SAFETY PLAN REVIEW

Project Neptune - Hydrogen Safety Plan

Equilon Enterprises LLC (d/b/a Shell Oil Products US)
GFO-19-602, Hydrogen Refueling infrastructure

Background

Members from the Hydrogen Safety Panel (HSP) reviewed the Shell Project Neptune "Hydrogen Safety Plan," submitted by Equilon Enterprises LLC (Shell Hydrogen), in support of the California general funding opportunity GFO-19-602, "Hydrogen Refueling Infrastructure." The project designs and constructs 51 hydrogen gas storage and light-duty vehicle hydrogen refueling stations (HRS) integrated into Shell-branded retail stations in California. Each HRS has a light-duty capacity of 716 kg per day, which involves two to four tube trailer deliveries per day from 500-kg tube trailers, with partial offloading from cascade methods. Shell Hydrogen supplied one safety plan for all 51 sites because the equipment is nearly identical among sites. The HSP previously reviewed 30% design documentation for the initial seven Project Neptune stations.

Project Neptune will be managed by Shell Hydrogen. Project partners include (1) Maximator as equipment supplier and operations and maintenance service provider and (2) CoreStates Group (CSG) as detailed design engineering, permitting, and construction contractor. Maximator and CSG both contributed to the project safety plan. Execution of the first stations for Project Neptune is anticipated mid-2021, with the first station opening by the end of 2021. Development of sites will continue for 5 years.

Summary of Results

Shell Hydrogen's safety plan is well written with the majority of expected safety topics fully addressed. For the few areas not completely covered, there was adequate information to conclude that Maximator and CSG are capable of providing a safe system. Annex A provides a summary evaluation of the safety plan against the HSP template, with all topic areas noted as meeting template requirements.

The HSP is honored to be involved in Project Neptune and looks forward to future involvement with Shell Hydrogen to ensure all hydrogen-related hazards are safely managed. The HSP would appreciate any feedback on how its review has enhanced the safety of the project or if any of its conclusions are inaccurate.

Recommendations

The HSP accepts the safety plan as quality tool for the management of Shell Hydrogen's Project Neptune. Shell Hydrogen and its partners should address the detailed HSP comments below to ensure project safety and the overall improvement of the safety culture, and to continue updating their safety plan as new information is obtained or conditions change.

Comments

General

- The safety plan is well done, with the following topics noted for their completeness and high quality.
  - Shell Hydrogen addresses safety vulnerabilities from conception through operation and maintenance.

- An explanation of the system supporting structure is provided with most responsibilities defined.
- A communications plan is in place for incidents to/from Maximator process.
- A plan is included for ensuring communication of safety, policies and procedures, and training with all party's groups.
- The safety controls for each location or equipment are provided on the flow diagram.
- Management of change explanation is provided for the equipment design, installation, and operations/maintenance.
- The emergency response groups are inclusive of the appropriate parties, which include Maximator, CSG, station operators, and the area emergency responders.
- There is a capability to isolate the hydrogen supply on the trailer using the tube trailers valving in the case of an emergency.
- CSG does not have direct experience with hydrogen station design and construction and will need to be carefully managed, but it appears that Shell Hydrogen and Maximator are addressing this issue.

- The safety plan has minimal information on the subcontractor/supplier providing the on-site hydrogen storage compared to other Shell Hydrogen and Maximator systems, and appears to be treated more as a "black box" connected to the Maximator components. The safety plan should clarify who will source this equipment and how their system will be integrated into applicable safety reviews and planning.
- The HSP made four major comments in the 30% design review that are relevant for further consideration in the safety plan:
    - Understand the impact of a large-scale hydrogen release with delayed ignition on the surroundings.
    - Look at the potential for and result of damage/failure in the single integrated vent stack.
    - Review the vulnerabilities inherent in the implementation of the connections between the hydrogen storage banks and the control system, specifically the lack of isolation of the cylinders or banks upstream.
    - Review the proximity of/protection for pedestrians and customers during the fuel transfer from the trailers into the station storage.

Description of Work (Scope)

- The description does not explicitly state that the vehicle fill pressure is 700 barg per H70 or 350 barg per H35.The process flow diagram shows that the hydrogen supply storage is 750 kg, but this data should be detailed in this section.
- The flow diagram should include more details on equipment connections points, including vent lines/crossover lines and the safety pressure relief device location(s).

