Module 2
Responding to an Incident

HTEC
FUELING THE DRIVE TO HYDROGEN
www.htec.ca

Disclaimer

Thank you for you interest in hydrogen! Hydrogen is a key driver in Canada's transition to clean energy. Like any fuel, it must be handled responsibly, with a strong understanding of its properties and well-established safety protocols. At HTEC, we prioritize safety at every level—from infrastructure design to fuel storage and refueling operations—ensuring hydrogen is integrated safely and effectively into our energy system.

Disclaimer

This module is intended as a compendium of information to support training and awareness for first responders. The guidance provided should be interpreted in the context of applicable national, regional, and local regulations, protocols, and operational procedures.

This document is for general informational purposes only and does not replace official emergency response protocols or professional judgment. It reflects current knowledge and best practices at the time of publication and may be updated as new information becomes available.

While the content has been developed with care and input from industry professionals, HTEC accepts no liability for how this information is used.

Users are encouraged to provide feedback and consult with their respective agencies before applying any of the guidance in practice.

If you have comments or questions, please contact: **info@htec.ca**

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CONTENTS

Hydrogen Emergency Response
RESOURCES AND REFERENCE MATERIALS

There are several sources that were accessed to create this module. Links to these sources will be provided for further research and understanding.

In addition, we **HIGHLY RECOMMEND** that you visit:

CENTER FOR Hydrogen SAFETY

Weblink

Offers a free "CHS First Responder Micro Training Learning Plan," which helps equip first responders with technical knowledge to mitigate hydrogen-related risks.

European Train the Trainer Programme for Responders

Hy Responder

Fuel Cells and Hydrogen Joint Undertaking (FCH JU)
Grant Agreement Number 875089

Weblink

European Emergency Response Guide

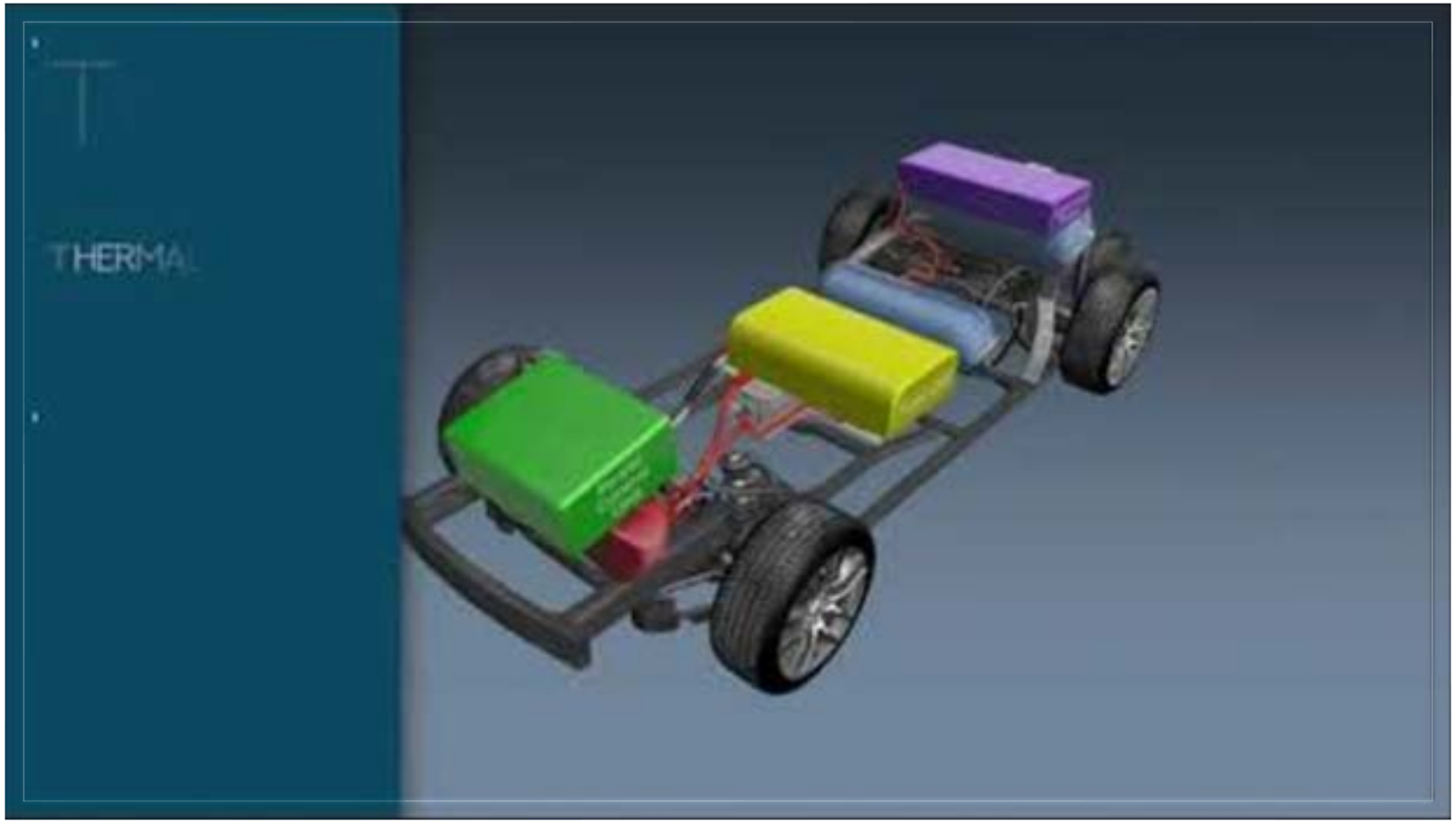
European based leading hydrogen incident guide for trained responders. It includes several tactics depending on different scenarios and supports decisions from first call to final inspection.

