineering solutions to spread the weight of the base unit | -expected total weight 150,000-230,000 lbs<br>-T shaped terminal has a given weight limit for existing pilings | Not unique to tankers |

| Id | System | Component | Failure mode(s) | Failure cause(s) | Effect of failure(s) | Existing Safeguards | Con. | Prob. | Risk | Recommendations | Comments | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.4 | Base unit | Barge-based | The movement of barge may cause relative movement btw adaptor and stack. It may add additional load onto the stack. | -Swell, surge, passing traffic | relative movement between crane boom and stack | Flexible duct is used to adapt to the relative movement. | 3 | 2 | M | -Flexible duct length to be adjusted purposely for tankers.<br>-Operator of C&C technology adjusts the angle of place boom accordingly.<br>-Controlling the vacuum and response time with long ducting. | -Gravity spuds are considered for the current design concept for tankers. The vertical position of the barge changes according to the tide.<br>-Suction/magnetic mooring arrangement may be considered. | Not unique to tankers |

| Id | System | Component | Failure mode(s) | Failure cause(s) | Effect of failure(s) | Existing Safeguards | Con. | Prob. | Risk | Recommendations | Comments | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.5 | Base unit | Barge-based | The self-propelled barge is constructed without meeting the regulation requirement or constructed with a low quality. | Poor design and construction | Not possible to operate | | 2 | 2 | L | -Class the barge with class society and consider a periodical inspection plan;<br>-Determine the operating area and clarify with US Coast Guard on the regulatory requirements; | CAEM's current concept is designed for use in the enclosed water in POLA/POLB, but not California Bay Area or transit in open water. The preliminary assessment indicates that the barge does not have to be USCG inspected. License are also not required. However, CAEM plans to provide specific training for the crew regarding navigation and operating the capture and control system. | Described |

| Id | System | Component | Failure mode(s) | Failure cause(s) | Effect of failure(s) | Existing Safeguards | Con. | Prob. | Risk | Recommendations | Comments | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.6 | Base unit | Barge-based | Low qualification of the crew | Poor management of the barge | Flawed and/or delayed operation | | 3 | 3 | M | -Ensure the crew of the barge is trained properly considering the complexity of the capture and control operation, traffic congestion, etc.;<br>-Ensure the crew operating the capture and control technology is familiar with the terminal facility and the local navigation system;<br>-Develop operation procedures involving port, terminal, and capture and control service provider. | | Described |

| Id | System | Component | Failure mode(s) | Failure cause(s) | Effect of failure(s) | Existing Safeguards | Con. | Prob. | Risk | Recommendations | Comments | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.7 | Base unit | Barge-based | Spudding operation is operating without meeting environmental permitting requirement. | Disturbance to the vegetation, marine mammal through spudding | Environmental damage/environmental liabilities | | 3 | 3 | M | -Verify the environment requirement regarding spudding from state agency and if CSL CEQA requirement is needed | Any environmental permitting requirement for spudding?(superfund, sensitive vegetation? marine mammal)Chevron eelgrass POLA vegetation growth start at 15feet depth | Described |
| 3.8 | Base unit | Barge-based | Airborne noise distrubance to the adjacent area | Noisy operations | Noise pollution | | 3 | 3 | M | -Install silencer onto the exhaust of the barge | | Not unique to tankers |

| Id | System | Component | Failure mode(s) | Failure cause(s) | Effect of failure(s) | Existing Safeguards | Con. | Prob. | Risk | Recommendations | Comments | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.9 | Base unit | Barge-based | Spudding may damage the underground piping. | Lack of knowledge of underground installations | Domestic utilities or installations affected | | 5 | 3 | H | -Collect the information about any underground pipelines from the terminal guide and arrange the spudding operation based on the specific terminal arrangement. | The barge will have an emergency anchoring system | Described |
| 3.10 | Base unit | Barge-based | The barge may not have sufficient station keeping capacity. | Strong surge/swell Passing traffic | Collision between tanker and barge/ operation hampered | -The current design concept uses 2 spuds. The barge has 6 spuds installed. More spuds may be used to increase the station keeping capacity. | 4 | 4 | H | -Evaluate the spud station keeping capacity against the local climatology. | -SF bay wave height 4-6 times greater than Richmond harbor. | Described |

