HYDROGEN Safety Panel

SAFETY PLAN REVIEW

Jensen 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 of the Hydrogen Safety Panel (HSP) reviewed the Jensen/Linde 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 project team includes three participants. Based on the documentation provided, it appears that the safety plans are not specific for this project activity and that safety integration among the project partners has not been completed or demonstrated (the Narrative document indicated that the supplied Linde and Fastech plans will be combined into a functional safety plan as part of the scope of the fueling station project). Topics not adequately addressed in the safety plan include identification of safety vulnerabilities, risk reduction plan, operating procedures, equipment and mechanical integrity, project safety documentation, project safety reviews and self-audits. 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.

Comment 1: Page 22 of the Narrative states that fueling hoses will be compliant with SAE J2600 or ISO 17268, but these documents apply to fueling nozzles. Hoses should comply with ANSI/CSA HGV 4.2.

Comment 2: Narrative, page 30, states, "Fastech's and Linde's Safety Plans [will] be integrated, adapted and customized for this specific station. Linde, Fastech and RV Jensen will accomplish this together as part of the scheduled scope of work activities funded by this project, as some of the policies and procedures are technical, some are procedural and some relate to the organization and personnel." Page 31 states "The template safety plans included from Fastech and Linde both provide example organizational safety policies and procedures which will be customized and incorporated into the final safety plan for the RV Jensen site." Based on these statements, it appears that the safety plans provided are not specific for this project activity and that safety integration among the project partners has not been completed or demonstrated for the GFO submission.

Comment 3: Narrative, page 32, states, "The safety plans provided with this proposal from Linde, Fastech and RV Jensen identify all known operational safety vulnerabilities and

establish appropriate risk reduction plans." A detailed look at the safety plans could not identify where this information was provided.

Comment 4: Narrative, page 34, discusses third-party station component certification. Jensen and its partners should provide specific information on what elements will be certified and what standards/requirements they will be certified to. This information should be provided to AHJs and stakeholders. Equipment not included in a listing or certification will still require approval by the AHJ.

Comment 5: Since the project's design relies on the use of enclosures, documentation should be provided that identifies how this equipment conforms to the hydrogen equipment enclosure requirements of NFPA 2 (7.1.23).

Comment 6: Narrative, page 32, states that the system includes safety and alarm systems, but no specific examples of safety systems are provided.

Comment 7: Per the Narrative, page 33, Jensen defers to Linde's plan for equipment and mechanical integrity. Page 20 of the Narrative states "All hydrogen piping will be pressure tested prior to delivery and employ hardware proven to be reliable in our systems installed and operating worldwide." Page 33 states, "Linde selects materials and components for hydrogen service based on available data, experience at Linde R&D facilities, and recognized standards. When selecting materials for hydrogen service, Linde makes the following considerations according to the operating temperature and pressure, for example:

- Hydrogen embrittlement
- Elastomer pre-load (tensile strength v elongation)
- Explosive decompression of synthetic rubbers in hydrogen service
- Shore hardness'"

The Narrative includes a maintenance list for some items on pages 33 and 34. There is no mention of the relief device testing/change out or safety device checking except for the emergency shutdown. The list should be more comprehensive and specific to this project.

Comment 8: General - Although a mobile tube trailer refiller is discussed in the Narrative, there is no description of its size, storage capacity, pressure rating, which codes under which it will be built, or how the siting will be managed as it is filled or used.

Linde Safety Plan Comments

Comment 9: General - The safety plan provides only generic information and does not provide many project-specific details as directed by the safety guidance document (https://h2tools.org/sites/default/files/Safety_Planning_for_Hydrogen_and_Fuel_Cell_Projects-March_2016.pdf).

Comment 10: General - The Linde safety plan does not provide the required discussion on project safety documentation, including 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 11: Sections 3.1 and 3.2 provide a general overview of the Linde's risk analysis approach but do not provide discussion or detail on the actual risks and associated risk reduction measures for the intended equipment. The identification of safety vulnerabilities, including methodology, stewardship, significant accident scenarios, significant vulnerabilities and safety critical equipment, is not provided in the submission. The major hazards identified include hydrogen flammability, stored energy of hydrogen, and the fueling process. There are additional major hazards including those associated with liquid storage (cryogenic hazards), liquid transfer to the site (leakage/ignition), and a broader hazard related to leakage/ignition in the high-pressure system. Without additional information it is not possible to determine adequacy of the project's safety planning.

Comment 12: Section 3.2 - The risk analysis and management plan is based only on code compliance and industry practices. No standard risk analysis methodology was documented, as stipulated in the safety plan requirements guidance. Because the safety vulnerabilities are only treated in a general way in the plan, specific risk reduction measures are not addressed. Indirect reference to an FMEA and HAZOP is made in the Safety Review section, although no details are provided.

Comment 13: Section 3.3 - Operating procedures are only addressed at a very high level, non-specific way, and operating procedures for the equipment and the system are omitted. Specifically, the plan does not address:

- 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

Comment 14: A project operational readiness inspection procedure should be considered by the project team for startup and commissioning. Such a document would help ensure that all HAZOP and safety items are completed, the design is per the design documents, all safety items are online and operational, and all personnel have been trained, to name a few benefits.

Comment 15: Section 3.4 does not define equipment and mechanical integrity. The section should provide project-specific details on:

- Initial testing and commissioning
- Preventative maintenance plan
- Calibration of sensors
- Test/inspection frequency basis
- Documentation

Comment 16: Section 3.5, Management of Change Procedures, does not provide detailed information on 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.

Comment 17: Section 4.3, Safety Reviews - The safety review process is not well identified. This section should provide additional, detailed discussion on applicable Linde safety reviews beyond the ISV and third-party certification.

Comment 18: Section 4.4, Safety Events and Lessons Learned, does not provide project-specific information on the system and/or procedure used to investigate events or how corrective measures will be implemented. 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 19: Section 4.5, Emergency Response - Good emergency response plan stewardship and processes are included, but additional detail is needed to understand what plans/procedures are provided for station operators to respond to emergencies. Is any training provided for the station operators?

Comment 20: Section 4.7 describes self-audits to be compliant with previously listed policies and procedures (e.g., SHEQ) and with Linde standards, legislative requirements, and national standards. However, it does not provide detailed information to evaluate how Linde and the project team will verify that safety-related procedures and practices are being followed throughout the life of the project.

Comment 21: Section 5 - The regulations, codes, and standards listed in this section omit key component-level standards such as ANSI/CSA HGV 4.2 and 4.4. Additionally, the list of codes should be updated to the latest version adopted by California (local California Building Code-2016 and NFPA 2-2016) .

Fastech HASP

Comment 22: This document is a health and safety plan, not a hydrogen safety plan in accordance with the safety guidance document (https://h2tools.org/sites/default/files/Safety_Planning_for_Hydrogen_and_Fuel_Cell_Projects-March_2016.pdf).

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: Jensen/Linde
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
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

SAFETY PLAN REVIEW

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	No
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	No
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	Yes
Safety Reviews	• Applicable safety reviews beyond the ISV described above	No
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	No