HYDROGEN Safety Panel

SAFETY PLAN REVIEW

Hydrogen-XT 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 Hydrogen-XT 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 lacks suffiently detailed project-specific information for most of the elements required by *Safety Planning for Hydrogen and Fuel Cell Projects*, dated March 2016 (https://h2tools.org/sites/default/files/Safety_Planning_for_Hydrogen_and_Fuel_Cell_Projects-March_2016.pdf). Critical elements such as ISV and risk reduction, safety-relevant operating procedures, equipment and mechanical integrity, management of change, training, lessons learned, safety documentation, and self-audits lacked the information necessary to demonstrate adequate safety planning. As a result, the safety plan is incomplete, without much consideration for safety.

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: Narrative, pages 81 and 86 - The claim that Bennett Pump Co. is the only hydrogen dispenser certified for use in California is misleading, as it likely only applies to Division of Measurement Standards approval, and is not based on electrical or high-pressure safety certification.

Comment 2: Narrative, page 89, incorrectly states that the fueling hoses are compliant with SAE J2600 or ISO 17268; these documents apply to the fueling nozzle.

Comment 3: Narrative, page 92 – The H2Logic universal manifold that allows for the off-loading and on-loading of hydrogen from/to tube trailers using a connection interface has not been standardized nor independently tested/verified as being safe for service.

Comment 4: Narrative, page 101, states, "should a tank leak or a line break, the hydrogen molecules will go straight up into the atmosphere. Since the hydrogen molecules are so light, they will 'outrun' any oxygen molecules on their way up; it is therefore virtually impossible to light the gas on fire or create an explosion." This is not consistent with industry experience and is not a good fundamental assumption for applying safety to this project.

Comment 5: Architectural Drawings - Many of the fueling stations' hydrogen supply locations (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.

Comment 6: General - Since the project 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).

Safety Plan Comments

Comment 7: General – A process flow diagram was not provided.

Comment 8: Section 1, Scope of Work, states that the safety plan is an extension of the Nuvera and H2Logic safety plans; however, these safety plans were not provided for evaluation, and more importantly, details on how safety is integrated across the project participants is not addressed. The plan states that the H2Logic plan was included in the submittals, but it was not found.

Comment 9: Section 2.1, Organizational Policies and Procedures, provides insufficient detail. The section does not identify the project-specific safety-related policies and procedures applicable to the work being performed. The plan provides general assurances that safety is the highest priority and that there is a strong safety culture, however, no policy information is provided. The section also states that site-specific procedures are written following manufacturer recommendations, but no details are provided to enable an evaluation of their efficacy for ensuring that safety issues are addressed.

Comment 10: Sections 3.1, 3.2, and 5 provide insufficient detail. The documentation does not provide discussion or detail on the actual safety risks and associated risk reduction measures for the intended equipment or address the criteria identified in *Safety Planning for Hydrogen and Fuel Cell Projects*, dated March 2016 (https://h2tools.org/sites/default/files/Safety_Planning_for_Hydrogen_and_Fuel_Cell_Projects-March_2016.pdf). There is an initial ISV presented in the appendix, however, this includes few safety vulnerabilities—three of the six risks involve system cleanliness, fuel purity, and operability concerns—the lack of an indepth discussion of process safety issues is inadequate. The ISV should be a series of processes involving HAZOP, FMEA, LOPA, etc., but none of these are provided in the submission. Without a suitable discussion safety vulnerabilities and risk reduction features, it is not possible to determine adequacy of the project's safety planning.

Comment 11: Section 3.2, Risk Reduction Plan, focuses on compliance with codes and standards and provides information on several safety features; however, these safety features are not linked to a risk analysis, so the mitigation features provided cannot be linked back to risk scenarios of concern. As a result, an evaluation of the feasibility and adequacy of the risk reduction plan could not be made. Additionally, the criteria for operation of safety shutdowns and system logic as a result of sensor detection within the enclosure are not provided for evaluation. A section is devoted to a general discussion of

underground storage of hydrogen; however, no discussion of risks, hazards, scenarios of concern or mitigation features are included for evaluation.

