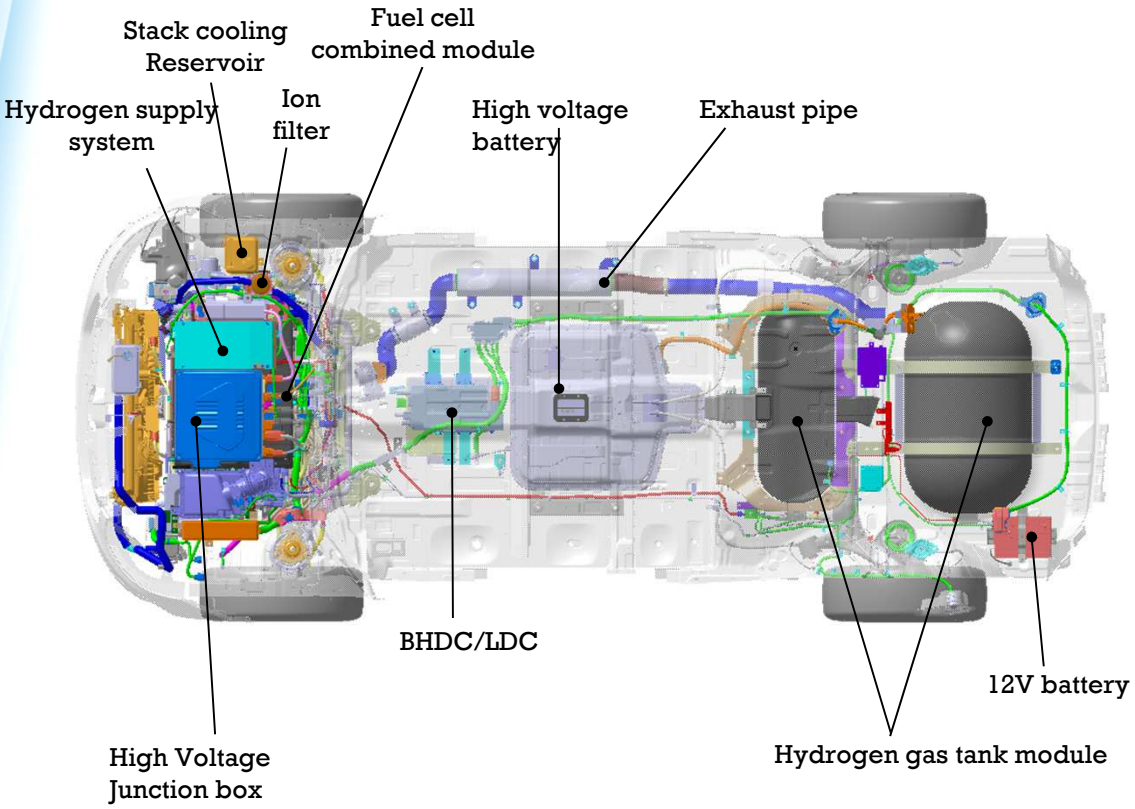
Emergency Response Guide

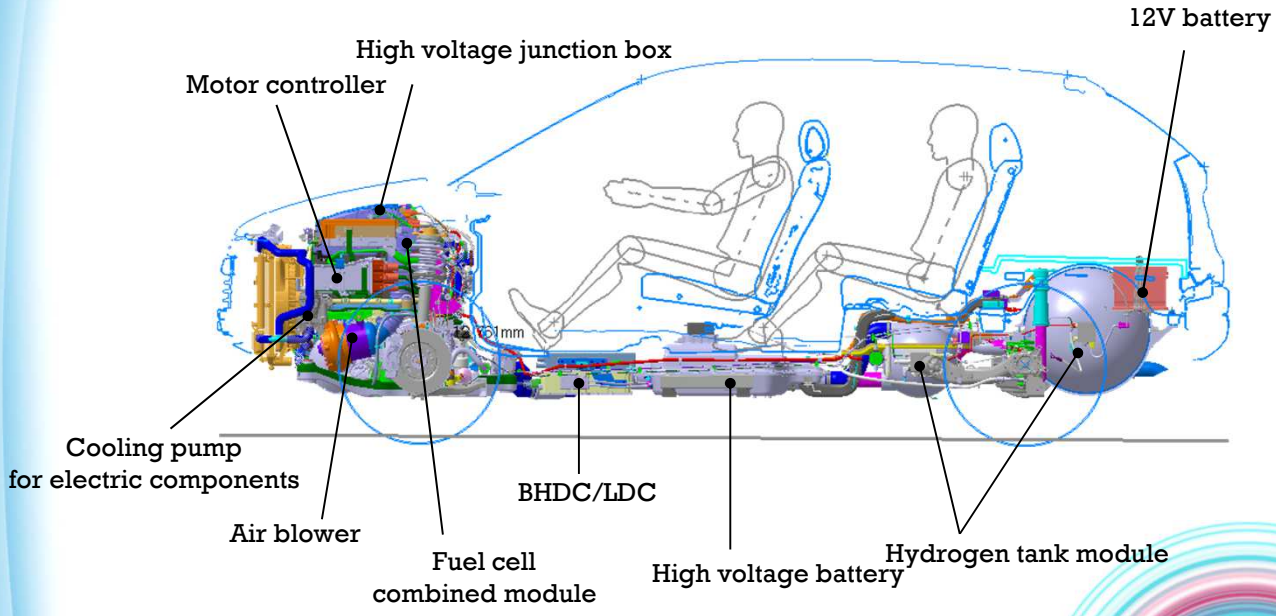
ix35 Fuel Cell Electric Vehicle

HYUNDAI·KIA MOTORS

Contents

Key Components





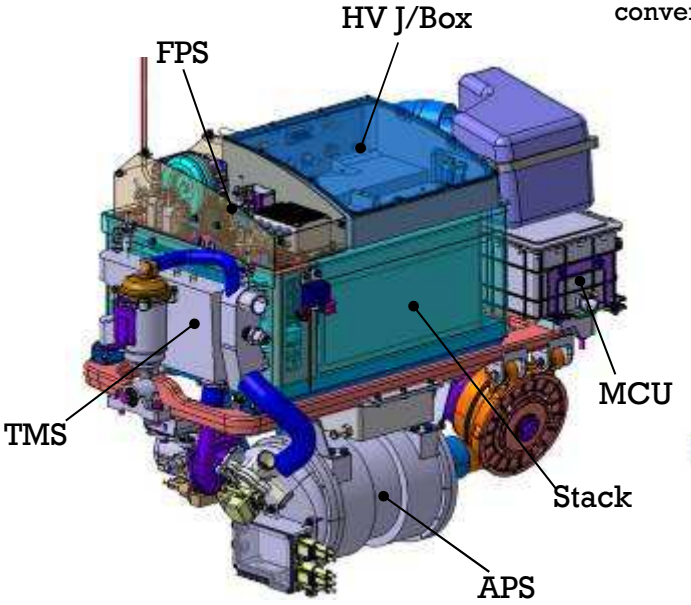
※ BHDC : Bidirectional High voltage DC-DC Converter
LDC : Low voltage DC-DC Converter

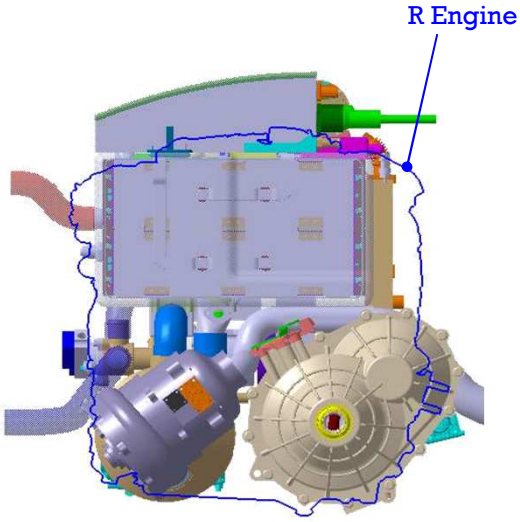
FCEV Configurations and functions

Features of Fuel Cell Electric Vehicle

ix35 fuel cell electric vehicle (FCEV) is an electric vehicle that generates an electrical energy by a fuel cell system. ix35 FCEV is manufactured with the same platform of conventional Tucson SUV. However, the power train system is totally different from the conventional vehicle; an internal combustion engine.

As shown in Figure, the power train system of ix35 FCEV is placed in the engine room of conventional vehicle which means that its power train system has almost same size of conventional vehicle.





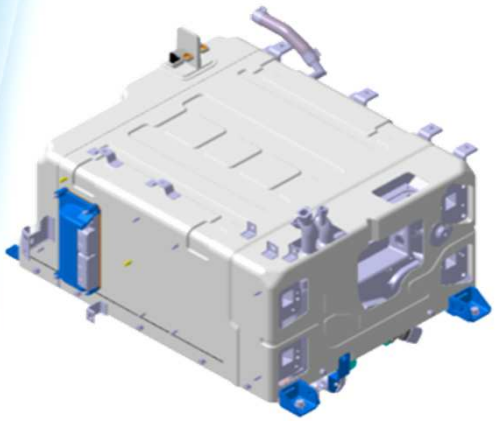
[Engine Vs Module Comparison]

※ **FPS** : Fuel Processing System, **TMS** : Thermal Management System
APS : Air Processing System, **HV J/BOX** : High Voltage Junction Box

※ Stack and BOP parts integrated into modules
: Stack + {APS+FPS+TMS} + HV J/BOX + Inverter

