HYDROGEN Safety Panel

SAFETY PLAN REVIEW

Air Liquide Hydrogen Fueling Station Safety Plan Review

Submission for the California Energy Commission General Funding Opportunity GFO-15-605

Background

At the request of the California Energy Commission, members from the Hydrogen Safety Panel (HSP) reviewed the Air Liquide Hydrogen Safety Plan. The Panel's feedback on the plan is summarized below, followed by specific comments on the plan. Annex A provides the Panel's evaluation on how adequately the safety plan addresses the required topics.

Summary of Results

The safety plan follows the formatting identified in the HSP safety planning guideline document. While the project team clearly has the expertise and experience to provide a comprehensive hydrogen safety plan, most items in this safety plan are generalized, and more project-specfic information is needed to validate its adequacy. Topics not adequately addressed in the safety plan include identification of safety vulnerabilities, risk reduction plan, operating procedures, project safety documentation and personnel training. As result of the lack of project-specific detail, the HSP team members could not perform a thorough review of the applicant's submission, and therefore, the safety plan is incomplete, but promising.

Comments

The following comments include specific observations and recommendations that the HSP review team believes will result in a safer hydrogen fueling station. Many of the comments are based on the lack of detail in the safety plan and do not necessarily reflect inadequate safety planning. Alternative approaches may result in a station with equivalent safety, and these specific recommendations are not intended to limit the approach taken by the project team. The project team is encouraged to consider these comments early in the design of the hydrogen fueling station.

Narrative Document

Comment 1: The Capitola and Dublin locations appear to be very close to new and existing buildings. The Sacramento station appears to have property line separation distances that are less than required by NFPA 2. Final distances should be verified as meeting the requirements of NFPA 2 or have an AHJ-approved alternate method based on sound technical justification. Since parking is provided on the adjacent property at the Sacramento location, agreements may need to be worked out with neighboring property owners.

Comment 2: Page 73 of the Narrative states that the station "will be built to all NFPA 2:2011 standards." Air Liquide should consider using the 2016 version of NFPA 2 for this activity since this code has been adopted by California.

Comment 3: Some of the hydrogen supply locations for the anticipated fueling stations (including storage tanks and hydrogen equipment enclosures) do not appear to have adequate separation distances from lot lines and exposures in accordance with NFPA 2. Final siting locations should be in accordance with NFPA 2 or have locations approved by the AHJ based on a technically justified alternative methodology.

Safety Plan

Comment 4: Section 2 does not describe application of safety-related policies and procedures to the work being performed. There is an overview of the personnel structure, but no explanation of how the project would be managed within this structure. A table of high-level procedures is provided, but there is no explanation on how they fit into this project.

Comment 5: Section 3, Identification of Safety Vulnerabilities, generally describes the how HAZOP; accident risk analysis; generic risk assessment; and failure modes, effects, and critical analysis are used to ensure safety on the hydrogen systems. This section discusses safety reviews for each site in general but lacks specifics or examples of a HAZOP or the safety issues around the installation and startup, filling the hydrogen system, and its operation. Although two of the "most feared" events are included, along with their expected frequencies and risk mitigations, more information on other significant accident scenarios should be identified. In particular, low-probability, high-consequence events should be analyzed rather than ones that have a high probability of occurring. A broader discussion of hazards and risk associated with anticipated equipment would have more fully enabled Air Liquide to demonstrate safety in their proposal. For example, are there other potential events associated with the storage and possible use of enclosures for processing equipment? Also, what are the safety features associated for such equipment? It is assumed that the project teams can provide this information since Section 3 states that the Air Liquide hydrogen station design process flow diagram is globally consistent and therefore the HAZOP and accident risk assessment apply to all hydrogen installations.

Comment 6: Section 3, Identification of Safety Vulnerabilities – What is the strategy used to fill the system containers and how will this keep the public safe during the fill process?