TRANSPORTATION

Light Duty FCEVs
Heavy Duty FCETs

Transportation

INTRO TO HYDROGEN FUEL CELL ELECTRIC VEHICLES (FCEVS)



SOURCE: AIChE Academy, https://youtu.be/aoH9xFCBxKk

Transportation
FCEV FIRE RESPONSE AND EXTRACTION

SOURCE: AIChE Academy, https://youtu.be/KQLaMcqP7vA

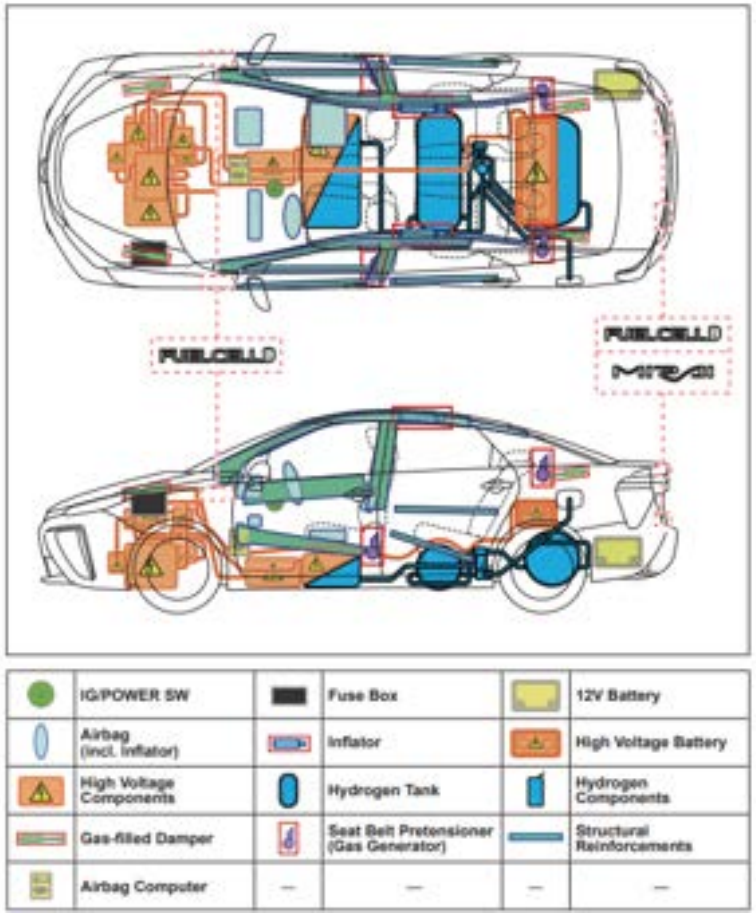
Transportation
RESPONSE GUIDES

H2tools keeps a page of current hydrogen light and heavy-duty hydrogen fuel cell vehicle models available in North America and links to applicable information pages.

Note: the H2 Tools website is currently missing some links to heavy duty truck models. It is expected that these models will be available on the H2 tools website soon.

In the following slides, links are provided to emergency response guides for vehicles commonly found on roads where HTEC operates.

Transportation
RESPONSE GUIDES – LIGHT DUTY FCEVs

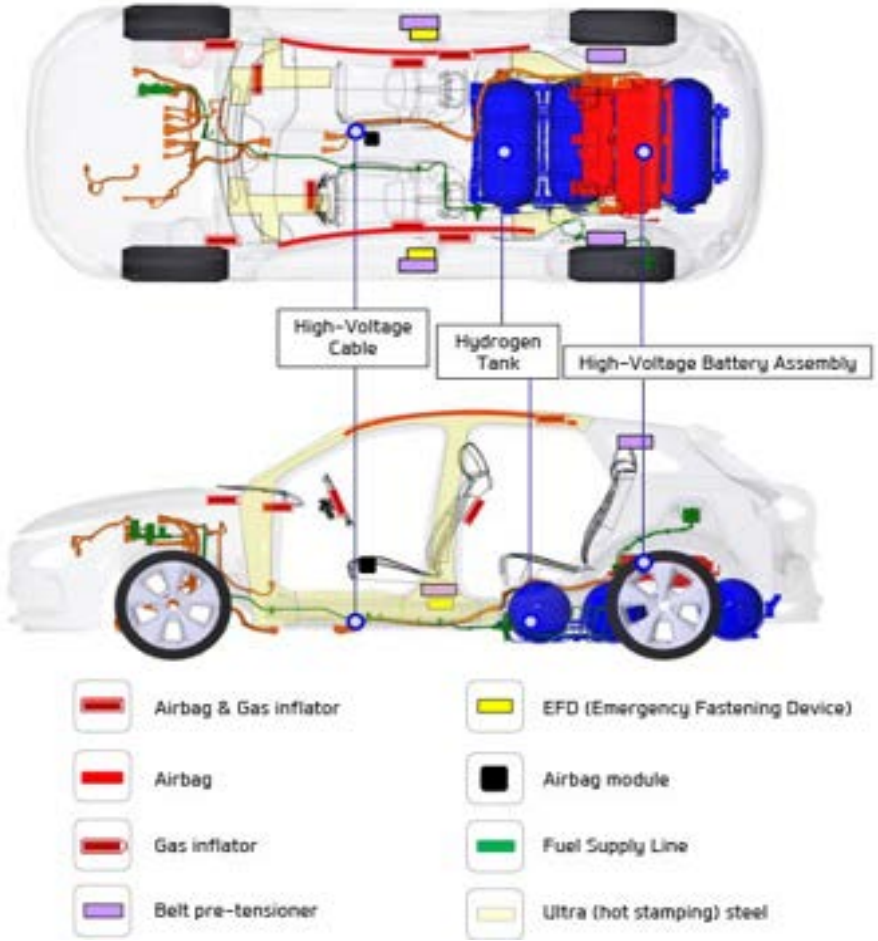


[2015 Mirai ER Quick Guide]