FCEV Configurations and functions

Fuel cell vehicle mainly comprises four items. i) Fuel cell system which is generating electric power, ii) Electric power system which is making driving-force, iii) Hydrogen storage tank system which is installed under the luggage space of the vehicle, iv) Auxiliary power supply system which is to support the power or to storage the energy regenerated. Additionally it includes a lot of controllers, voltage converters and distributors. These components are installed in engine room or underneath the vehicle

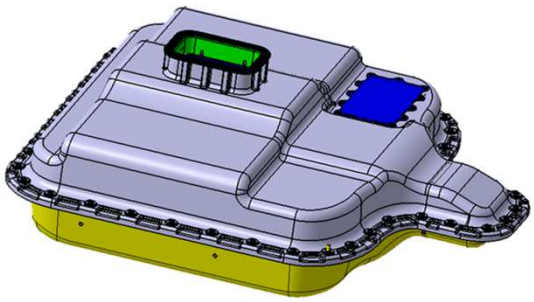


Fuel Cell Stack

Fuel cell stack is an energy source which can be generated by the chemical reaction using oxygen and hydrogen. It drives the vehicle with electric motor power as an conventional vehicle does.

Batteries are either primary or secondary. Primary batteries are used only once because the chemical reactions that supply the electrical current are irreversible. Secondary batteries can be used, charged, and reused. In these batteries, the chemical reactions that supply electrical current are readily reversed so that the battery is charged.

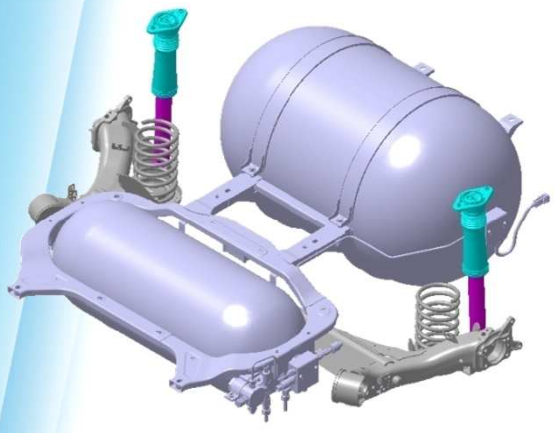
Generally, fuel cell could be considered that it is not a battery because it is more likely to be closer to a kind of generators, which is using the energy by combining hydrogen and oxygen.



High voltage battery

FCEV has a high voltage battery which is directly connected to fuel cell stack through DC/DC converter. This battery stores the electric energy, which comes from the fuel cell stack or the vehicle's regeneration braking system.

FCEV Configurations and functions



High pressure hydrogen storage tanks

Compressed hydrogen tank system is composed of three tanks which are filled with Hydrogen gas in a gas station. Each tank is made of aluminum and covered additionally with carbon fiber which makes the storage tank sustain high pressures. There are magnetic valves, pressure regulators and thermo-pressure sensors in the vicinity of the cylinder's inlet. The hydrogen in the tanks comes into the pressure regulator which has a pressure sensor. The manual valve located between the regulator and hydrogen vent socket is used to control the flow amount during Hydrogen vent. The compressed hydrogen system is designed using pressure of 700 bar, temperature range -40℃~85℃. Maximum allowable pressure is limited to 875bar (12,691psi) @ 85℃.

High Voltage Cables

The electric energy which is generated from fuel cell system or high voltage battery module is distributed to the various components. Most of the cables are located in the inside or bottom of the components. These cables use orange colored cover to distinguish from other lines. It is required to handle the cables with care.

12V Battery

Conventional 12 Volt battery is located in the luggage room(under the luggage room cover). The battery supplies the power to head lamps, audio, and other electric components. This battery is also being used to drive fuel cell system at Initial stage after start.

Vehicle Specifications

Vehicle		Capacity	5 persons
		Wheel base	2,640 mm
		Wheel track	1,585 mm
		Weight	1,815 kg
Spec.	**Driven Motor**	Type	Induction motor
		Output	100kW
	Sub-electric source	High voltage battery 24kW	
	Hydrogen storage System	700bar / 144L	
Fuel economy		Combined mode	25.0 km/L
Distance to empty		525 km	
Minimum cold start temperature		-25℃	
Performance		Max Speed	160kph
		Acceleration Performance (0 → 100 km/h)	14sec

High Voltage Safety System in FCEV

Fuel Cell Stack

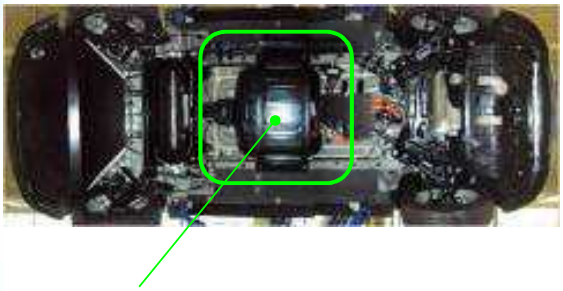
Fuel Cell Electric Vehicle, unlike the regular internal combustion engine vehicle, use an high voltage electrical energy generated in the fuel cell stack as a power source. Owing to this high voltage electricity, it requires to handle with a care for the high voltage hazard. The followings are safety guideline of high voltage in fuel cell stack of ix35.

