Working Group #4: Liquefied Natural Gas (LNG) Facility Operation and Maintenance

Summary Report-Out

Roadmapped Research Gaps

Prioritized Gap #1: Available technologies to enhance inspection of in-service legacy liquefied natural gas (LNG) storage tanks (Part 193.2623 Inspecting LNG storage tanks).

1. What is the suggested gap name for this research project?

   - Identifying/Recommending Technologies for Inspecting In-Service Legacy LNG Storage Tanks.

2. What is the suggested objective statement for this gap?

   - To identify technological enhancements that support the inspection of in-service legacy LNG storage tanks, in accordance with (IAW) Part 193.2623.

3. Can any regulatory, congressional, or National Transportation Safety Board (NTSB) drivers (more than one category can be included) be identified as associated with this gap?

   - Part 193.2623.
   - Suggest PHMSA investigate relevant enforcement actions and recommendations, including those by Federal Energy Regulatory Commission (FERC).

4. What key technical details or scope items are necessary and recommended to be incorporated into the research project?

   - Search literature of relevant technologies for tank inspection.
   - Identify inspection areas, IAW National Fire Protection Association (NFPA) 59A 2019, Section 18.10.11, with legacy or other cryogenic and propane storage tanks, including looking beyond U.S. LNG facilities to international partners.

- Identify the feasibility, capabilities, and limitations of identified legacy tank inspection technologies.

5. Which research output is being suggested from the gap (technology development or general knowledge)?

   - General knowledge of available technologies for tank inspection.

6. [Answer if relevant] What type of data output or tool/model functionality is required to successfully address the gap?

   - N/A.

7. Does the gap address a related consensus standard (i.e., NFPA 59A) or best practice?

   - American Petroleum Institute (API) 653.
   - NFPA 59A 2019, Section 18.10.11 (and Annex material).

8. What are anticipated targets or timeframes to complete this research (months)?

   - 12 – 18 months.

Prioritized Gap #2: Potential impacts of hydrogen-enriched natural gas feedstock on existing LNG storage tank systems (e.g., determine the potential for stratification/ rollover, whether the Hydrogen (H_2) stays in the LNG to some degree, and whether the H_2 becomes concentrated in various vapor spaces, such as the dome or annular space, within various storage tank styles).

1. What is the suggested gap name for this research project?

   - Potential Impacts of Hydrogen-Enriched Natural Gas Feedstock on Existing LNG Storage Tank Systems.

2. What is the suggested objective statement for this gap?

   - Ensure the safe operation and maintenance of LNG storage tank systems (e.g., double wall, single wall, full containment) containing H_2-enriched natural gas, including issues of leakage, stratification, H_2 diffusion in concrete, H_2 flammability, and metallurgy

3. Can any regulatory, congressional, or NTSB drivers (more than one category can be included) be identified as associated with this gap?

   - PHMSA should identify an H_2 concentration of concern in the feedstock and vapor space within the tank.

4. What key technical details or scope items are necessary and recommended to be incorporated into the research project?

   - Issues and challenges related to H_2-enriched natural gas.
   - H_2 concentration of concern in the feedstock and vapor space within the tank.

5. Which research output is being suggested from the gap (technology development or general knowledge)?

   - General knowledge.

6. [Answer if relevant] What type of data output or tool/model functionality is required to successfully address the gap?

   - N/A.

7. Does the gap address a related consensus standard (i.e., NFPA 59A) or best practice?

   - NFPA 59A 2001, Chapter 4.
   - NFPA 59A 2006.
   - NFPA 59A 2019, Chapter 8.
   - National Association of Corrosion Engineers (NACE) SP21430-2019, Standard Framework for Establishing Corrosion Management Systems.

8. What are anticipated targets or timeframes to complete this research (months)?

   - 12 – 18 months.

Prioritized Gap #3: Would an Occupational Safety and Health Administration (OSHA) Process Safety Management (PSM) performance-based approach for establishing Recognized and Generally Accepted Good Engineering Practice (RAGAGEP) provide a higher level of protection in concert with risk-based regulations, as addressed in Protecting Our Infrastructure of Pipelines and Enhancing Safety Act (PIPES 2020) Section 110 for LNG facilities?

1. What is the suggested gap name for this research project?

    - Process for Establishing Recognized and Generally Accepted Good Engineering Practices (RAGAGEP) Relevant to Large-Scale LNG Facilities.

2. What is the suggested objective statement for this gap?

    - Evaluate the appropriateness of the current OSHA PSM performance-based approach.

3. Can any regulatory, congressional, or NTSB drivers (more than one category can be included) be identified as associated with this gap?

    - 2016 OSHA enforcement policy memo outlining the PSM approach.

4. What key technical details or scope items are necessary and recommended to be incorporated into the research project?

    - No technical details.
    - Scope:
        - Identify relevant large-scale LNG facilities.
        - Identify recommended best practices and policies.
        - Determine how an alternative approach would meet established protection level baselines.

5. Which research output is being suggested from the gap (technology development or general knowledge)?

    - General knowledge.

6. [Answer if relevant] What type of data output or tool/model functionality is required to successfully address the gap?

    - N/A.

7. Does the gap address a related consensus standard (i.e., NFPA 59A) or best practice?

    - No current regulation addresses this issue.

8. What are anticipated targets or timeframes to complete this research (months)?

    - 12 – 18 months.

Prioritized Gap #4: Develop standardized stratification thresholds based on operating mode and across facilities (monitoring and alarm levels for temperature and density).