Identification of Safety Vulnerabilities (ISV)

- The HAZID review process described by Shell Hydrogen is consistent with safe industry practices to identify safety vulnerabilities. Shell Hydrogen uses a staged design approach in which safety reviews are defined for the project stages from concept through operation. This approach is well defined and covers all phases of the system life cycle.
- CSG is not mentioned in the ISV. Since CSG is designing the site layout and vehicle access, it is recommended that it be involved in the HAZID for each station, specifically addressing the location the hydrogen equipment and delivery vehicle access.
- This section does not address a significant release of hydrogen that accumulates and later ignites, resulting in a deflagration. It is recommended that the HAZID be expanded to address potential vulnerabilities related to large releases and potential delayed ignition and also the risks associated with damage to the integrated vent stack system.
- The safety plan notes an NFPA 2 compliance check under “HRS Equipment.” This is an excellent verification tool, but the safety plan does not identify who performs this, and if it is solely Maximator, how this verification is applied to the overall system.

Risk Reduction Plan

- The automatic pressure/leak testing of the vehicle supply system is well done. Using the automatic leak check component of the design and by managing the valves on the tube trailers, Shell Hydrogen can isolate the hydrogen supply on the trailer in an emergency.
- The safety plan should identify the methodology used to manage the setbacks/safety distances to reduce the risk to the surrounding facilities and personnel.
- It is recommended that the safety control system be fail-safe with a defined safety integrity level for safety system shutdown functions.
- Shell Hydrogen should clarify the logic of using a set point of 40% of the lower explosive limit (LEL) instead of 25% of the LEL per NFPA 2, Section 10.5.3.2.2.6, Dispensing Equipment.
- The potential and key effects of the following additional key hazard scenarios should be considered/expanded:
  - Venting from the delivery vehicles relief devices or system vent stacks on facility and public surroundings.
  - Hydrogen delivery trailer interaction with other vehicles while offloading and ingress/egress.
  - Hydrogen leak from the piping routed through the public retail station area from either the fill trailer supply panel to the storage, or the MAX Flowtech HP panel to the dispenser.
  - A one common vent stack failing from external (wind/seismic) or internal (high flow/reaction forces).
- The loss of chiller and impact on vehicle is described in the risk table. It is recommended that the attestation standard (e.g., CSA HGV 4.3) used to confirm compliance with SAE J2601 be cited, and considered for mitigation if not addressed.

Codes and Standards

- Shell Hydrogen's listing of applicable codes and standards is extensive; however, it would be more valuable to expand the descriptions here to identify their application to the physical systems, for example: *pressure systems will be designed to ASME and comply with California plumbing code.*
- Consider adding as applicable:
  - Codes and standards used to define the safety relief devices and the vent stack design
  - OSHA Process Safety Management for Highly Hazardous Chemicals (29 CFR 1910.119)
  - OSHA 1910.103 – Hydrogen
  - DOT Regulation 49 CFR 171-179 – Safe Transport of Hydrogen in Commerce

Equipment and Mechanical Integrity

- The description of integrity of equipment manufacturing is exemplary. The area that needs additional consideration is verifying integrity of the completed systems. Mechanical and electrical integrity checks in commissioning should be expanded upon to ensure adequate acceptance and operational testing. For example, is there a program for validating the integrity of the system software and safety interlocks while commissioning the control system?
- Maintenance programs are well described but should be expanded upon to mention specific safety procedures associated with equipment safety functionality, such as leak checks, depressurization, and purging.
- Acronyms associated with Intertek testing (LBC, LPC, and ATM) need to be defined.

Safety Reviews

- Shell Hydrogen has a good safety review/audit program from the design concept through startup. Safety reviews after the installation are not included in this section, but are discussed in the Equipment and Mechanical Integrity section and in the line of defense (LOD) assessments. The description should be expanded to address the following strategies.
  - Periodic internal audits to ensure compliance with corporate policies and national and local standards, including those related to safety health and environmental regulation using the LOD assessment.
  - The product delivery process is evaluated to ensure that procedures and practices are followed.
  - Specifically state that a functional test of emergency shutdown system components is performed.
- Consider identifying the HSP as part of the formal safety review program.

Training

- Are there additional training programs for contractors after hydrogen loading in both commissioning, and for convenience store operators and the public during normal and off-normal operation? Design review indicates unique training aids for the public at the fill station as part of the computer controls. Consider describing these, along with posters, signs, and banners for alerting customers of unique equipment operation.

Safety Events and Lessons Learned

- A more thorough review and documentation of related equipment incidents on the h2tool.org lessons learned database would be valuable, specifically searching on fueling station and hydrogen storage tank incidents. For example, the Shell White Plains[1] incident is relevant to the HRS design, operation, and safeguards.