1) A metal chassis and electro-conductive enclosure is located in the fuel cell stack to prevent an electrical shock due to the direct or indirect contact of users. Fuel cell stack has a high protection degree of IPXXB.
2) Live parts and high voltage buses which are generating over DC 400V in the fuel cell stack are designed to maintain a reliable insulation resistance with an electro-conductive enclosure. When the insulation resistance is lower than the regulated value, it is alarmed to the user and limited the output current of fuel cell stack.

- Direct contact: the contact of persons with live parts
- Indirect contact: the contact of persons with conductive parts which can be touched, and which becomes electrically energized under isolation failure conditions.

High voltage battery system

This system supplies the energy which can be applied vehicle's acceleration phase. The system also is being used to store the energy generated during regeneration braking phase.



Battery system
→ underneath the vehicle(center)

High voltage battery system	
Battery pack voltage	180 Volts(Max 206V)
Battery type	LI-POLYMER
Number of cells	48 Cells
Battery system total weight	47 Kg

1) High voltage system is located underneath the floor and protected with a steel case.
2) The system consists of 48 cells. Each cell is sealed with an aluminum case to protect an electrolyte spillage. There is rare possibility to spill the electrolyte in the cell even if a battery module is cracked.

3) For safety, an over-current protection and ceramic coating isolation layer are used.

4) Non-flammable material electrolyte is applied to prevent explosions or fire in an emergency case such as a car accident.

5) High voltage cable(orange color) is connected to the battery system with DC converter.

6) There is a high voltage regulator to control the high voltage line. In addition, there are a high voltage fuse and safety plug to separate the electrical sources in the system for safety.

Safety of high voltage system

The followings are safety guideline to prevent an electric shock caused by a high voltage system of ix35.

1) High voltage components of FCEV such as solid insulator, insulation distance and etc. are designed to maintain a reliable insulation resistance with a metal chassis of vehicle as ground over vehicle service life.

2) All of live parts of high voltage components are covered with an enclosure to prevent a direct contact. These are not possible to be dissembled without special tools.

3) There is a high risk of electrical shock due to a indirect contact when an insulation resistance between a high voltage component and electro-conductive enclosure rapidly decreases. All of electro-conductive enclosure maintains an electrical continuity with a chassis of vehicle as ground.

4) Ground Fault Detector (GFD) detects a current leak over permissible level at the electrical conductive chassis parts. In addition, it shut down the current from high voltage relay immediately when there is the current leak.

5) All power supply cables are insulated from metal chassis parts. There is no possibility to get a electric shock at contacting the chassis parts.

6) High voltage fuse are a protective device against overheating due to an excessive current.

7) Safety plug of high voltage battery is located in the inside of the battery system case.

Safety Issues of Compressed Hydrogen

General Features of Hydrogen

Hydrogen is a unique gaseous element and possessing the lowest molecular weight of any gas. It is a colorless, odorless, tasteless, non-corrosive, flammable and high volatile. Hydrogen therefore is necessary to be handled with care due to its gaseous properties. However, it is no more dangerous and it is rather less dangerous than other commonly used fuels in some respects. Hydrogen is much lower density which gives it a comparative advantage from a safety point of view. Owing to this, hydrogen gas tends not to mix with the air and disperses upwards in the air. This means that the concentration levels of hydrogen necessary for ignition or detonation are unlikely to be achieved.

Diffusion and Relative Leak Rates for Laminar and Turbulent Flow

Gas	C_3H_8	CH_4	H_2
Diffusion	0.63	1.0	3.8
Laminar Flow	1.38	1.0	1.26
Turbulent Flow	0.6	1.0	2.83

Hydrogen Gas Features

A hydrogen gas leak should be prevented for hazard of ignition or detonation for a safety point of view.

The followings are properties of gaseous hydrogen.

