



SURFACE VEHICLE RECOMMENDED PRACTICE

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Gaseous Hydrogen and Fuel Cell Vehicle First and Second Responder Recommended Practice

RATIONALE

Many countries are adopting goals to increase the use of alternative fuels for vehicles, including hydrogen. The use of this alternative fuel in the automotive sector creates additional procedures that are not already addressed in SAE J2990 associated with the hydrogen storage systems and potential leakage of flammable gas. First and second responders must take special measures when working around hydrogen vehicles, regardless of their condition. Considerable work is needed to develop common and consistent procedures for emergency responders across the automotive industry towing, storage, repair, and salvage personnel.

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1. SCOPE

Electric and alternative fueled vehicles present different hazards for first and second responders than conventional gasoline internal combustion engines. Hydrogen vehicles (H2V) including Fuel Cell Vehicles (FCVs) involved in incidents may present unique hazards associated with the fuel storage and high voltage systems.

The electrical hazards associated with the high voltage systems of hybrid-electric vehicles and FCVs are already addressed in the parent document, SAE J2990. This Recommended Practice therefore addresses electric issues by reference to SAE J2990 and supplements SAE J2990 to address the potential consequences associated with hydrogen vehicle incidents and suggest common procedures to help protect emergency responders, tow and/or recovery, storage, repair, and salvage personnel after an incident has occurred. Industry design standards and tools were studied and where appropriate, suggested for responsible organizations to implement.

1.1 Purpose

This SAE Recommended Practice (RP) provides guidelines and education to first and second responders of incidents associated with hydrogen vehicles (H2V), including fuel cell vehicles (FCVs). The RP is not intended to replace an emergency response guide (ERG) or to be referenced at the scene of an emergency incident. Automotive OEM's are encouraged to reference this RP for industry design guidance when creating vehicle requirements and ERGs.

2. REFERENCES

2.1 Applicable Documents

NOTE: Users should ensure that the latest revision and legislative updates of these documents is being referenced.

The following publications are provided for information purposes only and are not a required part of this document. Each was used by task force as a reference source during the development of this working document.

2.2 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org

SAE J2990 Hybrid and EV First and Second Responder Recommended Practice

SAE J2754 Fuel Cell Vehicle Terminology

SAE J2578 Recommended Practice for General Fuel Cell Vehicle Safety

2.3 ISO Documents

Available from International Organization for Standardization, 1, rue de Varembe, Case postale 56, CH-1211 Geneva 20, Switzerland, Tel: +41-22-749-01-11, www.iso.org.

ISO 17840-1: 2015 Road vehicles – Information for first and second responders – Part 1: Rescue sheet for passenger cars and light commercial vehicles

2.4 Other Documents

2012 Emergency Response Guidebook – A Guidebook for First Responders During Initial Phase of a Dangerous Goods/Hazardous Materials Transportation Incident

Available from the US Department of Transportation (DOT) Pipeline and Hazardous Materials Safety Administration (PHMSA) website at <http://phmsa.dot.gov/hazmat/library/erg>

3. DEFINITIONS

Except as noted below, all definitions are in accordance with SAE J2754.

3.1 Compressed Hydrogen Storage System (CHSS)

Consists of the pressurized containment vessel(s), Pressure Relief Devices (PRDs), shut off device(s), and all components, fittings and fuel lines between the containment vessel(s) and these shut off device(s) that isolate the stored hydrogen from the remainder of the fuel system and the environment

3.2 DIAGNOSTIC TROUBLE CODE (DTC)

Information provided by an on-board diagnostic system for operators and repair technicians.

3.3 EMERGENCY RESPONDER (ER)

Personnel responsible for mitigation activities in a medical, fire, or hazardous materials incident or a natural disaster.

3.4 EMERGENCY RESPONSE GUIDE (ERG)

Summary of steps to perform in emergency situations involving a vehicle or hazardous materials.

NOTE: There is a hazardous materials ERG independent of ERG's produced by automotive OEM's.

3.5 FIRST RESPONDERS

Include but not limited to fire department, rescue squads, emergency medical, law enforcement, and in some instances military where the personnel are trained in assessing and treating injuries.

3.6 FUEL CELL MODULE OR STACK

Fuel cell modules are comprised of one or more fuel cell stacks; connections for conducting fuels, oxidants, and exhausts; electrical connections for the power delivered by the stacks; and means for monitoring and/or control. Additionally, fuel cell modules may incorporate means for conducting additional fluids (e.g., cooling media, inert gas), means for detecting normal and/or abnormal operating conditions, enclosures or pressure vessels, and ventilation systems.