| Id | System | Component | Failure mode(s) | Failure cause(s) | Effect of failure(s) | Existing Safeguards | Con. | Prob. | Risk | Recommendations | Comments | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.11 | Base unit | Barge-based | The tanker and barge move when there is a passing traffic but the barge is well stationed. | Passing traffic | Collision between tanker and barge | | 4 | 4 | H | - The safe operating envelope of the barge should be defined with enough clearance between the tanker and the barge based on the mooring analysis for each terminal;<br>- The maximum clearance that the capture and control technology could provide should be evaluated and compared with the required clearance.<br>- The barge may also be equipped with a fender system. | According to MOTEMS, in general, vessels shall remain in contact with the breasting or fendering system. Vessel motion (sway) of up to 2 feet off the breasting structure may be allowed under the most severe environmental loads, unless greater movement can be justified by an appropriate mooring analysis that accounts for potential dynamic effects. | Described |

| Id | System | Component | Failure mode(s) | Failure cause(s) | Effect of failure(s) | Existing Safeguards | Con. | Prob. | Risk | Recommendations | Comments | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.12 | Base unit | Both | Inusfficient operational planning | Modification of the terminal operation induced by using the capture and control technology | Out of MOTEMS compliance. | | 3 | 3 | M | -Consider performing Management of Change review before implementation;<br>-Monitor marine terminal regulation updates and ensure compliance. | | Described |

| Id | System | Component | Failure mode(s) | Failure cause(s) | Effect of failure(s) | Existing Safeguards | Con. | Prob. | Risk | Recommendations | Comments | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.13 | Base unit | Barge-based | Traffic in the channel is affected and in a worst-case scenario, collisions | Narrow channel | The usage of barge may block the traffic in the channel. | barge equipped with GPS, VHF radio, and compass | 4 | 2 | M | -Assess the berthing location of barge based on the local traffic and channel navigation system to avoid adverse impact to the passing traffic;<br>-Ensure that the barge is not berthing inside the regulated navigation area;<br>-Consider moving the barge temporary to allow passing traffic following the provision from CARB at-berth regulation regarding removing the capture and control technology temporarily;<br>-Develop communication platform btw all parties (pilot, terminal, capture and control service provider) and install communication and navigation equipment (VHF, GPS, Satellite compass) onboard the barge;<br>-Consider equipping the barge with an automatic identification system (AIS). | | Described |

| Id | System | Component | Failure mode(s) | Failure cause(s) | Effect of failure(s) | Existing Safeguards | Con. | Prob. | Risk | Recommendations | Comments | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.14 | Base unit | Barge-based | Large footprint of the barge | The usage of barge may involve encroachment to other's property. | Unable to berth the barge | | 2 | 2 | L | -Assess the footprint of the barge and discuss with the neighbour regarding the possibility of using the property | | Described |
| 3.15 | Base unit | Barge-based | Emergency situations | The capture unit cannot be quickly released. The barge may not be able to move away in time during emergency. | Out of compliance, injuries, damage to property | | 5 | 3 | H | -Develop an emergency response procedure<br>-Perform training of the crew<br>-Potentially perform drills to evaluate the impact in reality | | Described |
| 3.16 | Base unit | Barge-based | Boundary conditions not well-defined during design | Deep water in the terminal; Short spud length | The spud length may not be sufficient for the water depth. | Terminal specific pre-assessment | 3 | 3 | M | -Review the water depth during the design stage of the barge and adjust the spud length according to the terminal arrangement. | | Described |
| 3.17 | Base unit | Barge-based | Vessel operations hampered | The barge may interfere with the normal tanker operation (mooring, deballasting). | Unable to berth the barge or install the floating platform | | 3 | 4 | M | -The location arrangement of the base unit should consider the normal operation of the tankers and ensure it does not interfere and is not interfered by the normal operation of the tankers. | Deballasting normally at the bow of the tankers | Described |