- It has the lowest molecular weight, and is the smallest molecules of any elements.
- It has the lowest density and the highest buoyancy of any element.
- It can cause brittleness in some materials, including metals (but materials chosen for hydrogen applications are not susceptible to brittleness).
- It is colorless, odorless and tasteless.
- It burns invisibly and without smoke.
- It has the lowest ignition energy of any fuel (less than one-tenth that of other fuels).
- It has a wide flammability concentration range of 4% to 75%

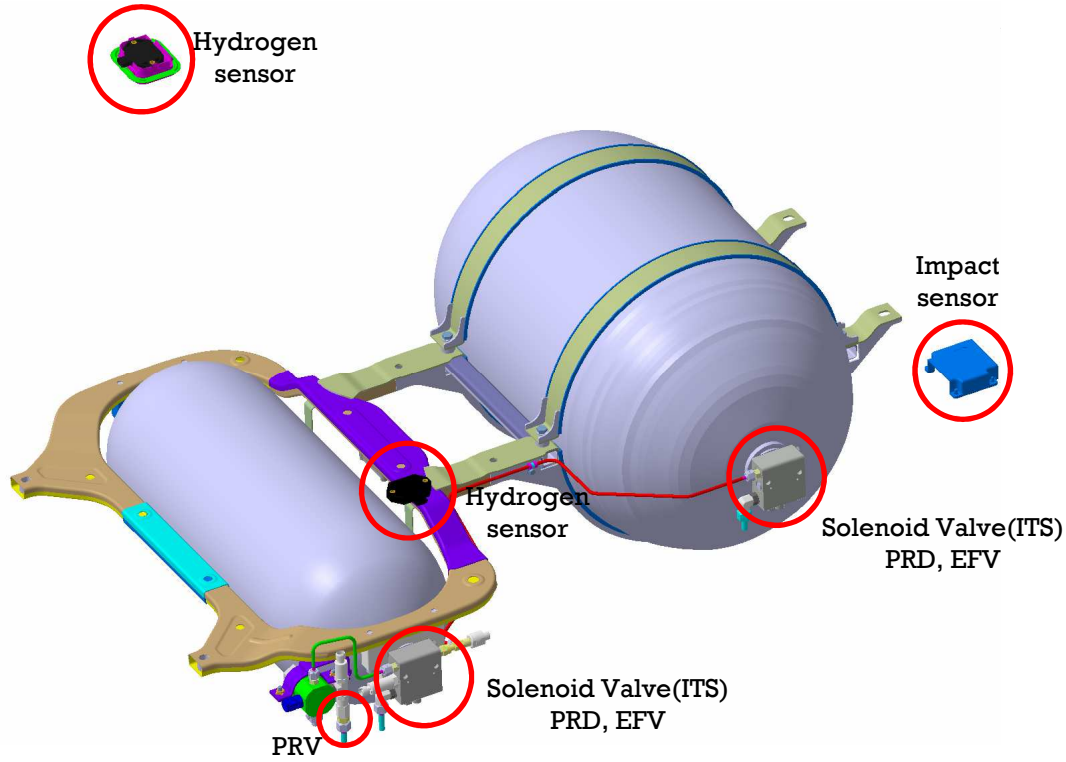
Hydrogen Gas Leak Detection System

Hydrogen gas detector sensor detects a hydrogen leak. If there is a hydrogen leak, a hydrogen storage system and electrical systems will be shut down. Sensors typically start to trigger a warning alarm at concentrations below the minimum flammability limit of hydrogen.

Hydrogen Gas Ventilation

FCEV releases low concentration hydrogen while operating FCEV. The released gas is diluted through a ventilation system equipped in the vehicle before the gas gets into the inside of vehicle and the diluted gas releases to the surroundings.

Hydrogen Safety System



Hydrogen Gas Detection Sensors

It detects a hydrogen leak and informs a warning of hydrogen leak to a driver. As informing a warning, the sensors automatically shut off hydrogen. Sensors are installed at the fuel cell stack, hydrogen supply system(FPS), in-between hydrogen storage tank ceiling of vehicle. These sensors prevent a hydrogen leak in an emergency.

