SAFETY PLAN REVIEW

ITM Power (#4) 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 ITM Power/Greenlight (ITM#4) 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 has provided a well-written safety plan that appropriately addresses the criteria provided in the safety planning guidance document. The safety plan has provided reasonable documentation of a HAZOP performed on the system along with controls to decrease the risk from safety vulnerabilities. Considering that Greenlight has minimal hydrogen fueling station experience, the safety plan is marginal but would be good if the applicant considered the comments and recommendations, and is based on the ITM safety plan covering all project activities (see Comment #1). If the activities covered by ITM's partners (Greenlight and StratosFuel) are not addressed by the ITM safety plan, the document would be 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. 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: General - The ITM safety plan appears to comprehensively address the hazards and risks associated with the proposed stations. Since Greenlight and StratosFuel are also participating in this project, are the hazards and risk reduction features associated with partner activities covered by the ITM plan? If not, how will the hazards, analysis, and risk reduction features be coordinated? Since Greenlight has minimal hydrogen station experience, it is essential that ITM Power oversee the ISV and risk mitigation plan for the Greenlight CSD design.

Comment #2: General - A flow diagram was included, but should be expanded to identify equipment and safety devices used as well as the design parameters of the system. This helps answer questions regarding the frequency of deliveries and others such as:

- In the project narrative, page 34 states, "Each of the sites proposed will be capable of and be permitted for receiving hydrogen via a tube trailer delivery or from a mobile hydrogen refueler." How will this be accomplished as these are normally different pressure delivery vehicles?

Comment #3: General - Since the project's design appears to rely on the use of enclosures, it would be beneficial to see documentation that identifies how this equipment conforms to the Hydrogen Equipment Enclosure requirements of NFPA 2 (7.1.23).

Comment #4: General - Codes and Standards - The safety plan does not provide a listing/summary the codes and standards that this system will meet. There are a few codes and standards identified in several locations in the document, but some relevant codes and standards appear to be missing. The project team should consider providing a list of codes and standards applicable to the station design and operation.

Comment #5: General - The location of the fueling trailer is important as it affects the safety of the people and vehicles in the fill area. How the fill is managed is important also, as it drives the number of deliveries (drop and swap vs. cascade into existing tubes). This should be more fully integrated into risk assessment and risk reduction discussions in the safety plan.

Comment #6: Narrative page 38 states, “The components that will be used for the station have been identified and their certification status has been identified. This is particularly important for any safety critical or hydrogen specific components, where third party accreditation will be enforced; CSA, UL and Intertek are 3 examples of acceptable approvals.” It is important to understand what the equipment will certified for and what standards it is certified to. Also, will the certification cover only part of the station or all equipment, enclosures, etc.? ITM and its partners should make it very clear to AHJs and stakeholders exactly what this listing covers. Unlisted equipment will still require approval by the AHJ.

Comment #7: Section 1, Scope of Work - Based on information provided in this section, there would be a minimum of 95 kg delivered each day. There is no mention of type of delivery used, such as drop and swap or cascade delivery. The number of deliveries and when they occur is important for the safety of the personnel and vehicles in the area.

Comment #8: Section 3.5, Safety Critical Equipment - Based on Section 1.2, the compressor will be housed in a shipping container. Section 3.5 does not identify hydrogen detection for this enclosure consistent with the requirements of NFPA 2-2016, Section 7.1.23.

Comment #9: Section 3.6.6, Possible Leakage - What is the basis for using a 0.25 mm^2 hole size for non-catastrophic leaks? Additionally, this section states “the risks of these have been semi-quantitatively assessed by ITM, and determined to be tolerable.” What are the criteria for “tolerable?”

Comment #10: Section 3.6.8, Detection - What are the actions should hydrogen be detected by direct or indirection detection methods (alarms, equipment shutdown, increased ventilation, etc.)?