| Id | System | Component | Failure mode(s) | Failure cause(s) | Effect of failure(s) | Existing Safeguards | Con. | Prob. | Risk | Recommendations | Comments | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.18 | Base unit | Barge-based | There is no storage space in the port available for the barge when it is not in use. | Insufficient planning/home work | Functionality affected | | 2 | 1 | L | -Consider spud the barge at a storage location as opposed to tied up against the berth and identify the location with Port authority (it may be acceptable for USCG/port to leave the barge attended) | The Port of Long Beach only has 2000 linear feet of wharf space – equivalent to two berths. And all other space is leased out, which means the Port will be limited in its storage capacity of emissions capture and control systems. | Not unique to tankers |

| Id | System | Component | Failure mode(s) | Failure cause(s) | Effect of failure(s) | Existing Safeguards | Con. | Prob. | Risk | Recommendations | Comments | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.19 | Base unit | Barge-based | The operating condition may be too harsh for the barge design. | Harsh environmental condition | The barge cannot be maneuvered as planned or do not have sufficient station keeping capacity. | | 3 | 3 | M | -Purposely design the barge according to the environmental conditions for the planned operation areas. | -The current design is having 3-5knots speed.<br>-Northern California terminals have a harsher environment compared with POLA, POLB. | Described |
| 3.20 | Base unit | Barge-based | The barge does not have sufficient stability. | Poor design and construction | Damage to barge/vessels | | 4 | 2 | M | -Perform stability analysis | | Not unique to tankers |
| 3.21 | Base unit | Barge-based | Safety of personnel | Work at height | Fatality to personnel | | 4 | 2 | M | -Elevator is available | | Not unique to tankers |

## 6.4 HAZOP Results – Capture and control

| ID | Phase | Applicability (Shore, Barge, both) | Hazard / Deviation | Cause | Consequence | Existing safeguards | Cons. | Prob. | Risk | Recommendations | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Normal Operation | Barge | Operation not possible | Unexpected high traffic | No sufficient capture & control available | | 2 | 3 | M | -Evaluate demand based on historical traffic data<br>-Consider use innovative concepts | Not unique to tankers, more relevant to commercial aspects |
| 2 | Normal Operation | Both | Complex and long operation | Human fatigue | Injuries, damage of the property, accidents | | 3 | 3 | M | -Develop proper training and operation procedures for the whole process including:<br>--normal operations such as connection, start up, disconnection, and maintenance<br>--emergency response including safety plans<br>-Provide accommodation and ensure proper working conditions for the crew<br>-Develop proper working schedule and shifts for the crew and ensure the proper rest. | Described |
| 3 | Normal Operation | Barge | Movement of barge | Inadvertent thruster operation | Collision, relative movement | | 3 | 1 | L | -Lockout procedure to be implemented when spudding | Not unique to tankers |
| 4 | Normal Operation | Both | Extreme movement of the vessel | Surge | The adaptor may cause damage to the funnel or disconnect from the funnel. | | 3 | 3 | M | | Not unique to tankers |

| ID | Phase | Applicability (Shore, Barge, both) | Hazard / Deviation | Cause | Consequence | Existing safeguards | Cons. | Prob. | Risk | Recommendations | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | Normal Operation | Both | Poor visibility | Darkness<br>Fog<br>Wild fire | Unable to connect | | 2 | 4 | M | -Develop procedure for response in the bad visibility situation<br>-Utilize emission credit | Not unique to tankers |
| 6 | Normal Operation | Shore | Strong wind | Harsh weather | Crane unable to operate | | 3 | 4 | M | -Operating under MOTEMS regulations. Need to develop operational envelop to obtain weather criteria | Not unique to tankers |
| 7 | Normal Operation | Barge | Strong current | Harsh weather | The barge is not able to manoeuvre safely by itself. | | 2 | 2 | L | Using tug? | Northern California ports have a more exposed water. |
| 8 | Normal Operation | Barge | Hull damages | Harsh weather | Larger relative movements between hood and tanker. It may cause damage of the hull. | | 4 | 2 | M | | Not unique to tankers |