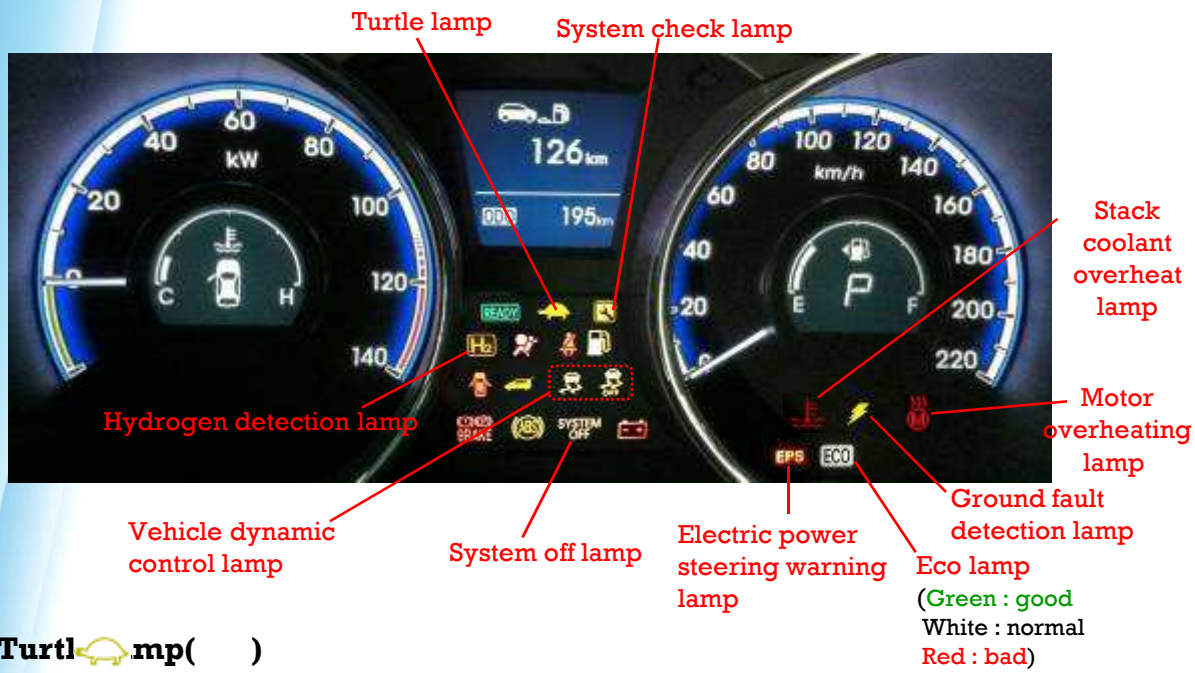
Hydrogen Safety Devices

- In-Tank Solenoid valve (ITS)
  : It supplies hydrogen at a normal operating condition. In an emergency, it has a role to shut off hydrogen safely.
- Pressure Relief Device (PRD)
  : It detects temperature and pressure of the hydrogen tank and vent hydrogen to the surrounding atmosphere in case of fire.
- Excessive Flow Valve (EFV)
  : It detects an excessive hydrogen flow and then shut off hydrogen safely in case of pipes damaged.
- Pressure Relief Valve (PRV)
  : It is installed on the regulator and it vent hydrogen to the surrounding atmosphere in case of regulator failure.

Front, Rear Impact Sensors

The sensors are installed on the front and rear bumpers. It shuts off supplying hydrogen, and helps not to cause the secondary damage.

Warning Lamps on Cluster



Turtle lamp( )

1) It indicates that an electric power supply is being limited.
2) It is activated when an ignition key is turned "on"
3) When the lamp is "on", refrain from operating the vehicle. In this case, it is possible the vehicle moves back in steep road due to power supply limit. When the lamp keeps "on" after restarting, please contact an engineer.

Hydrogen Gas Leak Detection Lamp( )

1) When there is a hydrogen leak in the vehicle, this lamp keeps "on". When this lamp is : "on" in an operating mode, park the vehicle and turn off the vehicle.
2) Please contact an engineer after turning off the vehicle.

Stack coolant overheating lamp( ) and Motor overheating lamp( )

1) This lamp would be turned "on" in cases that stack coolant is quantitatively insufficient, cooling systems does not work or overheating of stack. When the lamp is "on", please refill coolant (PG).
2) The lamp would be turned "on" in case that motor or motor control unit is overheated due to the lack of coolant. Check the level of coolant and operating condition of pump.
3) When the lamp is "on" even after refilling coolant, please contact to an engineer.

System Check Lamp ( )

1) When this lamp is turned "on" at the ignition mode, it means an failure of starting. Try to start the vehicle after one minute.
2) When this lamp is turned "on" in the operating mode, it means the vehicle shutdowns. Park the vehicle and try to start again.
3) When the lamp keeps "on", contact an engineer.

→ It is helpful informing the event code indicated in the cluster.

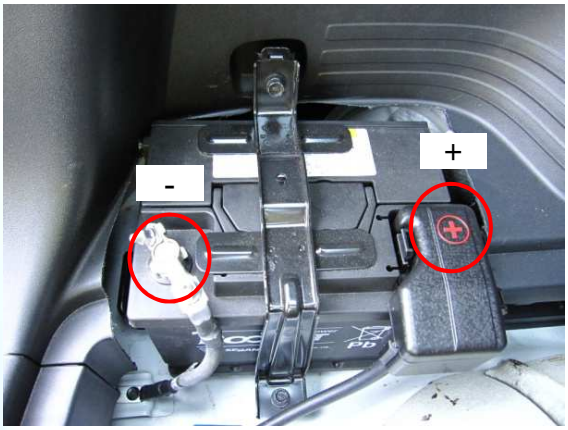
Trouble Shooting: Starting Problem

Check Items for not starting

1. Confirm the transmission position in "N" or "P".
2. Check EDS button is properly pressed
   (It should be pressed for starting mode).
3. In case of luminous intensity of the bulb located in the luggage room is weak, recharge the battery and then restart.
4. In case of the inevitable, try to start "jump starting" explained by the following.