Comment #11: Section 3.11, Risk Reduction - The risk reduction plan uses a risk binning approach for significant safety vulnerabilities identified in the ISV. The detailed risk reduction plan suggests that the proponent has conducted an ISV, even though it is not provided in the submission. A few comments on the risk reduction plan are provided below:

- Regarding the drive-away scenario, the applicant should indicate that the breakaway coupling will be approved or listed to ANSI HGV 4.4 (p. 33)
- Regarding the over-pressurization during refilling of high-pressure hydrogen storage scenario, the applicant should consider PRV sizing based on the requirements specified in CSA S-1.1, 1.2, and 1.3. PED-sized PRVs may not be applicable in the United States (p. 36). In addition, the vessels should be compliant to ASME code, not per PED requirements (p. 36)

Comment #12: Risk Matrix, Page 16 – The definition for “likelihood” includes a frequency of “generally a year.” Is there data to support the frequencies chosen (the basis for the “likelihood” category is less clear than the “consequence” category)?

Comment #13: Hazard tables beginning on page 17 – The following comments are provided for the project team’s consideration in evaluating the hazards:

- What is the process to ensure that the “action needed” steps are completed?
- Are all different pressure zones protected by check valves, regulators, double block, and bleed for maintenance and mechanical relief devices? This could affect the “likelihood” of occurrence in many hazard categories, such as:
  - Reverse flow of high-pressure hydrogen from the refueling station high-pressure vessels to the Buffer Tank assembly.
  - Backflow from tube trailer inlet / high-pressure storage vessels leading to over-pressurization and rupture of electrolyser buffer storage / manifold from storage.
- Under the Hazard Category “Loss of containment of hydrogen from external source”- How large of a leak is being discussed? The likelihood of “unlikely” to “very unlikely” seems conservative in this case. However, are there configurations where this could be as high as “somewhat likely?” For example, if there is a leakage of hydrogen from an external hose fitting, such as a tube trailer fill hose, the consequence could be more severe than “serious,” possibly as high as “extremely serious”. The result would be a “medium risk” rather than a “low risk.”
- Under the Hazard Category “Hydrogen leak inside the electrolyser stack compartment”:
  - What happens under loss of power?
  - Is an automatic, fail closed isolation valve used to ensure no flow from the storage rather than just a check valve?

  Depending on the answers, the probability may increase to probable and thus increase the overall risk to high.

- Under the Hazard Category “Hydrogen leak inside the electrolyser stack compartment”: The first bullet under Control of Projectiles states, “container walls provide enclosure to contain projectiles.” This appears to conflict with the event consequence, “pressure wave from resulting explosion may blow out doors / roof fans, which could become a projectile risk if detached.”
- Under the Hazard Category “Hydrogen leak inside the electrolyser stack compartment”: Forced ventilation is mentioned through the Loss of Containment Risk Analysis. How is forced ventilation power backed up per NFPA 2-6.7.1.1?
- Under the Hazard Category “Hydrogen leakage from process equipment / storage inside compressor / storage compartment of the container during operation (not including dispensing system)”:
  - Are all normal vent valves and safety relief devices vented to a stack built to CGA G-5.5?
  - What leakage rate is allowable? If the leakage rate is defined too high, this would increase the likelihood and make this a higher risk,
  - The likelihood could increase if personnel routinely do not follow the procedure to “keep the door open” per the statement “doors to be left open during maintenance to prevent asphyxiation.”
  - Will the project team be utilizing a leak testing procedure? It is called out for maintenance but not in the procedures section of the safety plan. As leak testing is identified in many locations, having a procedure for this and ensuring it is followed is important to keep the risk at the lower levels.
  - How is the system leak tested to ensure no major loose fittings or bad connection types (i.e., incorrectly assembled swagelocks)? There is no reference to a procedure for this testing.
- Under the Hazard Category “Leakage from tube trailer connection equipment (inlet / outlet) outside of use”:
  - What leakage rate is allowable? If the leakage rate is defined too high, this would increase the likelihood, so this is a higher risk,
  - Is the fill connection behind locked gates? If not, the likelihood may increase.
  - Hose breaks have occurred in the past, is there data for the likelihood of a hose break?
- Under the Hazard Category “On-site collision of passing vehicle with refueling station, (or vehicle being refueled) causing pressurized pipe work / vessel rupture and hydrogen leakage” – Is the tube trailer fill considered in this scenario?
- Under the Hazard Category “Hydrogen leak from worn / damaged filling nozzle and hose or from incorrectly attached filling nozzle to form potentially explosive atmosphere” – How often is the hose changed? This would affect the likelihood of an incident.

