Introduction to SAE Hydrogen Fueling Standardization Webinar: Q&A

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http://energy.gov/eere/fuelcells/2014-webinar-archives

Q: Could you talk about the crash-induced safety issues and the countermeasures implemented to minimize the spread of fire and/or explosion?

Vehicle hydrogen storage undergoes multiple crash and fire testing, which is much more extreme than conventional gasoline storage validation. For instance, in addition to the conventional crash and drop tests, hydrogen tanks are subjected to bonfire testing and ballistic (gunfire) testing in addition to temperature and pressure tests. The tanks themselves are covered in a thick layer of carbon fiber which is extremely resistant to penetration, overpressure, etc. Many tanks use glass fiber outer wraps for structural stability. In addition, to avoid the threat of an explosion in a fire, the tanks are equipped with a thermally activated pressure relief device which quickly vents and dissipates. The fire test also has a localized fire test to prove T-PRD activation under challenging conditions. The crash testing is done later to ensure that isolation valves function. The standards which address this in the United States are SAE J2578, SAE J2579, and HPRD-1.

Q: In the steps of standardization, there is no reference of testing being done during massive collisions in extreme temperature. Could you narrate about the reaction of the tanks in this situation?

Tanks are tested in pressure cycling with hydrogen from -40°C up to 85°C (185°F) under test conditions in validation (see SAE J2578 and SAE J2579) and are afterwards put into a bonfire test to confirm that the PRD activates and no issues with the tank occur (even in an engulfing fire). After the design has passed these rigorous tests, the tanks are also crash-tested at room temperature by automakers to confirm integrity during a crash.

Q: In terms of the cooling system, is it a dual cooling system? Is the car disabled when the cooling system is defective?

There are no fire cooling systems needed on a fuel cell vehicle (see above). However, there is a conventional cooling system on FCEVs that cools the fuel cell and other electronics (similar to engines in conventional vehicles).

Q: Should a fire protection technology allow the tank to be frozen upon collision, preventing it from catching fire or exploding, similar to systems in the construction industry?

No. There are no requirements prescribing the use of fire suppression systems for FCEVs.

Q: Is there also work on non-liquid H_2 delivery metal hydrides that can be bought like a bag of ice cubes at the local "gas" station? It might have an automated switch-out at the pump.

No. However, SAE J2579 was written to accept the possibility of metal hydride systems—but the subsection for metal hydride storage systems has not been added because there is currently no interest in such systems for road vehicles. Metal hydrides were investigated early in the 2000s for hydrogen bulk gas storage on stations, but at this time there are no applications in the field or planned. Hydrogen storage is being stored in liquid or gaseous form today.

Q: How do you see H_2 supply sources and the possibility of on-site H_2 production? Thanks.

Hydrogen is the largest industrial gas used worldwide. Reformation of gasoline is its largest use. Most of the hydrogen today comes from natural gas. There are different hydrogen station concepts which incorporate "trucked-in hydrogen" to on-site production. It is possible to produce hydrogen from natural gas at the station (such as is being done in Japan) or produce it through electrolysis (as it is being done in some places in the United States or the European Union) on-site.

Q: I'm new to this field, but 30 MPa to 70 MPa seems like very, very high pressure; much higher than I realized.
N/A.

Q: Danger issues and safety features for these pressures?
CNG vehicles have been in production for many decades at 35 MPa pressure. Automakers have been using 70 MPa vehicles in the field since 2002. The safety of the fuel cell vehicle and hydrogen station must be at the same level—or better—than conventional technologies. To ensure this, standards, codes, and regulations exist at SAE, CSA, NFPA 2, ICC, etc., to make sure that there are no danger or safety issues. To be specific, hydrogen vehicle safety is covered in SAE J2579 and hydrogen fueling is covered in SAE J2601. There are numerous standards with the CSA and National Fire Protection Association agencies that go above and beyond present conventional standard requirements. For instance, vehicle, bonfire, gunfire, overpressure, cycling, drop-testing, etc., must be validated before a tank is even put into a vehicle. On the station side, the National Fire Protection Association has released the NFPA 2 code on hydrogen technologies, which makes sure that the station has pressure protection, break-away (if a vehicle drives away), grounding, leak checks, and listing standards for the components used.