Jump Starting Process

1. Make sure not to contact both vehicles with each other in case that the charged battery is inside the vehicle.
2. Turn off the all lights or electric devices if these are not needed.
3. Connect the jumping cable to the positive (+) terminal of the discharged battery. And then, connect the other jumping cable to the positive (+) terminal of the battery supplied the power. Repeat this process with the negative (-) terminal of the jumping cable.
4. Keep charging the battery for several minutes. It helps charging the battery fully.
5. Remove the negative (-) terminal of jumping cable from the batteries and then remove the positive (+) terminal of jumping cables from the batteries.
6. In case of that the drivers cannot recharge the battery or find out the reason of discharging of the vehicle, contact an engineer.



Fuse Box Position and Engine Room Layout

Left: Fuel cell coolant reservoir
Right: Electric cooling reservoir

Left: fuse and relay box of fuel cell system
Right: fuse and relay box of conventional system

Conventional vehicle system related fuses and relays

Emergency Procedures

Submerged vehicle

Pull the vehicle out of water and then take a step to reduce the damage arising from the high voltage cable caused by high voltage current. There is no risk to be shocked as touching the submerged vehicle.

Hydrogen venting position

Incidents involving fire

If FECV is involved in a fire, follow the procedures below. Use the fire extinguisher in the luggage room for small fire. If the fire is too big to extinguish, pull back a safe distance and call to fire department. Keep away from the vehicle until the fire is completely out.

Emergency Venting of Hydrogen in a Fire

If tank pressure abnormally rises up caused by a fire or other reasons, the safety valve triggered by temperature controls the release valve to vent the hydrogen gas from tank to the atmosphere.

This event is characterized by a "hissing" sound, which is the sound of the hydrogen rapidly venting from the vent orifice. At this time, stay away from the ventilation area. This jet stream of hydrogen gas could be ignited.

Emergency Procedures(Continued)

General Treatment Procedure

In emergency cases, it's very important to confirm whether the hydrogen gas leak exists or to prevent the current flowing in high voltage cable.

Operating EDS Button

It is possible to shut off the vehicle and its system as turning off EDS button in case of emergency. When EDS button is turned "off", all valves including hydrogen valves and high voltage components would automatically cut off immediately.

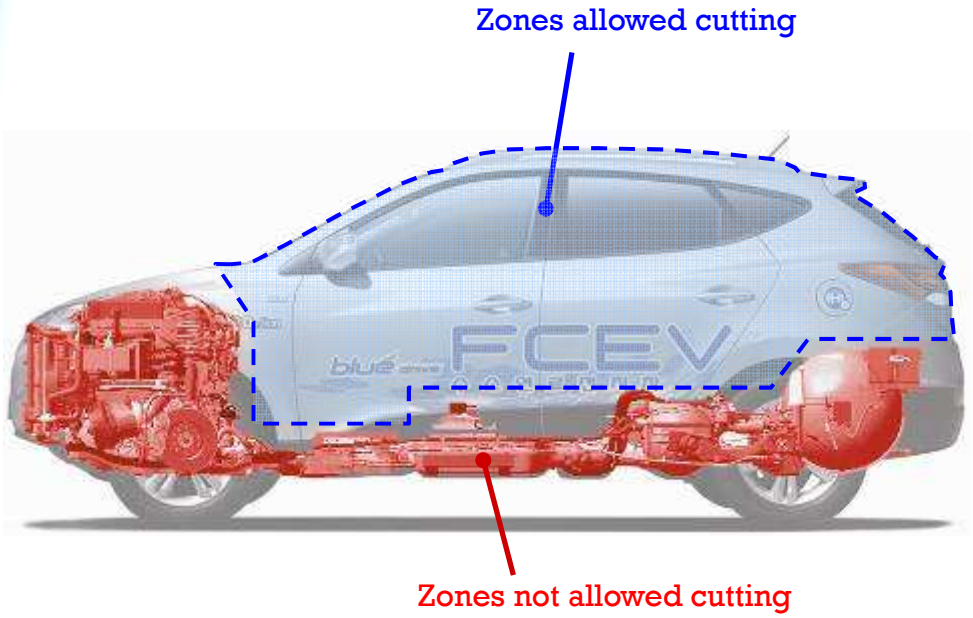
Ignition Key Off

A first step to prevent a hydrogen and current leak in the vehicle is to turn off "ignition key". It is possible to shut off supplying hydrogen and air to the fuel cell stack automatically and immediately as turning off "ignition key". This could prevent flowing the current into the high voltage cable. However, it is better to release EDC button in case of emergency such as a fire.

Disconnecting the negative (–) terminal of 12V Battery

A best way to prevent a hydrogen and current leak in the vehicle is to disconnect negative (-) terminal of 12 V battery. It is also a best way to reduce a secondary damage in case of fire caused by submerging and electrical short.