Comment 7: Section 3, Risk Reduction Plan – The accident risk assessment identifies only two "feared events," including one involving an easily mitigated leak accumulation scenario during hydrogen transfer to the station. A potentially higher risk and higher consequence scenario involving the failure of a transfer hose and/or piping is not identified. Additionally, the section does not cover risks with the hydrogen delivery system and its installation, operation, or maintenance.

Comment 8: Section 3, Operating Procedures - The intent of this section is to list existing and planned procedures that describe the operating steps for the system. Although some of these are listed in Section 2, more detailed information is needed on steps for operation, operating limits, and safety systems and their functions. Additionally, this section only provides a cursory overview of alarm response procedures. It describes how problems/alarms are monitored, but does not address specific operations issues, warnings, alarms, and failures or provide the safety features of the equipment, construction, or maintenance.

In accordance with the guidance document, this section should address:

1) operational procedures applicable for the location and performance of the work or

2) the operating steps for the particular project, critical variables, their acceptable ranges, and responses to deviations; these include:
   - Initial testing and commissioning
   - Preventative maintenance plan
   - Calibration of sensors
   - Test/inspection frequency basis
   - Documentation

The project team is also encouraged to address the following items in the safety plan:
- Shutdown table for safety shutdown strategy.
- Does this system require back up power and if so, how is this managed in loss of power (standby power required by NFPA 2-6.7)?
- What are the standards on the use and testing of mechanical safety devices?
- How/what devices are implemented to meet redundancy requirements, such as pressure shutdowns backup by mechanical safety devices?

More detailed information on the operating and maintenance procedures is necessary to evaluate the Air Liquide's consideration for safety in this topic.

Comment 9: Section 3, Equipment and Mechanical Integrity, discusses PLC control, gas detectors, flame detectors, leak checking, and the codes used to design the system. However, the section does not address design, testing, commissioning, PM plans, equipment calibration, training, or documentation.

Comment 10: Section 3, Equipment and Mechanical Integrity, states that station equipment and the dispenser are certified to NFPA 2 and 496. Who provides this certification and what parts of these codes/standards are covered by this certification? This information should also be shared with the AHJ to ensure a clear understanding of what components are certified and to what criteria they are certified to. In addition, there is no acknowledgement that many existing components will in fact not be "listed" per NFPA 2, and no indication of the mitigation plan (e.g., self-declaration of equivalent level of safety by equipment manufacturer or applicant).

Comment 11: Section 3, Equipment and Mechanical Integrity, states that equipment and mechanical integrity is ensured through an EIS program, but does not provide specifics. For example, an equipment list could have been provided, indicating how safety is ensured (e.g., equipment complies with the following component safety standards).

Comment 12: Section 3, Equipment and Mechanical Integrity, does not appear to provide a comprehensive list of applicable codes and standards. If other component-level standards are used, such as ANSI/HGV 4.2 (fueling hoses), 4.4 (breakaways), and 4.6/4.7 (dispenser valves), it would be beneficial to have these listed in this section. In addition, the plan refers to fueling hoses being compliant with SAE J2600/ISO 17268, but should have also referred to fueling nozzle compliance.

Comment 13: Section 3, Equipment and Mechanical Integrity, does not indicate that materials will be selected for their resistance to hydrogen embrittlement, nor does it reference the applicable references that could support compliance (e.g., SAE J2579 Table B2).

Comment 14: Section 3, Equipment and Mecahnical Integrity, should provide additional discussion on hydrogen flame detector and leak detector calibration requirements.

Comment 15: Section 4 does not provide details on how needed safety information is communicated and made available to all participants, including partners. Safety information includes the ISV documentation, procedures, references such as handbooks and standards, and safety review reports.

Comment 16: Section 4, Training, does not provide enough information to assess:

- Required general safety training - initial and refresher
- Hydrogen-specific and hazardous material training - initial and refresher
- How the organization stewards training participation and verifies understanding

Comment 17: Section 4, Safety Events and Lessons Learned, generally complies with the hydrogen safety planning guidelines document, but should discuss how lessons learned from incidents and near-misses are documented and disseminated. The project team should also report near misses and incidents to the California Energy Commission. It is also recommended that hydrogen related incidents and near misses be submitted to the Lessons Learned database (https://h2tools.org/lessons).