[2020 Mirai ER Guide]

[Hyundai Nexo ER Guide]

Hyundai Nexo



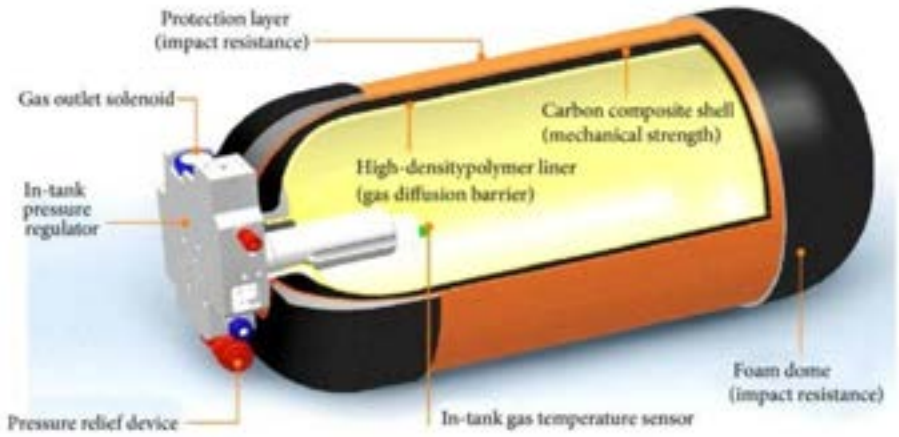
Transportation
H2 STORAGE ON LIGHT DUTY FCEVs

Light Duty Vehicles General Specifics

Tank Construction	Type IV
Tank Size (water volume)	~60 L
Max Pressure	70 Mpa (700 barg / 10,000 psig)
Number of tanks	2-4
Hydrogen stored on board	~4.5 kg

Key Facts

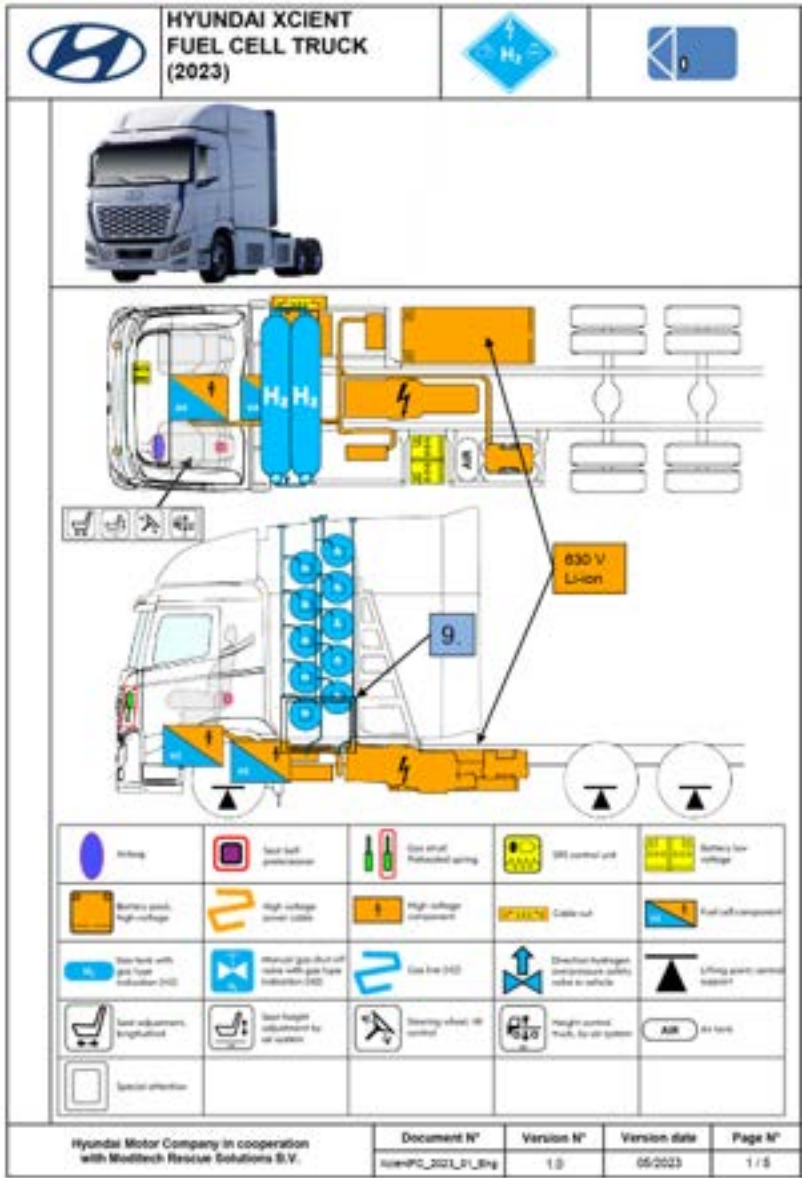
- In-Tank Pressure Regulator – High pressure hydrogen is only stored inside the tank. In-tank regulators limit the pressure down stream of the tank.
- TPRDs:
  - Activated with heat – 110°C (230°F).
  - Exit of TPRD located near the rear wheel well, pointing downwards.
  - Full pressure of tank vented through TPRD.
  - Each tank has its own TPRD



Type IV Tank used in FCEV vehicles

Hydrogen tank and TPRD venting direction:
(a) the installed TPRD near the hydrogen tank and
(b) the hydrogen tank position in the fuel cell electric vehicle (FCEV).

