Research Activities of HFCV in Korea

May 26 ~ 29, 2009

Ministry of Land, Transport and Maritime Affairs,

Korea Transportation Safety Authority

(Korea Automobile Testing and Research Institute)

In corporation with Hyundai Motor Company

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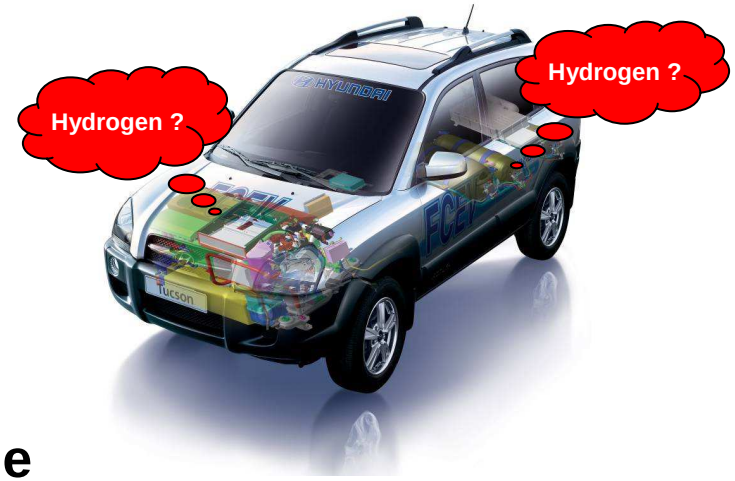
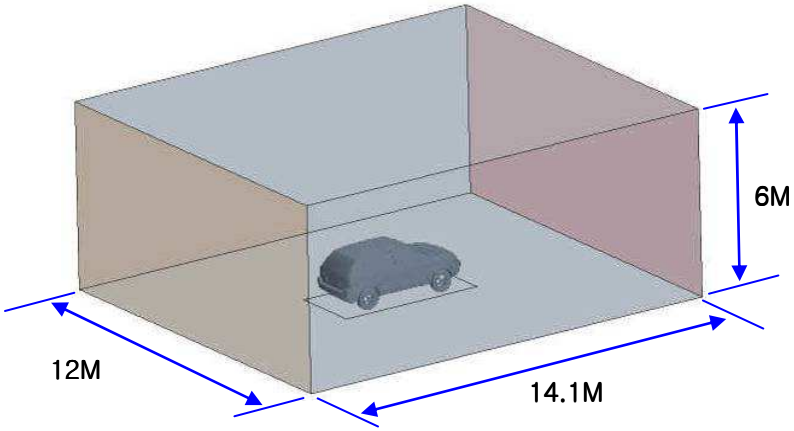
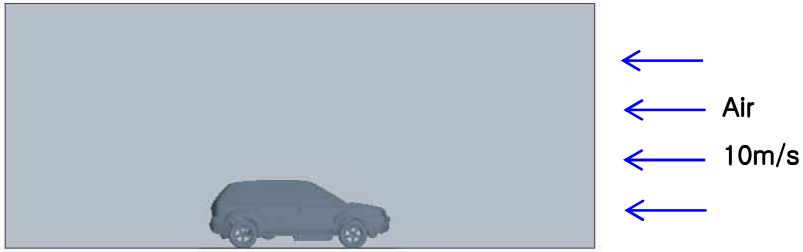
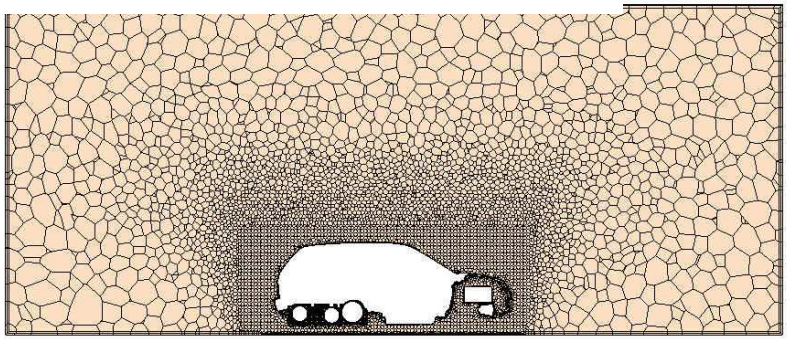