Comment 12: Section 3.3, Operating Procedures, provides insufficient detail. This section does not provide adequate project-specific detail on:

- 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 13: Section 3.4, Equipment and Mechanical Integrity, provides insufficient detail. The section does not provide adequate project specific detail on:

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

Comment 14: Section 3.4 states, “key components including the H2Logic and Nuvera have been certified by third party Nationally Recognized Testing Laboratories (NRTL) such as CSA, UL and Intertek to assure the AHJ that the systems employed in the Hydrogen-XT hydrogen fueling stations meet the safety requirements in NFPA-2.” What does the certification cover–all mechanical and electrical equipment, enclosure requirements, separation distances, etc.? Hydrogen-XT and its partners should make it very clear to AHJs and stakeholders exactly what this covers. Unlisted equipment will still require approval by the AHJ.

Comment 15: Section 3.4 uses very general statements about components meeting standard requirements to satisfy NFPA 2, but there are no specifics on matching equipment to applicable standards. The submission refers to an obsolete standard (ISO 11114-4) to establish hydrogen compatibility of materials; more suitable references include CSA CHMC 1 and SAE J2579 Table B2, among others.

Comment 16: Section 3.5, Management of Change, provides insufficient detail. This section does not provide adequate project-specific detail 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. Also, no information is provided on this system integration. Because the system will be composed of subsystems from the different contributors, MOC during operation of the system needs to be clarified to indicate which organization is managing which types of changes. Additional questions around Hydrogen-XT’s MOC process include:

- What is included in Hydrogen-XT’s change management system?
- How are changes across different companies implemented?
- How does maintenance accomplish needed changes after installation?

- Who approves these changes?
- How are changes completed if there is an urgent need during construction (e.g., a walk down finds a change already in place that is different from the drawings)? How is this addressed and who makes the decision, assuming multiple companies are involved in the change?

Comment 17: Section 4, Communications Plan, does not discuss how needed safety information is maintained, communicated, or made available to all participants, including project partners. Safety information includes the ISV documentation, procedures, references such as handbooks and standards, and safety review reports.

Comment 18: Section 4.1, Training, provides insufficient detail. This section does not provide adequate project-specific detail on the required general safety training (initial and refresher), hydrogen-specific and hazardous material training (initial and refresher), or how the organization stewards training participation and verifies understanding. Training provided for station attendants should also be identified.

Comment 19: Section 4.2, Safety Reviews – The section should be should be expanded to address all project phases, design, development and operation. The involvement and responsibilities of individual project staff in such reviews and how the reviews will be documented should be included.

Comment 20: Section 4.3, Safety Events and Lessons Learned, provides insufficient detail. This section does not provide adequate project specific detail on:

- 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

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 21: Section 4.4.1, Emergency Response Procedure - Emergency response procedures have been thought out and sample information is provided. However, the action levels of sensors are not detailed, and it is unclear how the 24-hour response call center will be alerted to an incident; there are no instructions to call them in the event of an incident.

Comment 22: Section 4.5, Self-Audits, does adequately address how the team will verify that safety related procedures and practices are being followed throughout the life of the project.

Comment 23: Section 6.1, Codes and Standards, provides a good list of codes and standards, but some key documents are missing, e.g., ANSI/CSA HGV 4.2 (fueling hoses) and 4.4 (breakaway devices), SAE J2600 (fueling nozzles), and CGA G-5.4 and G-5.5.

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: Hydrogen-XT, Inc.
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 comments
Organizational Policies and Procedures	• Application of safety-related policies and procedures to the work being performed	No
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	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	No
Safety Reviews	• Applicable safety reviews beyond the ISV described above	Yes with comments
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	No
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