| ID | Phase | Applicability (Shore, Barge, both) | Hazard / Deviation | Cause | Consequence | Existing safeguards | Cons. | Prob. | Risk | Recommendations | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 9 | Emergency Scenario | Both | Environmental damage/oil spills | Operational impact/emergencies/breach etc. | Emergency evacuation required | | 4 | 3 | M | It is recommended to develop a safety response plan with terminals and ports for oil spillage. The barge will likely need to shut down power and provide shelter (accommodation) with air recirculation for the crew onboard. Proper procedure and equipment for communication between the emergency response team, tanker, terminal, port, and capture and control service provider should be provided. | |
| 10 | Emergency Scenario | Both | Earthquake, tsunami, fire | Natural disasters | Emergency evacuation required | -Current terminal design is designed to be compliant with MOTEMS (for any permanent structures) | 5 | 1 | M | -Evaluate the time required for emergency response when connecting to hood (disconnect hood, disconnect barge, manoeuvre away from berth)<br>-Develop emergency response procedure | |
| 11 | Emergency Scenario | Both | Dropped objects | -Crane failure<br>-Poor maintenance<br>-Human error | -Dropped object on barge<br>-Dropped object on shore<br>-Dropped object on ship | | 3 | 3 | M | -Analyze the hydraulic failure with crane provider | |

| ID | Phase | Applicability (Shore, Barge, both) | Hazard / Deviation | Cause | Consequence | Existing safeguards | Co ns. | Pr ob. | Risk | Recommendations | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | | | ISPS and MTSA compliance | Opertional issues | Non compliance | | 3 | 2 | M | -Investigate the applicability and ensure compliance | |
| | | Both | Backpressure / Additional pressure from the emission capture and control technology may impact the safe operation of the ship | -Blockage of exhaust flow<br>-High flow of emissions which is the emission treatment is unable to process<br>-Shutdown of capture and control system (i.e. Primary fan failure) | | | | | | Built up pressure needs to be evaluated<br>-Identify alarm interfaces and safeguards that would prevent backpressure build up within the tank vessel exhaust systems<br>-Pressure relief arrangement? | Not used |
| | | | Variation of boiler pressure | | | | | | | | Not used |
| | | | Accumulated heat in the system | | | | | | | | Not used |
| | | | Reverse flow of emissions? | | | | | | | | Not used |
| | | Shore | Blackout on terminal side | | | | | | | | Not used |
| | | Both | Blackout of ship | | | | | | | | Not used |
| | | Both | Hood damaging the funnel | Adverse weather, relative motion control not sufficient | | | | | | | Not used |
| | | Barge | Barge capsizing due | Poor barge maintenance and | -Damage to tanker funnel | | | | | -Maintenance and inspection regime on barge | Not used |

| ID | Phase | Applicability (Shore, Barge, both) | Hazard / Deviation | Cause | Consequence | Existing safeguards | Co ns. | Pr ob. | Risk | Recommendations | Relevance for tanker |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | to adverse stability | quality control | | | | | | | |

DNV is the independent expert in risk management and assurance, operating in more than 100 countries. Through its broad experience and deep expertise DNV advances safety and sustainable performance, sets industry benchmarks, and inspires and invents solutions.
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Wallenius Wilhelmsen

Angela Csondes
Manager, Marine Strategies Section, CARB
Angela.Csondes@arb.ca.gov,
Shorepower@arb.ca.gov

30-June-22,

## Re: At-berth regulation – Interim Evaluation Feedback
## Compliance Solution, Supply Chain Delays

Dear Angela,

The Wallenius Wilhelmsen group is an Oslo-based leader in RoRo shipping and vehicle logistics, engaged in global transport of autos and heavy machinery. The group employs 2,500 people in the US, 371 in California, who ensure the smooth flow of billions of dollars of cargo each year through 10 major US ports. We are the owner-operator of a fleet of 130 globally-trading Vehicle Carrier vessels, having 100 calls per year to over 3 Ca. ports and are the commercial operator of the RoRo terminal in Wilmington, California.