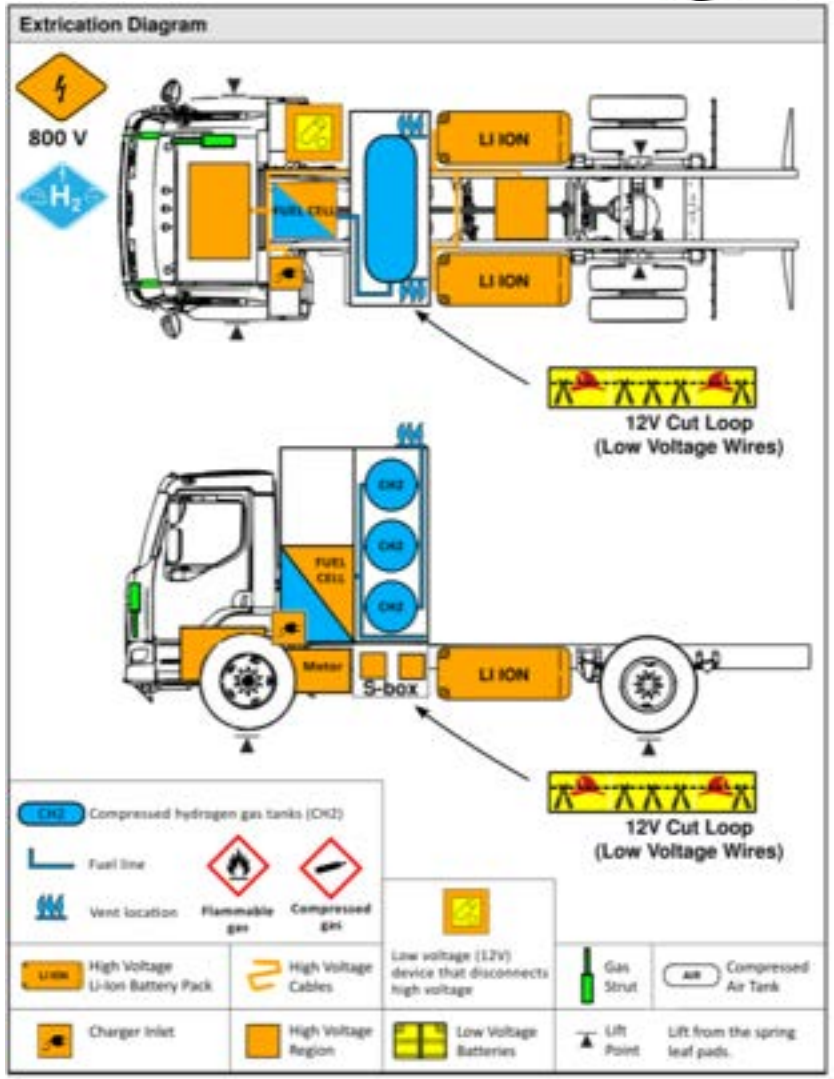
Transportation
RESPONSE GUIDES – HEAVY DUTY FCETs



[Hyundai Xcient Truck ER Guide]

[Nicola ER Guide]

Unilia 220 FC



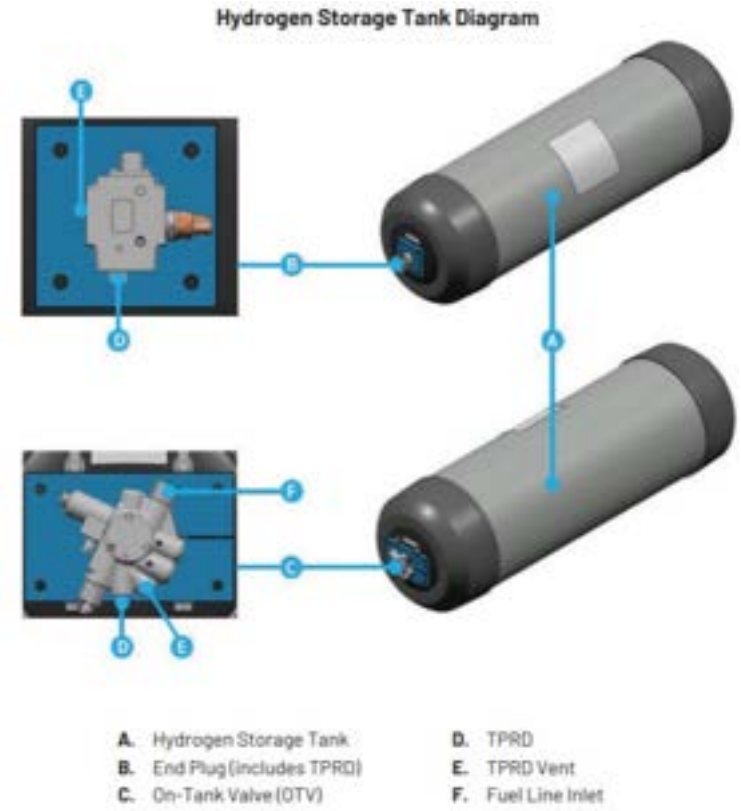
Transportation
H2 STORAGE ON HEAVY DUTY FCETs

Heavy Duty Vehicles General Specifics

Tank Construction	Type IV
Tank Size (water volume)	~175 L
Max Pressure	70 Mpa (700 barg / 10,000 psig)
Number of tanks	4-10
Hydrogen stored on board	~60- 70 kg