3.7 HYDROGEN VEHICLE (H2V)

A surface vehicle whose primary fuel source is hydrogen.

3.8 THERMALLY ACTIVATED PRESSURE RELIEF DEVICE (TPRD)

A device that, when activated under specified thermal conditions, is used to vent the container contents.

3.9 KEY FOB

A small hardware device with built in authentication mechanism; for example, keyless entry and security for a vehicle.

3.10 QUICK REFERENCE SHEET (QRS)

A condensed version of an ERG, usually consisting of no more than two pages, and including the most pertinent of information for vehicle fire and patient rescue.

3.11 SECOND RESPONDERS

Include but not limited to tow/recovery personnel, vehicle storage operators, repair/ service technicians, dismantlers and auto salvage personnel.

3.12 SUPPLEMENTARY RESTRAINT SYSTEM (SRS)

The passive vehicle occupant safety systems in a vehicle (e.g., airbags) which supplement the use of seat belts.

4. RECOMMENDATIONS FOR H2V IDENTIFICATION

4.1 Background

H2V identification is necessary to provide first and second responders with information to clearly, accurately, and reliably determine that a given vehicle encountered at an unplanned incident (collision, fire, water submersion, etc.) contains a CHSS. SAE J2578 provides vehicle requirements related to FCV safety and includes H2V identification recommendations for the vehicle manufacturer to properly badge a vehicle. SAE J2990-1 focuses on providing the H2V identification information which is considered critical to an emergency responder at an accident. Furthermore, many H2Vs will contain high voltage, and the identification requirements of electrified vehicles (xEVs) are described in SAE J2990.

4.2 Identification Methods

There are several means an emergency responder can use to identify an H2V including interior and exterior badging, and key components, such as, the hydrogen storage system and hydrogen receptacle. However, badging is critical to allow a responder to identify the vehicle as they approach the vehicle, so they can make tactical adjustments.

4.3 Exterior Badging

At an unplanned incident, the initial and most important means for first or second responders to identify that a vehicle contains hydrogen systems should be through the use of compliant badges that are placed at standardized and consistent locations on the exterior of the H2V. Manufacturers can identify an H2V in one of two methods:

When an H2V has one exterior badge, it should be located at an exterior location, rear surface of the vehicle, such as the trunk, hatchback, or lift gate, but not on the bumper, so as to be clearly visible upon approach to the rear of the H2V.

When an H2V has three exterior badges, they should include the location described above and one on each side of the vehicle. One on the left side and one on the right side of the vehicle such as the front fender, front door panel, or roof pillar trim, that allows the H2V badging to be clearly seen upon approaching either the left or right side of the H2V.

Additional H2V exterior badging is possible on the front surface of the vehicle, as well as, at additional exterior locations.

4.4 Interior Badging

When only one exterior H2V badge is provided, an interior H2V marker can also exist. The interior badge is often located in a position where it can be seen when first responders are turning OFF the ignition system of any vehicle involved in an incident.

The interior marker on the H2V should be a durable emblem or insignia securely affixed at a location visible from the driver or passenger window near the key ignition switch or the Start or power button on the instrument panel, console, or steering column.

An alternate location for the interior H2V marker is on one side/surface of the driver's sun visor if said location allows conformance with applicable FMVSS 208 Standard or similar regulations.

4.5 Badging Design

H2Vs can have several variations, including internal combustion, fuel cell, fuel cell hybrid, etc. Therefore, emergency responders and vehicle designers should be aware that the badge design can include any or all of the designs listed in Sections 4.5.1 and 4.5.2.. Additionally, if the H2V is also an electric vehicle (for example, an electric hybrid), the badging defined in SAE J2990 should also be reviewed for implementation to apprise emergency responders of potential high voltage hazards.

In lieu of the designs listed below, automotive manufacturers may use a unique symbol, word or name plate or a nationally/internationally approved symbol as their exterior badging. Current examples of badging are shown in Appendix C.

4.5.1 Hydrogen Vehicles

Badging design for H2Vs should clearly contain in its design one of the following:

1. The word 'HYDROGEN' or letters 'H2'
2. The words 'COMPRESSED HYDROGEN' or letters 'CH2', 'CHG'

4.5.2 Fuel Cell Vehicles

FCV are a version of H2V which use a fuel cell to convert hydrogen into electricity. Pure and hybrid FCV badging should clearly contain in its design one of the following to indicate that it has both a hydrogen fuel system and a high voltage system:

- a. the words 'FUEL CELL', or letters 'FC', 'FCV', 'FCHV', 'FCEV'

4.6 Hydrogen Component Badging Design

4.6.1 Hydrogen Storage System

H2Vs containing compressed hydrogen storage systems (CHSS) often consist of one or more cylindrical storage tanks as shown in Figure 1. These tanks may be visible from the bottom of the vehicle, but may also be covered by shielding. See APPENDIX A for further examples of H2V CHSS.