- Under the Hazard Category "Driving away / vehicle moving when refueling nozzle attached - leading to breakage of filling line and hydrogen leak" – What is the history of leaks/releases after a drive away? This may affect the likelihood.
- Under the Hazard Category "Over-pressurization during refilling of high pressure hydrogen storage tanks, leading to rupture" – Is there a fail-safe, hard-wired shut down as well as the PLC shutdown? PLCs have been known to operate but not always follow the programming. This may change the likelihood and thus increase the risk.
- Under the Hazard Category "Leakage from tube trailer connection equipment" – One of the Existing Controls states for "Site boundary fence / wall minimises unauthorised access to vicinity of hydrogen dispenser, and no hazardous areas that extend outside the boundary fence / wall." This section does not appear to address the safety of personnel or the public during a tube trailer fill. If a tube trailer is onsite to fill/back up to the electrolyze system, the safety of persons near this equipment should be considered in this section.
- Under the Hazard category "Leakage from tube trailer connection equipment (inlet / outlet) outside of use" – The table states that a "flame detector trained on tube trailer connection area instigates fire alarm sounder for the fuelling station, and notifies the monitoring company, who in turn can notify the fire brigade and security." The project should consider having the flame detector cover the tube trailer hose as well.
- Under the Hazard category "Reverse flow of high pressure hydrogen from the Buffer Tank assembly to the gas handling room" – In conjunction with reverse flow valves, automatic isolation valves and double block and bleeds are recommended between different pressure range equipment. PRVs are recommended by ITM Power. This is a good design; however, the PRVs should be a last resort after operational methods fail to resolve the condition. Additionally, the opening of a relief valve should be considered a near-miss or incident.

Comment #14: Section 3.12, Operating Procedures - An important procedure that was not included in the list was a procedure for startup and commissioning, specifically an operational readiness inspection of the equipment. This document would ensure that all HAZOP and safety items were completed, the design was per the design documents, all safety items are online and operational, all personnel had been trained, to name a few. These documents are referenced on the table in Section 3.15, the project Safety Documentation, but the procedure requiring them is not. On page 57 it states, "Ensure factory commissioning checks, tests and reports completed" as well. These would indicate that there is a procedure around startup and commissioning.

Comment #15: Sections 3.12 and 3.13 - In the risk assessment there are mitigation of hazards using "leak testing"" to reduce the risk or likelihood of a release. However, there is not a leak testing procedure in the maintenance procedures. How is this done?

Comment #16: Sections 3.12 and 3.13 - There is a hydrostatic testing procedure for the site commissioning. Is this completed using hydrostatic testing or pneumatic testing (see reference to SP3-30 Hydrostatic Pressure Testing)?

Comment #17: Section 3.13.5, Calibration of Safety Related Devices - The section includes a discussion only on pressure relief devices. The section would benefit from additional discussion on other safety devices such as flame detectors, hydrogen detectors, smoke detectors, etc. Note that the section is titled "equipment mechanical integrity" instead of "equipment and mechanical integrity" – this could explain the oversight.

Comment #18: Section 3.13.6, Testing and Inspection - Testing and inspection of pressure equipment is discussed, but other key components such as compressor, dispenser, pre-cooler, etc., are not covered.

Comment #19: Section 3.15, Project Safety Documentation - How is the safety information shared with non-ITM personnel, station operators, and others?

Comment #20: Section 4.1, Training - What training will be provided for the station owner/operator (convenience store personnel)?

Comment #21: Section 4.3.4 - The project team should also report near misses and incidents to the California Energy Commission.

Comment #22: Section 4.4, Emergency Response - An outline of an emergency response plan is provided but no actual example is provided in the submission.

Comment #23: Section 4.5, Self Audits - No detailed information or documentation is provided other than a general reference to an existing process. The plan 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: ITM Power/Greenlight (ITM#4)
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	Yes
Hydrogen and Fuel Cell Experience	• How previous organizational experience with hydrogen, fuel cell and related work is applied to this project	Yes with comments

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
		Yes with comments

Risk Reduction Plan	• Prevention and mitigation measures for significant vulnerabilities	Yes with comments
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	Yes

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

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.	Yes with comments
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 with comments
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
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 with comments