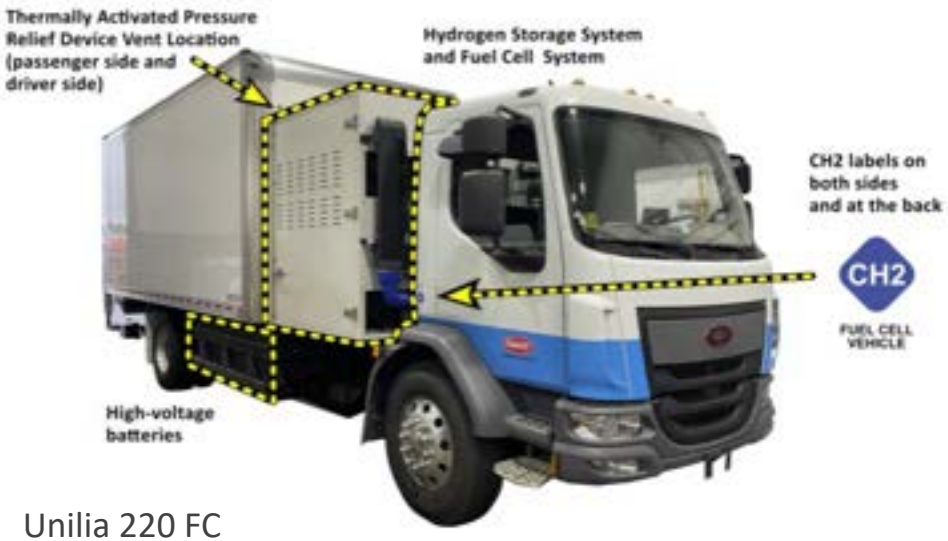
Key Facts:

- In-Tank Pressure Regulator – High pressure hydrogen is only stored inside the tank. In-tank regulators limit the pressure down stream of the tank.
- 14x the amount of hydrogen stored onboard compared to light duty vehicles

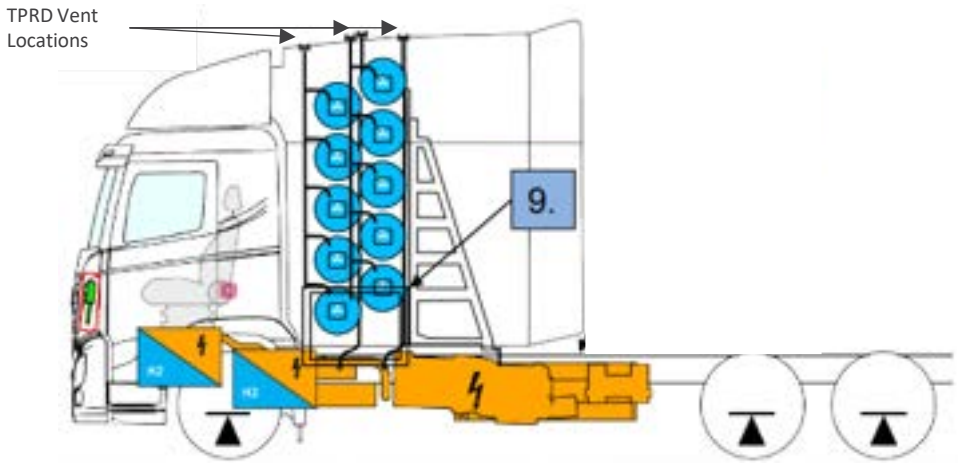


Type IV Tank used in FCET heavy duty vehicles

Transportation
STORAGE TPRDS ON HEAVY DUTY FCETS



Unilia 220 FC



Hyundai Xcient

TPRDs (Thermally Activated Pressure Relief Devices) on heavy duty vehicles are currently located in different locations on vehicle when compared to light duty vehicles

- Activated with heat – 110°C (230°F).
- Exit of TPRD located at top of vehicle and sometimes below vehicle behind the driver's cab.
- Full pressure of tank vented through TPRD.
- Each tank has its own TPRD, on either end of the tank

BASIC RESPONSE CONSIDERATIONS

- Transportation

Transportation
APPROACH ANGLES – LIGHT DUTY VEHICLES

SOURCE: Air Liquide, https://youtu.be/GknSr3yp5Rw

Transportation

BASIC RESPONSE CONSIDERATIONS FOR HYDROGEN FUEL CELL VEHICLES

Over and above standard first responder protocol (see *The EU Emergency Response Guide*)

Arrival

- Ensure fire equipment doesn't cross a flammable gas cloud, arrive upwind of incident scene
- Stop the fire equipment between 50 and 100 meters from incident

Size up the scene

- Determine the incident details - What is the distance between the fire and the fuel cell vehicle? Is hydrogen leaking? Have the TPRDs been activated?
- Should the safety zone be expanded? Determine the energies present in the vehicle involved (tank type, pressures, capacities)

Rescue

- Various tactics can be implemented here depending on the incident, H2 leaks, vehicle on fire, approaching fire, etc.

TACTICS LISTED IN THE EU ER GUIDE

Object Involved	Guide Chapter	Tactic Number	Scenario
Fuel Cell Vehicle	20.1	1	No Leak, No Fire
Fuel Cell Vehicle	20.2	2	H2 Leak without fire
Fuel Cell Vehicle	20.3	3	Vehicle on Fire
Fuel Cell Vehicle	20.3	4	External Fire Threatening the Application
Large Fuel Cell Vehicle	21.1	5	No Leak, No Fire
Large Fuel Cell Vehicle	21.2	6	H2 Leak without fire
Large Fuel Cell Vehicle	21.3	7	Vehicle on Fire
Large Fuel Cell Vehicle	21.4	8	External Fire Threatening the Application

Transportation

BASIC RESPONSE CONSIDERATIONS FOR HYDROGEN FUEL CELL VEHICLES

Over and above standard first responder protocol (continued)

Exposure Protection

- Press the emergency shutdown devices in vehicle
- Repeatly check H2 sensors
- Check for H2 tank temperatures with thermal imaging camera.