Comment 18: Section 4, Emergency Response, does not provide a manual or example of a manual and does not describe the plan/procedures for potential safety issues or responses to these emergencies. The plan should more thoroughly address what procedures are in place for the station operators in responding to emergencies. Also, what specific actions will be taken to work with the first responders in the event of an incident at the station?

Comment 19: Section 4, Self Audit, should describe how the project team will verify that safety-related procedures and practices are being followed through the duration of the project and continued use of the equipment.

ANNEX A: CEC Safety Plan Review Checklist

This checklist is a summary of desired elements for safety plans taken from Safety Planning for Hydrogen and Fuel Cell Projects – March 2016.[1] The checklist is intended to help project teams verify that their safety plan addresses the important elements and can be a valuable tool over the life of the project. The items below should not be considered an exhaustive list of safety considerations for all projects.

GFO SUBMITTER OR TITLE: Air Liquide
DATE: December 20, 2016

Element	The Safety Plan Should Describe	Adequately Addressed? (Yes or No)
Scope of Work	• Nature of the work being performed	Yes with Narrative
Organizational Policies and Procedures	• Application of safety-related policies and procedures to the work being performed	Yes with comments
Hydrogen and Fuel Cell Experience	• How previous organizational experience with hydrogen, fuel cell and related work is applied to this project	Yes with Narrative

Identification of Safety Vulnerabilities (ISV)	• What is the ISV methodology applied to this project, such as FMEA, What If, HAZOP, Checklist, Fault Tree, Event Tree, Probabilistic Risk Assessment, or other method
	• Who leads and stewards the use of the ISV methodology
	• Significant accident scenarios identified
	• Significant vulnerabilities identified
	• Safety critical equipment
	• Storage and Handling of Hazardous Materials and related topics
	  ○ ignition sources; explosion hazards
	  ○ materials interactions
	  ○ possible leakage and accumulation
	  ○ detection
	• Hydrogen Handling Systems
	  ○ supply, storage and distribution systems
	  ○ volumes, pressures, estimated use rates
		No

Risk Reduction Plan	• Prevention and mitigation measures for significant vulnerabilities	No
Operating Procedures	• Operational procedures applicable for the location and performance of the work including sample handling and transport • Operating steps that need to be written for the particular project: critical variables, their acceptable ranges and responses to deviations from them	No

[1] URL: https://h2tools.org/sites/default/files/Safety_Planning_for_Hydrogen_and_Fuel_Cell_Projects-March_2016.pdf

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Element	The Safety Plan Should Describe	Adequately Addressed? (Yes or No)
Equipment and Mechanical Integrity	• Initial testing and commissioning • Preventative maintenance plan • Calibration of sensors • Test/inspection frequency basis • Documentation	Yes with comments
Management of Change Procedures	• The system and/or procedures used to review proposed changes to materials, technology, equipment, procedures, personnel and facility operation for their effect on safety vulnerabilities	Yes
Project Safety Documentation	• How needed safety information is communicated and made available to all participants, including partners. Safety information includes the ISV documentation, procedures, references such as handbooks and standards, and safety review reports.	No
Personnel Training	• Required general safety training - initial and refresher • Hydrogen-specific and hazardous material training - initial and refresher • How the organization stewards training participation and verifies understanding	No
Safety Reviews	• Applicable safety reviews beyond the ISV described above	Yes
Safety Events and Lessons Learned	• The reporting procedure within the team • The system and/or procedure used to investigate events • How corrective measures will be implemented • How lessons learned from incidents and near-misses are documented and disseminated	Yes with comments
Emergency Response	• The plan/procedures for responses to emergencies • Communication and interaction with local emergency response officials	Yes with comments
Self-Audits	• How the team will verify that safety related procedures and practices are being followed throughout the life of the project	Yes