Q: Will the MC method become industry standard? Your thoughts?
The SAE Interface Task Force is in the process of evaluating the field and lab testing results to determine if the MC default fill is ready for release as a standard protocol.

Q: Will the data used to develop the SAE J2601 be released to the public? (This is mentioned on the slide that started, "After 12 years of work...")
Yes. It is published in the SAE World Congress Technical Paper and can be downloaded from the SAE website: http://papers.sae.org/2014-01-1990/

Q: Are the changes in pressure tolerance levels the main reason for having considerably lower APRR (e.g., for T=20/25) in the new J2601 compared to the TIR J2601 (e.g., 18,5 MPa/min for H70-T40, 25C in table D22 and 28,8 MPa/min for table F-1 of the TIR)?
The reason for the change between the SAE TIR J2601 and SAE J2601 standard (in 2014) was to create a protocol which would have uniform precooling temperature categories T40, T30, and T20 without gaps—as with the TIR—to avoid the station shutdown if out of tolerance. Regarding your example of relaxing the ramp rates between 28.8 MPa and 18.5 MPa between the TIR and standard J2601: There was a significant study (over many years) that was done to understand the real-world thermal effects of the station dispenser to the vehicle storage under extreme conditions. Through a documented sensitivity study, and simulation and verification tests, the fueling tables were redone to ensure that there would not be overheating even under extreme conditions. For this reason, the ramp rates also were relaxed to give a robust fueling protocol under different locations worldwide.

Q: Do you feel there are adequate safety requirements contained in the latest editions of the IBC/IFC and NFPA 2 for the construction and maintenance of refueling stations?
Yes, the IBC/IFC and NFPA have adequate safety requirements to cover construction and maintenance of fueling stations. The only suggestion would be to confirm the pressure rating

(per SAE J2600) of the nozzle with the fueling station dispenser, in addition to the listing specification already in the document. It would be important for this to happen in both construction and maintenance.

Q: Is there a way to get a copy of the presentation? Or to hear the webinar recording?
Yes, it is posted on the DOE website at http://energy.gov/eere/fuelcells/downloads/introduction-sae-hydrogen-fueling-standardization.

Q: How long does the initial pressure pulse last?
The pressure pulse is generally in the millisecond range.

Q: What if your on-board storage is <2 kg H_2?
At this time, the SAE J2601 only covers fueling for light-duty vehicles. However, motorcycle fueling (<2 kg) is planned to be covered in the future.

Q: I may sound a little stupid, but if hydrogen is used directly as fuel in rocket engines, why is it not adopted in land vehicles?
Hydrogen has been attractive for spacecraft because the key parameter is the ratio of weight-to-thrust. For aerospace applications, hydrogen is therefore very attractive. In more earthly applications, such as road vehicles, hydrogen is attractive as zero emission vehicles that have carbon offsets and offer the possibility of high-efficiency fuel cells for energy conversion (propulsion). Hydrogen is therefore attractive for commercial applications too! There are, however, many factors regarding the time to market of a new technology, including maturity of technology and infrastructure to fuel this technology, as well as cost. With that said, production of the fuel cell vehicle is planned to start next year, as per a press announcement from automakers. In addition, though it will take some time to establish a widespread hydrogen infrastructure, as per the presentation there are initiatives to build stations in three areas of the world: California, Japan, and Europe (Germany, France, and the United Kingdom).

Q: The map showed China. Is there J2601 activity there?
Regarding standards, similar to SAE J2600, the Chinese nozzle standard was recently adopted into the Chinese standardization (released in 2002 first in the United States; adopted in China in 2014). It will take some time for the SAE J2601 standard to be adopted there. In addition, besides SAIC, there are little announcements regarding a Chinese hydrogen infrastructure.

Q: It should be stressed that J2601 was developed based on certain station and on-board tank system assumptions. These assumptions should be checked, as tank systems and stations are developed to ensure these assumptions are maintained. What are some of the assumptions that should be checked for novel concepts and approaches for tanks and stations that need to be verified prior to using J2601?
You are correct. The component property assumptions for the documented hydrogen station and vehicle originated directly from the hydrogen supplier and the automotive industry. These are state-of-the-art properties for fueling and automotive components and those building stations and vehicles also take these assumptions into consideration when designing these systems in the future. For example, the maximum pressure drop (see SAE J2601) should not exceed 10 MPa for the dispenser components and 20 MPa for the vehicle components. In addition, the range of thermal properties for the tank should be able to sustain the temperatures in the assumption. Note, it would be appropriate to verify hydrogen stations and on-board tanks that are different than the assumptions documented in the J2601 standard prior to assuming the hydrogen fueling protocol. Also, it may be helpful to include a tank parameter example (i.e., thermal conductivity) and highlight the full set of assumptions that are in the J2601 document.