Incident Treatment

- DO NOT:
  - cut or crush H2 lines
  - cut or crush High Voltage Lines (orange-coloured)
  - damage hydrogen tank
  - damage traction Battery Stack
- If possible, keep tanks cool with water mist – this will prevent TPRDs from activating, but sometimes this is necessary if extraction is required.
- Extinguish or isolate fire source from H2 storage systems

Final Inspection

- Cool the wreckage as soon as no heat point is detected using the thermal imaging device

DISTRIBUTION TRAILERS

Hydrogen Delivery Trailers
TYPICAL DESIGNS

Bulk hydrogen is transported on the road using 3 general vehicle designs. HTEC's supply chain includes the latter of the two:

1. Gaseous Hydrogen Tube trailer – using steel cylinders (Type I tanks)

2. Gaseous Hydrogen Tube trailer – using carbon fiber cylinders (Type III and Type IV tanks)

3. Liquid Hydrogen Trailer – Vacuum insulated tank

Hydrogen Delivery Trailers
TUBE TRAILER WITH STEEL TANKS

Type of Tank	Type I (Steel)
Typical Size of tank:	2600 L
Max pressure in tank:	22 MPa (220 Barg / 3,200 psig)
Number of tanks on board	~6-36 tanks
Stored hydrogen on board	300-400 kg

Hydrogen Delivery Trailers

TUBE TRAILER WITH CARBON FIBRE TANKS

Type of Tank	Type III or Type IV (Carbon Fiber)
Typical Size of tank:	300 L
Max pressure in tank:	45 MPa (450 Barg / 6,500 psig)
Number of tanks on board	20-60 tanks
Stored hydrogen on board	180 -540 kg

Currently, these delivery trailers have a max pressure of 450 bar, but higher pressure (700 bar) delivery trailers are in design.

Hydrogen Delivery Trailers
LIQUID HYDROGEN TRAILER

Type of Tank	Vacuum insulated, steel tank
Typical Size of tank:	5000 L
Max pressure in tank:	45 MPa (450 Barg / 6,500 psig)
Number of tanks on board	1 tank
Stored hydrogen on board	~4500 kg

BASIC RESPONSE CONSIDERATIONS

- Distribution Trailers

Hydrogen Delivery Trailers
INCIDENT RESPONSE

SOURCE: AIChE Academy, https://youtu.be/LsYq9jRkXsg

Hydrogen Delivery Trailers

BASIC RESPONSE CONSIDERATIONS FOR HYDROGEN FUEL CELL VEHICLES

Over and above standard first response protocols

(see *The EU Emergency Response Guide*)

Incident Treatment

- Various tactics can be implemented here depending on the incident, H2 leaks, trailer on fire, approaching fire, etc.
- If the fire concerns an ignited H2 leak, the only safe way to put out the fire is to close the appropriate valve.
- Only extinguish the fire when you can close the leak, otherwise let the H2 burn in controlled circumstances
- DO NOT:
  - cut or crush H2 lines
  - Damage the hydrogen tank
- Keep tanks cool – especially if there is fire
- Extinguish or isolate external fire sources from H2 storage systems

Tactics listed in the EU ER guide			
Object Involved	**Guide Chapter**	**Tactic Number**	**Scenario**
Fuel Cell Vehicle	20.1	1	No Leak, No Fire
Fuel Cell Vehicle	20.2	2	H2 Leak without fire
Fuel Cell Vehicle	20.3	3	Vehicle on Fire
Fuel Cell Vehicle	20.3	4	External Fire Threatening the Application
Large Fuel Cell Vehicle	21.1	5	No Leak, No Fire
Large Fuel Cell Vehicle	21.2	6	H2 Leak without fire
Large Fuel Cell Vehicle	21.3	7	Vehicle on Fire
Large Fuel Cell Vehicle	21.4	8	External Fire Threatening the Application

Hydrogen Delivery Trailers

BASIC RESPONSE CONSIDERATIONS FOR HYDROGEN FUEL CELL VEHICLES

Over and above standard protocol (Continued)

Keeping tanks cool – suggested response

- Gaseous Hydrogen Tube trailer – using steel cylinders (Type I tanks)
  - Spray water directly on tube trailer tanks
- Gaseous Hydrogen Tube trailer – using carbon fiber cylinders (Type III and Type IV tanks)
  - Avoid spraying water on TRPDs – if there is a fire these devices need to activate. Soaking them with water could prevent them from triggering and lead to escalation
  - If possible, to avoid TPRDs, spray water directly on tanks
  - If not possible, create mist spray over entire trailer
- Liquid Hydrogen Trailer
  - Spray water directly on tube trailer

Gaseous hydrogen tube trailer with TPRDs activated. Water mist over trailer keeping tanks cool.