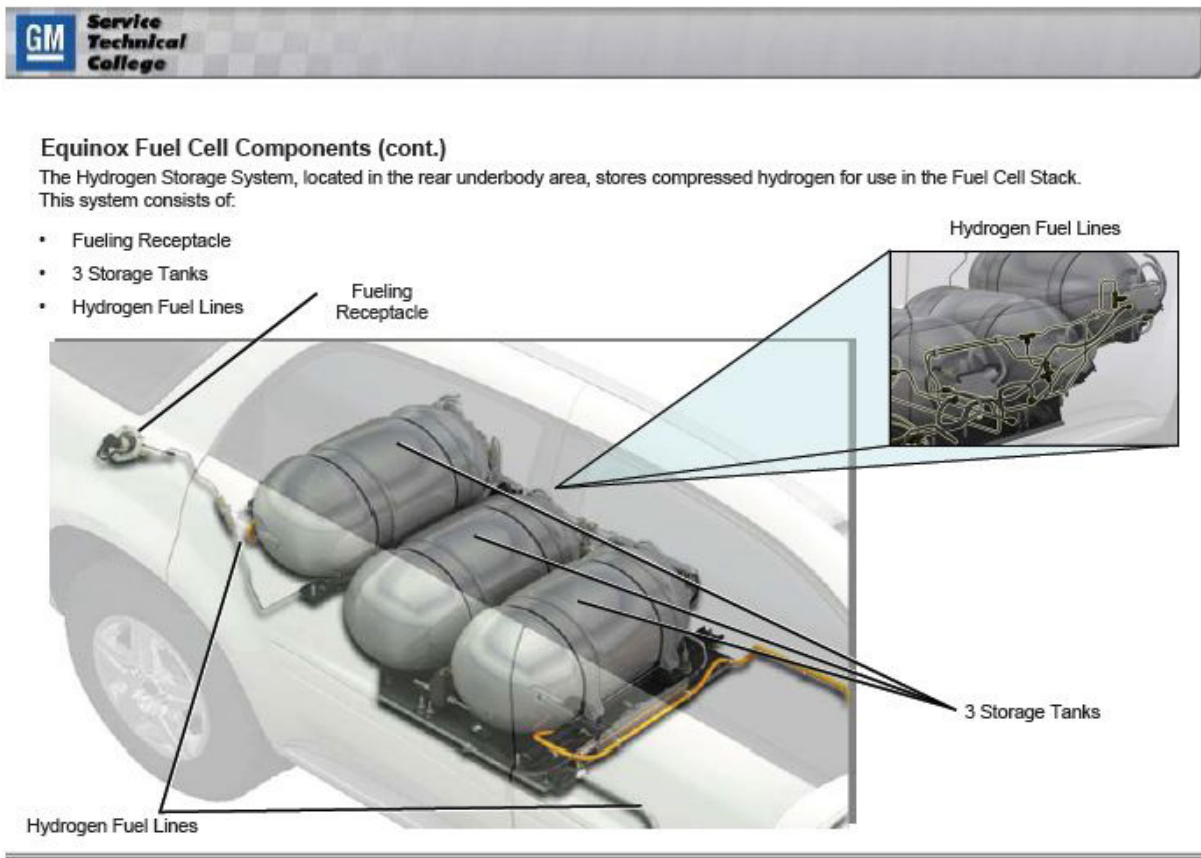


Figure 1 - General motors equinox CHSS

4.6.2 Hydrogen Receptacle

All H2Vs have hydrogen receptacles as shown in **Figure 1** which can be located anywhere on the vehicle, but currently are found in a similar location as gasoline receptacles, behind the fuel door. The use of hydrogen as fuel shall be indicated on a label by showing the pressure class of the vehicle near the fueling receptacle or on the fuel door. Two of the most common pressure classes are:

- H35—35 MPa (5,000 psi)
- H70—70 MPa (10,000 psi)

See APPENDIX B: HYDROGEN FUEL LABELING EXAMPLES for examples of hydrogen receptacles from a Honda FCX Clarity, Mercedes Benz B-Class F-Cell, and a Toyota Mirai.