Vehicle's Cutting Area for Emergency Escape



WARNING

If a vehicle cutting is required to evacuate passengers in emergency case like a car accident, it is entirely required that all high voltage systems and hydrogen supply system should be blocked.

1) It is a safe way to remove the battery safety plug, and disconnect (-) terminal of battery. In addition to these, it is recommended to shut off the 12 V power supply. It is requested to be handled with care when cutting the orange-colored cables because it is high voltage supply lines.
2) Hydrogen supply lines are installed in the underneath the floor. For preventing an accidental damage of hydrogen supply lines, it is handled with care.
3) Electrical shock may occur when high or low voltage supplies are not shut off properly.

Luggage Room Equipments

Inside view of luggage room

Containing Box

Figure of TMK

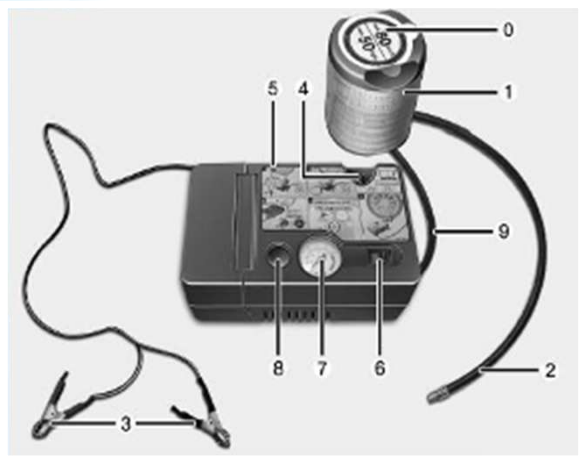
Fire Extinguisher

: A fire extinguisher is equipped at the left side of the luggage room. In case of fire, it is possible to use after removing the safety pin.

Tire Mobility Kit (TMK)

:The Tire Mobility Kit (TMK) is a portable compressor and tire sealant kit that allows drivers to stay mobile even after experiencing a tire puncture. The system of compressor and sealing compound effectively and comfortably seals most punctures in passenger car tire caused by nails or similar objects and re-inflates the tire. After you ensured that the tire is properly sealed you can drive cautiously on the tire up to 200 km at a maximum speed of 80 km/h in order to reach a vehicle or tire dealer to have the tire replaced. It is possible that some tires, especially with larger punctures or damage to the sidewall, cannot be sealed completely.

Luggage Room Equipments



Tire Mobility Kit (TMK)

0. Speed restriction label
1. Sealant bottle sealed by Hyundai dealership
2. Filling hose from sealant bottle to wheel
3. Connectors and cable for power outlet direct connection
4. Holder for sealant bottle
5. Compressor
6. On/Off switch
7. Tire pressure gauge for displaying tire inflation pressure
8. Releasing button for reducing tire inflation pressure
9. Connecting hose for compressor and sealant bottle or compressor and wheel

Using the Tire Mobility Kit (TMK)

Filling sealant bottle

1. Shake the sealant bottle.
2. Screw connection hose 9 onto the connector of the sealant bottle.
3. Ensure that button 8 on the compressor is not pressed.
4. Unscrew the valve cap from the valve of the defective wheel and screw filling hose 2 of the sealant bottle onto the valve.
5. Insert the sealant bottle into the housing of the compressor so that the bottle is upright.
6. Ensure that the compressor is switched off, position 0.
7. Connect between compressor and the vehicle power outlet using the cable and connectors.
8. With the engine start/stop button positioned on: Switch on the compressor and let it run for approximately 3 minutes to fill the sealant. The inflation pressure of the tire after filling is unimportant.
9. Switch off the compressor.
10. Detach the hoses from the sealant bottle connector and from the tire valve. Return the Tire Mobility Kit (TMK) to its storage location in the vehicle.

Luggage Room Equipments / Vehicle's Towing

Distributing the sealant

11. Immediately drive approximately 3 km (2 miles) to evenly distribute the sealant in the tire.

Producing the tire inflation pressure

12. After driving approximately 3 km (2 miles), stop at a suitable location.
13. Connect connection hose 9 of the compressor directly to the tire valve.
14. Connect between compressor and the vehicle power outlet using the cable and connectors.
15. Adjust the tire inflation pressure to 230 kPa (33 psi). With the engine start/stop button positioned on, proceed as follows.
    - To increase the inflation pressure: Switch on the compressor, position I. To check the current inflation pressure setting, briefly switch off the compressor.

Emergency Towing

When a damaged or disable FCEV needs to be moved a short distance such as to the side of the road, and the vehicle is still able to roll on the ground, shift the transmission to "neutral" and then mutually push the vehicle. When the vehicle needs to be towed away from the area, the preferred method is by flatbed truck. To prevent vehicle's damage, front towing hook and rear tire should be fixed firmly on a towing car. Tucson ix35 FCEV is a front wheel driving car.

Front towing hook and rear tire should be fixed firmly on a towing car