Hydrogen Delivery Trailers
TPRD AND VENT LOCATIONS

Over and above protocol (Continued)

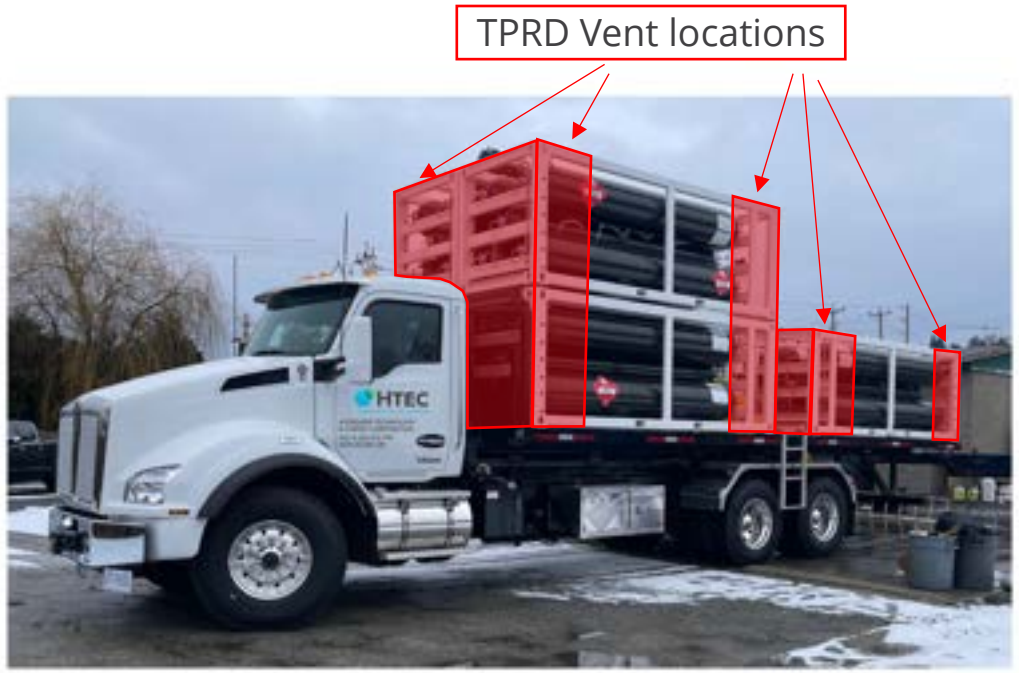
For tube trailers that have Type III or Type IV tanks, like all HTEC tube trailers, TPRDs are located at each of the tank ends.

On an HTEC delivery trailer, there could 4 to 12 modules or PC45s, with each module/PC45 containing 5 tanks.

Usually these PC45s are installed on the truck in ‘blocks’ of 4 modules/PC45s.

Therefore, TPRDs are located within 1m of the ends of these blocks. The TPRD vent exits are routed to the top of these blocks within these same 1m zones.

- These zones on the image to the right are just representative. Actual trailers do not have these zones marked.



DO NOT SPRAY WATER DIRECTLY ON THE TANKS WITHIN THESE RED ZONES.

Water can be directly sprayed on to the tanks between these zones

Hydrogen Refueling Stations

Response to an incident

Hydrogen Refueling Stations
Overview

Hydrogen Refueling stations can service either light- or heavy-duty vehicles.

A typical station includes:

1. H2 Supply Connection
    - Gaseous hydrogen tube trailer
    - Liquid hydrogen trailer
    - On site production
2. Low pressure storage up to 450 barg
3. Compressor unit (and vaporizer if LH2 source)
4. Higher pressure storage up to 1000 barg
5. Cooling unit to cool the hydrogen to -40°C
6. Dispenser: 350 or 700 bar dispensing

Hydrogen Refueling Stations
INCIDENT RESPONSE

SOURCE: AIChE Academy, https://youtu.be/kUgPdGzz2y0

Hydrogen Refueling Stations
ONSITE STORAGE

Most stations have a mix of 'low' pressure storage and 'high' pressure storage.

Depending on the capacity of the station and the equipment employed, the amount of each kind of storage will vary.

Low Pressure Storage (Gaseous)

Typical Size of tanks:	300-500L
Max pressure in tank:	25 - 45 MPa (250-450 Barg / 3600 – 6500 psig)
Number of tanks on-site	~6 - 10 tanks
Amount of hydrogen stored on site	100 – 500 kg

Low Pressure Storage (Liquid)

Typical Size of tanks:	19,000 - 34000L
Max pressure in tank:	1.2 MPa (12 Barg / 175 psig)
Number of tanks on-site	1 tanks
Amount of hydrogen stored on site	1,300 – 2,400 kg

Source: Tenaris

Source: Chart Industries

Hydrogen Refueling Stations
ONSITE STORAGE

High Pressure Storage (Gaseous)

Typical Size of tanks:	300-500L
Max pressure in tank:	87.5 - 100 MPa (875-1000 Barg / 13,000 – 15,000 psig)
Number of tanks on-site	~6 - 10 tanks
Amount of hydrogen stored on site	100 – 500 kg

Source: FIBA Technologies Inc.

Source: Hexagon Purus

Hydrogen Refueling Stations
ONSITE STORAGE

At HTEC stations there is a mix of tank types that are used for onsite storage including:

- Type I: Steel tanks
- Type III: Carbon Fiber tanks with Aluminum lining
- Type IV: Carbon Fiber tanks with polymer lining

Some tanks have TPRDs and some tanks do not.

Consult the specific station ERPs to determine what types of tanks are installed at which stations, and how best to cool tanks if there is a fire near the tanks.

BASIC RESPONSE CONSIDERATIONS

- Hydrogen Refueling Stations

Hydrogen Refueling Stations
BASIC RESPONSE

Over and above standard first response protocols

(see *The EU Emergency Response Guide*)

Incident Treatment

- Various tactics can be implemented here depending on the incident, H2 leaks, fire in the station, approaching fire, etc.
- If the fire concerns an ignited H2 leak, the only safe way to put out the fire is to close the appropriate bank valve.
- A remote site ESD, will isolate hydrogen storage, but there will be fittings and possible leak points between the tank and these isolation valves.
  - If an ESD does not stop hydrogen from leaking, then you will be able to stop the leak. Keep the tanks cool and allow the tank to vent.
  - Depending on the system, the station operator may be able to remotely vent the tank as well.