We welcome the leading at-berth emissions regulatory focus of CARB, but would like to raise some serious concerns about the possibility of meeting the 1st January 2025 compliance date for Vehicle Carriers. In saying that, we wish to note that Wallenius Wilhelmsen is committed to a shore power solution and has set a public target (featured in our formal Annual Reports for 2020 and 2021) to have our owned fleet equipped for shore power by 2025. In addition, the company presented it's 2021 USD100k 'Orcelle Award' for sustainable innovation to a California based start-up, Element Resource, for their novel zero-emission mobile fuel cell quay-based shore power concept. The core of the concept is the belief that shore power does not have to mean grid power. We are working hard with Element Resource and many others to make that concept a reality.

The assessment we did of compliance options accounted for the fact that at-berth regulations emerging elsewhere in the world are likely to require a zero-emissions standard; a performance level that stack-capture systems cannot reach, hence our conclusion that shore power is the only viable option.

In keeping with our global perspective on at-berth regulation development, we initiated a shore power IEC/IEEE standard-setting process for the Vehicle Carrier segment and encouraged other same segment carriers to participate. That process is well underway, but it will not conclude till next year, meaning it is not possible to know the detail shore-power retrofit specification till that time.

Notwithstanding the specification uncertainty, which prevents us from being able to make full and final vessel retrofit plans, we have begun dialogue with a range of major electrical equipment makers to at least prepare to the furthest degree that the current unknowns and uncertainties permit. During those vendor discussions we have been repeatedly advised of the serious supply chain delays they are experiencing. Most have been reluctant to make a public statement about their inability to supply, however three of the most prominent were prepared to go on record (see attachments):

- **Yara** issued a letter back in January with 11-13 months estimated delivery time for **one** vessel. In the revision they issued *in* May the lead time had increased to 12-15 months.
- **Kongsberg** have not specified an actual delivery time, but instead summarised the reasons why their supply chains are disrupted.
- **Wartsila** advise that, in addition to component supply delays, installation delays can arise due to travel restrictions.

Finally, the supply chain difficulty is compounded by the fact that the CARB at-berth regulation is effectively a "full global fleet" requirement for us. This is due to tonnage deployments demanding most of our vessels call a Californian port over the course of 2 years, typically more than once. Maintaining deployment flexibility is central to achieving optimal operational efficiency, a key factor underpinning fleet environmental and economic performance.

Each of Wallenius Wilhelmsen's global fleet of 130 vessels will require its own design, planning, procurement and retrofit process. However, the IEC/IEEE/ISO standard for Vehicle Carriers is not yet finalized and it will directly dictate what type of components the shore power system should include, as well as whether they should be placed on vessel or berth. Consequentially Wallenius Wilhelmsen will not be able to start the procurement process until these unknown factors are resolved. Based on our current insight of the standard development process and assuming the IEC/IEEE/ISO remains on track, we anticipate that it will be possible to place a fleet wide shore power order in Dec 2022. With current lead times and installation capacity from the suppliers (approx. 15 months per vessel, 4 vessels concurrently), the best-case scenario would give us about 40 vessels fully equipped before Jan 1st, 2025, and 80-100 vessels before Jan 1st, 2027."

As a result, we will not be able to complete our global retrofit program in time to be compliant with the current regulatory schedule. Furthermore, the company also does not have the resources to develop sufficient alternative strategies that would ensure compliance; we are committed to this zero-emission strategy. We also wish to note that even if zero-emission 'quay power' solutions were to materialise within 1st Jan 2025, they would not alter the situation given those solutions would still require the same shore power retrofitting of the fleet.

We request that CARB take account of the supply chain difficulties in its Interim Evaluation. In summary Wallenius Wilhelmsen is 'doubly' committed to meeting the January 1st 2025 compliance date and is playing an influential role in developing novel zero-emission quay power solutions that will exceed the performance offered by stack emission capture systems. We therefore believe it is unreasonable to be penalized for any failure to meet the compliance date despite best efforts and because of factors beyond our control. Thus, we ask CARB to consider offering relief relative to the compliance deadline until 2027 and/or a VIE phase-in in schedule starting at 50% in 2025 and decreasing by 10% per year thereafter.