Emergency Response

- The Emergency Response section notes additional training for first responders and convenience store operators. Convenience store personnel are a high-turnover, entry-level workforce, and appropriate training should be consistent with what they receive for the gasoline/diesel dispensing system (e.g., simply hit the E-stop and evacuate).

Other Comments or Concerns

- There are multiple pdf file icons noted in the appendices as “attached” files, but they do not open or are not direct links/embedded files. These had been viewed earlier in the 30% design review.

Supporting Documentation

- Appendix A states, “The Neptune Station is designed to fill light duty vehicles with tank sizes up to 5 kg in accordance to the fueling protocol SAE J2601.” The BES_4321.0003 process control narrative file notes “up to 10 kg” while 7-kg tanks have been noted in discussion. Confirm the accuracy of this statement.
- The Appendix A process flow diagram does not include a fire detector and gas detector for the MAX Flowtech Supply and MAX Flowtech HP blocks. Is this because they are physically integrated in such a way that they are protected by detectors in other blocks?
- In Appendix B, Critical Safety Shutdown Parameters, the compressor outlet system high-high temperature shutdown limit is shown as 60°C, which is the same as compressor inlet high-high temperature. Is the outlet temperature measured after the MAX Cool?

[1] https://h2tools.org/lessons/fire-hydrogen-fueling-station

ANNEX A: Safety Plan Review Checklist

This checklist is from the Safety Planning Guidance for Hydrogen and Fuel Cell Projects template – January 2020,[2] summarizing the data requested for each element. The last column represents the HSP's general conclusion if the safety plan has provided this data. This is only a general summary to highlight key areas of focus for safety plan improvement, and does not contravene the comments listed above.

SUBMITTER OR TITLE: Equilon Enterprises LLC (d/b/a Shell Oil Products US)
DATE OF SAFETY PLAN: May 2021

Element	The Safety Plan Should Describe	Adequately Addressed?
Description of Work	• Nature of the work being performed, including a description of the facility, pertinent processes or systems, partner organizations, and the anticipated quantity of stored/used hydrogen	Yes
Organizational Policies and Procedures	• Application of safety-related policies and procedures to the work being performed • Project leadership responsible for safety approvals	Yes
Hydrogen and Fuel Cell Experience	• How previous organizational experience with hydrogen, fuel cell and related work is applied to this project	Yes

Identification of Safety Vulnerabilities (ISV)	• 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
	• Significant vulnerabilities associated with the scenarios
	• Safety critical equipment
	• Storage and handling of hazardous materials and related topics
	  o ignition sources, explosion hazards
	  o materials interactions o possible leakage and accumulation
	  o detection
	• Hydrogen handling systems
	  o supply, storage, and distribution systems
	  o volumes, pressures, estimated use rates
	• Additional Documentation provided (see section below)
		Yes

Risk Reduction Plan	• Prevention and mitigation measures for significant vulnerabilities	Yes
Codes and Standards	• Governing codes, standards, and regulations applicable to the project • Alternate methods including their technical basis	Yes
Procedures	• Procedures applicable for the location and performance of the work • Operating steps that need to be written for the particular project: critical variables, their acceptable ranges and responses to deviations from them	Yes

[2] https://h2tools.org/sites/default/files/Safety_Planning_for_Hydrogen_and_Fuel_Cell_Projects.pdf

HYDROGEN Safety Panel

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Element	The Safety Plan Should Describe	Adequately Addressed?
Equipment and Mechanical Integrity	• Design basis, proof testing, commissioning • Preventative maintenance plan • Calibration of sensors • Test/inspection frequency basis • Documentation	Yes
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
Safety Reviews	• Pre-startup review to verify initial conformity to ISVs, mechanical integrity, etc. • Safety audits to verify continued conformity to ISVs, mechanical integrity, procedures, etc. • Other reviews normally conducted by the organization(s)	Yes
Project Safety Documentation	• How needed safety information is communicated and made available to all participants, including partners. Safety information includes the safety plan, ISV documentation, procedures, references such as handbooks and standards, and safety review reports.	Yes
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 Events and Lessons Learned	• The reporting procedure in 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 • Plans for communication and interaction with local emergency response officials	Yes
Other Comments or Concerns	• Any information on topics not covered above	See comments
Supporting Documentation	• Layout of the system at the planned location • Flow diagram (see Appendix IV for an example) • Equipment component descriptions • Critical safety and shutdown table (see Appendix IV for an example)	Yes
Safety Plan Approval	• Safety plan review and approval process	Yes