5. DISABLING RECOMMENDATIONS FOR HYDROGEN SYSTEM

5.1 Hydrogen System Disabling Background

For H2Vs involved in an impact or some other form of incident it is important to have multiple methods of stopping fuel flow and isolating hydrogen to the CHSS in order to reduce the risk the fuel system poses. This would serve to reduce the probability that a first responder or other person needs to manage the fuel while simultaneously reducing the probability that hydrogen be a part of secondary events after the initial incident.

This section describes multiple methods such that vehicle designers can incorporate features into H2Vs to allow automatic or manual disabling of the hydrogen storage system after a vehicle impact or other vehicle incident. Because of the possibility of the impact causing damage to some of the disabling circuits it is recommended that designers incorporate two or more of these methods into the design of an H2V and provide information on the QRS or ERC.

5.2 High Voltage System Disabling Summary

Many H2Vs, such as FCVs, also use high voltage power. The disabling requirements for high voltage systems are discussed in SAE J2990. Disabling the fuel system may not disable the high voltage system and vice versa.

5.3 Hydrogen System Design Considerations

H2Vs typically have a minimum of two methods of stopping the flow of hydrogen fuel. This is typically done by removing power to the electrically-activated CHSS solenoid valve (default position is closed). The following list shows typical methods, or a combination of methods, an H2V is automatically or manually disabled. The list is in the recommended order the vehicle should be disabled. The first responder should review the disabling procedures in the vehicle's QRS. If the shutdown system is damaged, some methods may not properly disable the vehicle. Responders should refer to SAE J2990 for disconnection of high voltage; they may or may not simultaneously remove the vehicle's 12V, 12V components or other non-high voltages from the vehicle.

To comply with this recommendation for stopping the flow of hydrogen fuel, the following methods are recommended (listed in order of preferred sequence):

- a. Automatic shutting of the in-tank solenoid based on the detection of a prescribed level of vehicle impact that might activate the vehicle's SRS. Assuming no damage to the shutdown circuits, this method should close the in tank solenoid valve(s) and isolate fuel to the CHSS as recommended by SAE J2578,
- b. Switching the H2V's ignition switch or power button to the OFF position and assuming no damage to the shutdown circuits. This method should initiate the process to close the in-tank solenoid and isolate fuel to the CHSS as recommended by SAE J2578,

NOTE: To prevent unintended reactivation of the ignition switch or power button, if the vehicle has a key-FOB that could restart the vehicle, the FOB should be moved at least 5 meters from the vehicle.

- c. Either cut or disconnect the negative and positive 12V battery cables individually to discharge the 12V system. Any additional 12V power sources which can be disconnected should be indicated. Assuming no damage to the shutdown circuits, this method should confirm that the in-tank solenoid has returned to the default, normally closed, position and isolated the fuel in the CHSS. If an alternative method such as disconnecting an accessible manual disconnect or fuse is recommended, the method should be described in the QRS.

DESIGN NOTE: OEMs should consider first-responder access when packaging the cables that are suggested to be cut or disconnected. To facilitate easy identification, OEMs should make cut-points close to the components that supply 12V power and should also clearly label the suggested cut points or disconnection points.

6. RECOMMENDATIONS FOR H2V EMERGENCY DOCUMENTATION

6.1 Emergency Response Documentation Background

Automotive manufacturers often provide two key documents to assist emergency responders at the scene of an accident.

The Emergency Response Guide (ERG) provides detailed information on the vehicle including identification, operation, disabling, key components, emergency response, roadside assistance, etc. The ERG can be several pages long and may not be read at the scene of an accident due to their complexity.

The Quick Reference Sheet (QRS) is a short summary intended to provide immediate information for first responders at the scene of an accident on the key safety features of a vehicle

Manufacturer provided information and guidance to first and second responders varies greatly between manufacturers. These documents use manufacturer graphics which are sometimes non-standard and contain two dimensional, three dimensional or even pictures of vehicles. The graphics also vary in that they are presented in color, black and white, or gray-scale. However, ISO (17840 part 1) rescue sheets may be an acceptable form of a standardized format. Appendix D shows examples of quick reference sheets. Readers should refer to SAE J2990 for high voltage requirements and additional background information on ERG's.

6.2 ERG Recommendations

ERGs need to provide information that can be summarized efficiently and be specifically tailored to first and second responders in the field. Below are specific recommendations to facilitate this goal.

ERGs provide detailed information on a vehicle for first and second responders. While it may be used at the scene of an accident, the ERG is intended to provide more detailed information which can be used when time permits.

6.2.1 Consultation with Responders

First and second responders should be consulted to ensure OEM recommendations are useable. (For example: terminology should be catered to first responders, not technicians).