Yours sincerely,

Roger Strevens

**VP, Global Sustainability**

February 2022

**General Information Letter for Customers - Supply Chain Disruption**

Please find general information from Kongsberg Maritime regarding global supply chain disruption, that is affecting multiple industries, companies and markets.

Supply Chain disruption is affecting the Kongsberg Maritime business in the following areas:

- Component shortages in the supply chain related to semi-conductors and other components affecting parts availability, lead-times and cost
- Raw material price increases including copper, steel, iron and aluminium
- Logistics disruption across sea, rail and air with higher lead-times, rates and lower delivery precision
- Reduced capacity at suppliers due to high global demand
- A demanding environment with quick decision making needed to secure parts, capacity and supply

The Kongsberg Maritime Supply Chain is doing its utmost to minimise disruption to Customers by taking actions appropriate to the Products affected. These include:

- Early engagement with Customers, Sales and Product teams
- Extension of order and forecasting horizons
- Analysis of critical parts to secure vital components, including advanced ordering of key components
- Increase of inventory where possible and update of ERP lead-times
- Re-use of available stock, repair and re-design to use available parts where possible
- Supplier engagement and sourcing activity to secure capacity and supply (including sub-suppliers)
- Regarding electronic components we are working very closely with component brand owners directly and through our production partners and global component distributor partners.

These actions are important to support delivery of Customer contracts and the better market intelligence and longer forecasting horizon from our Customers, the better we will be able to secure our Customer demands in the coming year.

Kongsberg Maritime will continuously keep you updated on specific information through our Delivery Organisation. Please link with your regular Kongsberg Maritime interface, who will assist if support is required from our Procurement and Supply chain responsible teams.

Best regards,

R. Anthony

Rob Anthony
Senior Vice President – Global Supply Chain
Kongsberg Maritime

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Knowledge grows

# Project lead time update

Knowledge grows

Att: Tomas Bahr Sandmo

Wallenius Willhelmsen

2022-01-19

**Subject:** ***Increasing lead times Shore Power projects***

Yara Marine Technologies as well as the rest of the industry are currently experiencing increasing lead times for Shore Power projects. This is a direct consequence of the increasing lead times of the critical main components included in a Shore Power installation onboard such as:

- High Voltage Switchboards,
- Transformers
- Semi-conductors
- Cables

We currently estimate an increase of 6-15 weeks and based on information from major component suppliers and there are concerns for even further increases as the year progresses. This means the delivery time for a complete installed shore power system for a typical RoRo or Container vessel can be approx. 11-13 months.

High demand and large order back logs, combined with Covid-19 related manufacturing and logistic disturbances, all contribute to the current situation.

Sincerely,

Yara Marine Technologies AB

Mats Olsson

Senior Sales Manager

**Yara Marine Technologies**

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Knowledge grows

# Project lead time update

Knowledge grows

Att: Tomas Bahr Sandmo

Wallenius Willhelmsen

2022-05-23

**Subject:** ***Increasing lead times and material price for Shore Power projects***

Yara Marine Technologies as well as the rest of the industry are currently experiencing increasing lead times and material cost for Shore Power projects. This is a direct consequence of the increasing lead times of the critical main components included in a Shore Power installation onboard such as:

- High Voltage Switchboards
- Transformers
- Semi-conductors
- Cables

We currently estimate an increase of 10-20 weeks, (in some extreme cases such as for semiconductors + 30 weeks). The information is based based on information from major component suppliers and
there are concerns for even further increases as the year progresses. This means the delivery time for a complete installed shore power system for a typical RoRo or Container vessel can be approx. 12-15 months.

There is also an increase of prices for transportation, raw material and electric components.

High demand and large order back logs, lack of capacity for production, combined with Covid-19 related manufacturing and logistic disturbances, all contribute to the current situation.

Sincerely,

Yara Marine Technologies AB

Mats Olsson

Senior Sales Manager

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