1. What is the suggested gap name for this research project?

    - Developing Standardized Stratification Thresholds for LNG Storage Tanks (Monitoring and Alarm Levels for Temperature and Density) Across LNG Facilities Based on Different Operating Modes.

2. What is the suggested objective statement for this gap?

    - Obtain recommended LNG storage tank temperature and density threshold data for LTD (level, temperature, density) systems to prevent rollover.

3. Can any regulatory, congressional, or NTSB drivers (more than one category can be included) be identified as associated with this gap?

    - NFPA 59A.

4. What key technical details or scope items are necessary and recommended to be incorporated into the research project?

    - Survey facility systems that address stratification management (manual, Digital Control System (DCS) alarms, or predictive software).
    - Determine stratification thresholds.

5. Which research output is being suggested from the gap (technology development or general knowledge)?

    - General knowledge.

6. [Answer if relevant] What type of data output or tool/model functionality is required to successfully address the gap?

   - N/A.

7. Does the gap address a related consensus standard (i.e., NFPA 59A) or best practice?

   - NFPA 59A (2001), Chapter 4.

8. What are anticipated targets or timeframes to complete this research (months)?

   - 12 – 18 months.

Prioritized Gap #5: Recommended allowable concentrations of trace components in renewable natural gas (e.g., siloxanes—perhaps Br, Cl, HBr, HCl or others) in feed gas to LNG liquefaction systems.

1. What is the suggested gap name for this research project?

   - Assessing Potential Impacts of Trace Components in Renewable Natural Gas (RNG) on LNG Facilities

2. What is the suggested objective statement for this gap?

   - Assess the potential impacts of trace components in renewable natural gas (RNG) that could impact the operation of LNG facilities
   - Identify potential system or equipment upgrades that may be needed to safely operate LNG facilities and to potentially inform enhanced guidelines for the interconnection of RNG facilities to gas pipeline systems

3. Can any regulatory, congressional, or NTSB drivers (more than one category can be included) be identified as associated with this gap?

   - None.

4. What key technical details or scope items are necessary and recommended to be incorporated into the research project?

- Assess the potential for siloxanes (Si-O-Si) or other organosilicon compounds to foul or poison pretreatment systems—or foul or deteriorate liquefaction, storage, or vaporization equipment—through analytical evaluation or potential physical analysis (e.g., condensation and solidification point in representative RNG composition).
- Assess and identify any key components, material or piping that may be more susceptible to potential constituents of concern in RNG.
- Identify other trace components in RNG that could impact LNG facility operations. Consideration may—for example—include Cl, F, Br, Hg, As, Cu; compounds such as ammonia, vinyl chloride, and other organochlorides; or those arising from halogenated hydrocarbons (e.g., HCl, HBr).
- Summarize existing relevant existing knowledge.
- Recommend potential follow-up research.

5. Which research output is being suggested from the gap (technology development or general knowledge)?

   - General knowledge.

6. [Answer if relevant] What type of data output or tool/model functionality is required to successfully address the gap?

   - N/A.

7. Does the gap address a related consensus standard (i.e., NFPA 59A) or best practice?

   - The research may, for example, build on prior PHMSA research project #293 (https://primis.phmsa.dot.gov/matrix/FilGet.rdm?fil=7664) and California Council on Science & Technology analysis (https://ccst.us/reports/biomethane-in-california-common-carrier-pipelines-assessing-heating-value-and-maximum-siloxane-specifications/) but instead focus on potential implications of trace components in RNG specifically on LNG facilities. This research could help refine utility best practices, such as "Interconnect Guide for Renewable Natural Gas (RNG) in New York State" (https://www.northeastgas.org/pdf/nga_gti_interconnect_0919.pdf), SoCalGas Rule 45, and other RNG interconnection guidelines.

8. What are anticipated targets or timeframes to complete this research (months)?

   - 18 – 24 months.

List of Prioritized Consolidated Gaps

#	**Consolidated Gap**
1.	Available technologies to enhance inspection of in-service legacy LNG storage tanks (Part 193.2623 Inspecting LNG storage tanks).
2.	Potential impacts of hydrogen-enriched natural gas feedstock on existing LNG storage tank systems (e.g., determine the potential for stratification/rollover, whether the H_2 stays in the LNG to some degree, and whether the H_2 becomes concentrated in various vapor spaces, such as the dome or annular space, within various storage tank styles).
3.	Would an OSHA PSM performance-based approach for establishing Recognized and Generally Accepted Good Engineering Practice (RAGAGEP) provide a higher level of protection in concert with risk-based regulations, as addressed in PIPES 2020 Section 110 for LNG facilities?
4.	*Update weld design, processes, testing, and assessment procedures for LNG structural pipes and storage containers.
5.	Develop standardized stratification thresholds based on operating mode and across facilities (monitoring and alarm levels for temperature and density).
6.	Recommended allowable concentrations of trace components in renewable natural gas (e.g., siloxanes--perhaps Br, Cl, HBr, HCl or others) in feed gas to LNG liquefaction systems.
7.	Effectiveness of relief valves (hard seated/soft seated) to seal below set lift pressure for gas streams that are potentially enriched (1-5%) with hydrogen.
8.	Improved methods of flaring off excess vaporized natural gas through flare-columns (e.g., replacing the sweep gas with cleaner burning gas such as hydrogen, capturing the excess gas for redistribution in the system, or utilizing carbon capture with the flare column).
9.	Expected life of an LNG tank that never cycles to empty.

*Gap #4 was skipped during the roadmapping session.