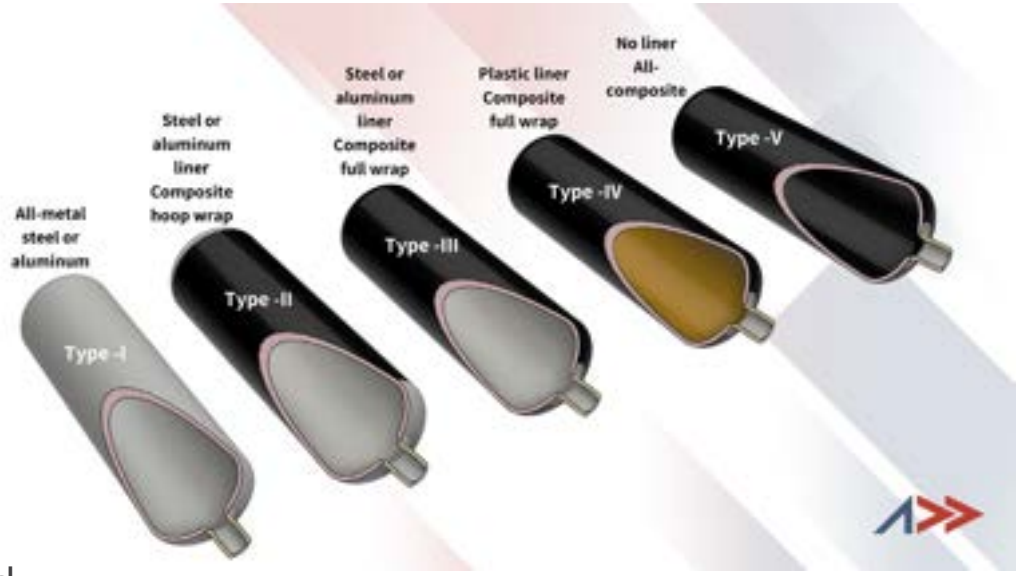
Tactics listed in the EU ER guide			
Object Involved	**Guide Chapter**	**Tactic Number**	**Scenario**
H2 Refueling station	23.1	13	No Leak, No Fire
H2 Refueling station	23.2	14	H2 Leak without fire
H2 Refueling station	23.3	15	Vehicle on Fire
H2 Refueling station	23.3	16	External Fire Threatening the Application

- DO NOT:
  - cut or crush H2 lines
  - Damage hydrogen tank
- Keep tanks cool – especially if there is fire (next slide)
- Extinguish or isolate external fire sources from H2 storage systems

Hydrogen Delivery Trailers
BASIC RESPONSE

Keeping tanks cool – very similar to hydrogen delivery trailers

- Gaseous Hydrogen Type I tanks: **Steel Cylinders**
  - Spray water directly on tanks
- Gaseous Hydrogen Type III and Type IV tanks: **Carbon Fiber Cylinders**
  - Avoid spraying water on TRPDs – if there is a fire these devices need to activate. Soaking them with water could prevent them from triggering and lead to escalation
  - If possible to avoid TPRDs, spray water directly on tanks
  - If not possible, create mist spray over entire trailer
- Liquid Hydrogen Tanks – double walled steel tanks with vacuum insulation between inner and outer tank walls
  - Spray water directly on tank



Source: Addcomposites

Consult the specific station ERPs to determine what types of tanks are installed at which stations, and how best to cool tanks if there is a fire near the tanks.

HYDROGEN PRODUCTION FACILITIES

Hydrogen Production Facilities
OVERVIEW

Types of hydrogen production (or transfer) facilities can range drastically in size, complexity, and amount of hydrogen storage stored onsite.

HTEC facilities range from producing 1,000 kg to 15,000 kg per day, filling gaseous tube trailers or liquid hydrogen tanker trucks.

Onsite hydrogen volume can range from 5,000 kg to 45,000 kg.

If there is a hydrogen production facility in your area, read the facility Emergency Response Plan to understand the nuances with that facility.

HTEC's Burnaby Clean Hydrogen Production Facility

HTEC's North Vancouver Liquid Hydrogen Production Facility

Hydrogen Production Facilities
OVERVIEW

HTEC production facilities incorporate:

- **Liquid hydrogen to gaseous hydrogen transfer equipment** for filling hydrogen tube trailers with up to 450 barg gaseous hydrogen.
- **Electrolysis generation and compression** – the production of hydrogen by splitting water into hydrogen and oxygen using electrical energy. The hydrogen is then compressed up to 450 barg into onsite storage and gaseous tube trailers.
- **By-product gas cleanup and liquefaction** – taking vented hydrogen from an existing chemical producer, cleaning the gas to high purity and liquifying the hydrogen for transport.

HTEC's liquid hydrogen tank

Electrolysis module
Source: accelera

BASIC RESPONSE CONSIDERATIONS

- Hydrogen Production Facilities

Hydrogen Production Facilities
BASIC RESPONSE

The basic response to a production facilities is very similar to that of a hydrogen refueling station.

- Keep tanks cool
- Storage and hydrogen trailers can be remotely isolated

What is different:

- The amount of hydrogen stored onsite is much larger, evacuation distances might be different
- Larger number of tanks and delivery trailers onsite at any one time
- Other chemicals may also be stored on site
- It is an industrial site, it is not public accessible
- The personnel onsite are all trained/authorized employees and understand what to do in an emergency

If there is a hydrogen production facility in your area, read the facility Emergency Response Plan to understand the nuances with that facility.

THANK YOU!

We appreciate your time and commitment to learning about hydrogen safety. Your role as first responders is essential to the safe rollout of this clean energy solution.

Want to learn more?

➡ Continue with our training modules
➡ Email us at info@htec.ca to arrange a workshop, live demo, or tailored presentation for your department.

Together, we can build a safer, cleaner future.