6.2.2 Quick Reference Sheet (QRS)

A quick reference sheet (preferably one sheet, front and back) is intended as a summary of key safety information which the first responders can refer to quickly at the scene of an accident. It should contain information which a first responder can use to secure the scene of an accident. Examples of a QRS are included in Appendix D. At a minimum, this QRS should contain the following information:

- a. Methods of identifying the vehicle, especially identifying if it contains hydrogen and high voltage electricity, especially if it is different than the procedures in §4
- b. Hydrogen system component locations
- c. Hydrogen storage system layout and components
- d. Supplemental Restraint System (SRS), including air bag inflators, and specially indicated cut points for rescue tools in high strength steel locations.

NOTE: SRS and high strength steel are not specific to H2Vs, but are key information for any QRS.

- e. A minimum of two disabling procedures (§ 5.3) with supporting diagrams as necessary (e.g., if a fuse is to be pulled, include a diagram of the fuse box indicating which fuse will be pulled).
- f. Any special considerations for the particular vehicle and hydrogen system including but not limited to
 - i. fire extinguishment
 - ii. tow & recovery
 - iii. submersion
 - iv. high pressure tanks
 - v. TPRD vent direction
- g. Responsible organization contact information (For example, phone number and/or a website for further information).
- h. For vehicles that do not meet the identification criteria listed in §0, then identification cues for responders should be included.
- i. High voltage locations (if applicable), see SAE J2990

See APPENDIX D: EXAMPLE EMERGENCY RESPONSE QUICK REFERENCE SHEETS.

6.2.3 Standardized Graphics

Manufacturers should adopt a standardized set of graphics and icons to represent vehicle hazards. Along with the recommendation in SAE J2990 for high voltage, these should also include the key safety features listed in this section.

- a. A top and side view representative of the vehicle should be utilized (reference APPENDIX D: EXAMPLE EMERGENCY RESPONSE QUICK REFERENCE SHEETS). The document should avoid overly-complicated graphic solutions such as 3D-style drawings or images. Consensus is that there is little value added and they may actually be too complex for fast, easy use on-site.

7. H2V INCIDENTS

7.1 Background

Inspection of H2V after an incident is necessary to ensure the hydrogen fuel system has properly shut down and has not been damaged. A two-stage inspection of these vehicles, one at the incident scene and a second at the storage site post incident, is recommended.

At the incident scene, the inspection is limited due to time constraints, accessibility trained personnel, tools and availability of appropriate personal protective equipment (PPE). For this reason, a series of initial inspection steps by first responders and/or and tow personnel is recommended prior to removing the vehicle from the incident scene. The initial inspection

process, described in §8, is to provide reasonable diagnostics to be used by first responders and tow personnel to determine if a vehicle may be safely removed from the incident scene. This initial inspection process relies on visual, audible and olfactory senses for indications of problems within the hydrogen fuel system and limits the use of specialized tools.

A second inspection process is recommended within 24 hours once the vehicle has been delivered to a repair shop or storage facility where time and resources are more readily available. The inspection may require high pressure specific tools and should be completed by trained personnel as identified in §9.

When a damaged H2V arrives at a storage facility, the vehicle should be secured in a well-ventilated and isolated storage area, as described in §7.3, until the vehicle has completed a full inspection and it has been determined that the H2V is not significantly damaged. During and after isolation, a placard or some other identifier should be placed on the roof and hood of the vehicle to identify and warn others it is an H2V with suspect damage. The OEM or responsible organization, as appropriate, should be contacted to determine additional inspection and diagnostic steps prior to removing the vehicle from isolation.

Many H2Vs will have high voltage electrical systems and SAE J2990 contains the inspection recommendations for these systems.

See APPENDIX F: INSPECTION FLOW CHART- H2V POST INCIDENT

7.2 Potential Hazards of Damaged H2Vs

H2Vs with damaged high pressure hydrogen gas systems may pose hazards during transit or during storage. These hazards may include release of high pressure, flammable gas, fire, asphyxiation, loud sounds and projectiles. Hydrogen is flammable, non-odorous, non-toxic, and fourteen times lighter than air. Hydrogen gas leaks may be small and difficult to detect therefore a flammable gas detector would be useful for monitoring gas buildup. It should be noted that H2Vs have a TPRD integrated into the CHSS, and that heat, including fires can result in a high pressure flammable gas vent. Because of these potential hazards, the vehicle should remain isolated until after the vehicle has passed inspections specified in §9. Tow operators, facility personnel and vehicle owners should be made aware of these risks when towing and storing a damaged H2V per the inspection steps listed in §8 below. The tow operator should make arrangements to tow the vehicle directly to a suitable offsite location where the vehicle can be isolated per the recommendations in the next step.