Q: What is APRR and CHSS?
APRR is the average pressure ramp rate for the SAE J2601 standard hydrogen fueling protocol. The CHSS is the compressed hydrogen storage system or tank system where the hydrogen is stored in the vehicle.

Q: How is the time of fueling being calculated from the table?
The fueling time starts a few seconds after the initial leak check, pressure pulse, and hold, and ends (unless it is stopped) at the SAE J2601 tables' target pressure. Note, in the United States there are codes requiring "integrity checks" where the fueling pauses and where fueling times will be slightly longer than the main fueling time (from the SAE J2601 standard tables).

Q: Question for Steve: What is the typical difference in fill time when you compare default MC method versus standard SAE communication fill?
The difference in fill time is determined by two things: 1) the dispenser's ability to pre-cool the gas effectively (typically, a good dispenser can keep the mass average dispenser outlet gas temperature between -35°C to -37°C, which is in the middle of the allowed range for a T40 station) and 2) the ambient temperature of the fill (the reduction in fill time increases with increasing ambient temperature; testing shows ~1 minute reduction in fill time at Tamb of 20°C and ~2.5 minute reduction in fill time at Tamb of 40°C).

Q: Regarding Jesse Schneider's presentation on tank construction and the step standardization that elaborates on the testing procedure used to certify the tank: Was fire and/or massive collision at extreme temperature ever used to determine the reaction of the tank?
Yes. The CHSS vessel tested to protocols that cover the full range of pressure and temperature as described in the items above. Before a tank can be put into a vehicle for production, it has to be validated according to SAE J2579 and SAE J2578. Within these standards, the tank is first pressure- and temperature-cycle tested, dropped, hit with a metal object (pendulum), covered in acid, and the side scored. Thereafter, the same tank must be tested in destructive tests. Two of them are bonfire and ballistic testing. Only after these tests have been passed will the tank be put into a vehicle and subjected to crash testing. All of this is to ensure a robust level of safety.

Q: Can you provide us with some crash-induced safety issues and some countermeasures used to minimize the loss of life?
As discussed above, the T-PRDs are also tested to activate when tanks are exposed to localized fires. In addition, note that every hydrogen tank is equipped with a temperature pressure relief device which activates at a set temperature to minimize the effect when engulfed in a fire. This technology is similar to that used to protect passengers in natural gas vehicles.

Q: Knowing hydrogen to be very flammable, what fire protection system is used to disable or incapacitate the tank (i.e., like in the construction of data center FM-200 or other gas suppression systems to protect the equipment and save lives)? I believe the same strategy can be used to freeze the tank and prevent it from being affected by its surroundings during collision and/or fire.
Hydrogen, as with other flammable gasses (e.g., CNG, etc.), needs to be contained in a vessel with a pressure relief device. Hydrogen vessels use the CSA HPRD-1 standard. Fire suppression is not needed on the vehicle as the tanks are developed to react in a controlled manner under engulfing and localized fire and tested and validated under SAE J2579 and SAE J2578.

Q: New firefighting strategies have to be implemented to educate the fire and police department about hydrogen cars to secure a certain perimeter during an emergency. Confirm that this will be done before the release of numerous hydrogen cars on the roads.
The U.S. Department of Energy has been training emergency response for fuel cell vehicles since 2007 and has a free general information website: http://www.hydrogen.energy.gov/firstresponders.html. In addition, there are industry resources published on the California Fuel Cell Partnership website: http://cafcp.org/toolkits/safety/downloads. The California Fuel Cell Partnership also published a guide of its own at: http://midsouthrescue.tripod.com/sitebuildercontent/sitebuilderfiles/04fuelcell.pdf. Also, SAE J2990-1 is under development to also address primary and secondary response issues for hydrogen vehicles.

Q: Does GSA have hydrogen fuel cell powered vehicles available for lease?
As of the 2013 Federal Fleet Report, there are five hydrogen vehicles in service in GSA fleets.

Q: What would be the additional cost to lease these vehicles versus gasoline?
Two automakers have released the prices of the fuel cell vehicles for production. In addition, one automaker released the cost of a lease vehicle, including the cost of hydrogen. Please contact these automakers directly for costs.

Q: What is/will be the cost per fueling station to install one at a federal facility?
The cost of a station is dependent on many factors that can affect the overall cost. In the case of a federal facility, one advantage could be reduced land costs. A recent report from the National Renewable Energy Laboratory provides analysis on station costs and can be found at: http://www.nrel.gov/docs/fy13osti/56412.pdf.

Q: Safety precautions for the station?
See NFPA 2 regarding safety precautions for stations and SAE J2601 regarding fault management. As an example, every station has a pressure relief valve which is set at a level that won't over-pressure a vehicle, in addition to software control. Each dispensing nozzle and hose assembly is fitted with a break-away to seal the dispenser in the event a vehicle moves too far away while connected to the station (even though the vehicles do not allow power to the wheels when the tank door is open). Also, every vehicle is grounded, similar to a conventional vehicle, through the tires. Note, in addition to this, every station has a hazard analysis which confirms safe usage even in extreme conditions.

Q: Emergency actions and spill requirements for the station?
See above. Also, compressed hydrogen does not spill.

Q: Maintenance requirements for the station?
The hydrogen station has general maintenance requirements also contained within the station standards (like the soon to be published ISO 19880-1 guideline). However, each station needs to set up its own maintenance schedule. It is important that stations make sure that any wearable parts (e.g., gaskets) and certified parts (e.g., pressure relief valve) are checked regularly.

Q: Is there a federal national contract to provide hydrogen to the stations?
No.

Q: Cost to the facility for the hydrogen?
The cost of hydrogen being delivered to a facility is typically negotiated between the fuel provider and buyer. Additional information on projected high volume costs can be found at http://hydrogen.energy.gov/h2a_analysis.html.

Q: What is the cost/benefit as compared to a comparable gasoline fueled vehicle?
Hydrogen and fuel cells offer a broad range of benefits for the environment, for our nation's energy security, and for our domestic economy, including reduced greenhouse gas emissions, reduced oil consumption, expanded use of renewable power (through use of hydrogen for energy storage and transmission), highly efficient energy conversion, fuel flexibility (use of diverse, domestic fuels, including clean and renewable fuels), reduced air pollution, and highly reliable grid support. Fuel cells also have numerous advantages that make them appealing for end-users, including quiet operation, low maintenance needs, and high reliability. In addition to using hydrogen, fuel cells can provide power from a variety of other fuels, including natural gas and renewable fuels such as methanol or biogas. Additional information can be found at http://energy.gov/eere/fuelcells/about-fuel-cell-technologies-office.

Q: Any plans for a hydrogen/electric hybrid? What would be its range versus the 300-mile range of the hydrogen or gasoline vehicle?
Please refer to individual automakers for this question.

Q: What storage systems are compatible with the dispensing SAE systems that were discussed? What types of storage tanks are compatible with the systems described? It sounds like a hydrogen storage tank may have to be cooled to -20°F. I was not sure on the storage type requirements.
The major automakers that participated in the SAE working groups for hydrogen station interface and vehicle safety all use hydrogen safety and fueling standards. Storage systems conforming to SAE J2579 and SAE J2601 are compatible to SAE hydrogen fueling. These include both type 3 and type 4 tanks for 35 MPa and 70 MPa. The temperatures go down to -40°C (-40°F) in these standards.

Q: What type of storage tanks inside the vehicles would be compatible with the dispensing system. Are the tanks just cylinders or are the storage tanks made of a cadmium metal that stores the hydrogen like a sponge.
See above.

Q: Will these standards be published in an SAE paper or how can I receive a copy of the slide presentation?
Yes, please see document. The presentation is posted on the DOE website at: http://energy.gov/eere/fuelcells/downloads/introduction-sae-hydrogen-fueling-standardization.

Q: Are there any recommendations for emergency power to finish customer refueling, a "safe" shutdown of the station for customer egress, shutdown of the hydrogen fueling systems, fire suppression, and communications capabilities?
Hydrogen stations should be equipped to respond safely even in the event of power outage, including backup systems where deemed necessary.