Hydrogen Leakage Test : Driving Mode

- ❑ Goal : Verification of single failure conditions
- ❑ Conditions
  - ▪ Driving speed : 36 km/h
  - ▪ Open space : 14.1 m x 12 m x 6 m
  - ▪ Leaking point : fitting area between high pressure fuel line and refilling line in the rear of vehicle
  - ▪ Leaking flow : 131 NL per minute
- ❑ Simulation Model
  - ▪ Tool : STAR-CCM+
  - ▪ Mesh : polyhedral mesh (1,060,000)
  - ▪ Turbulence model : κ-ε model
  - ▪ Steady-state analysis

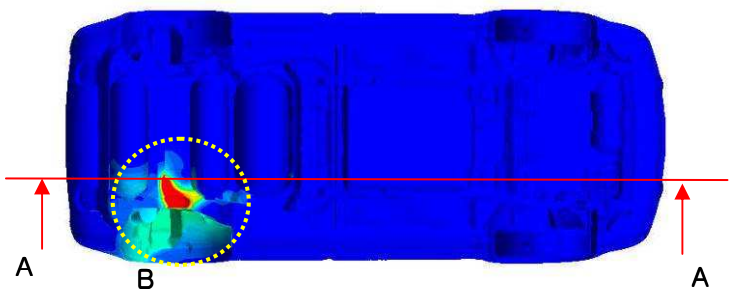




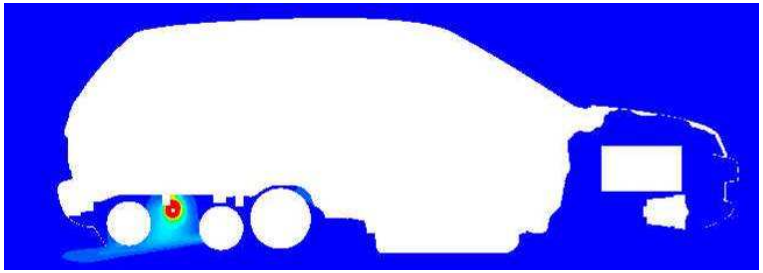


Driving Mode Simulation Results

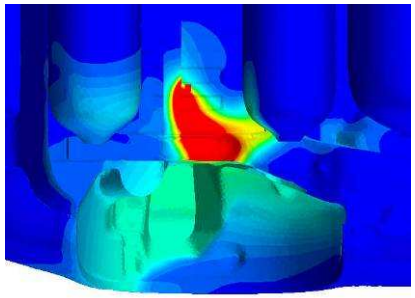
- Results
  - Hydrogen was diffused by outside air flow
  - Hydrogen concentration level over 4 % by volume in air is localized near leaking area



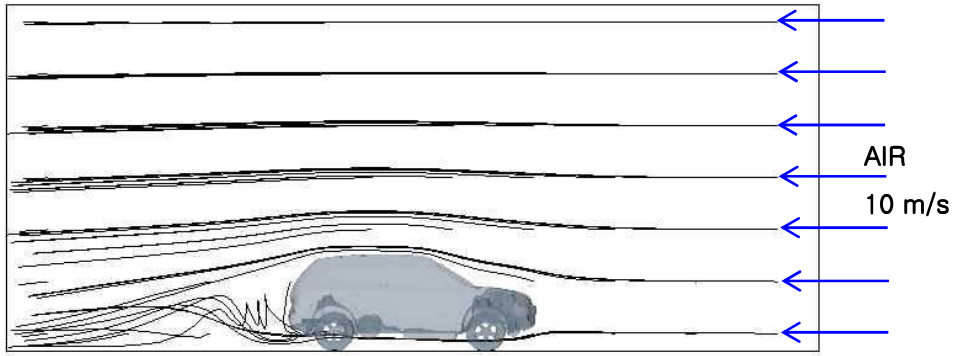
Vehicle underbody view



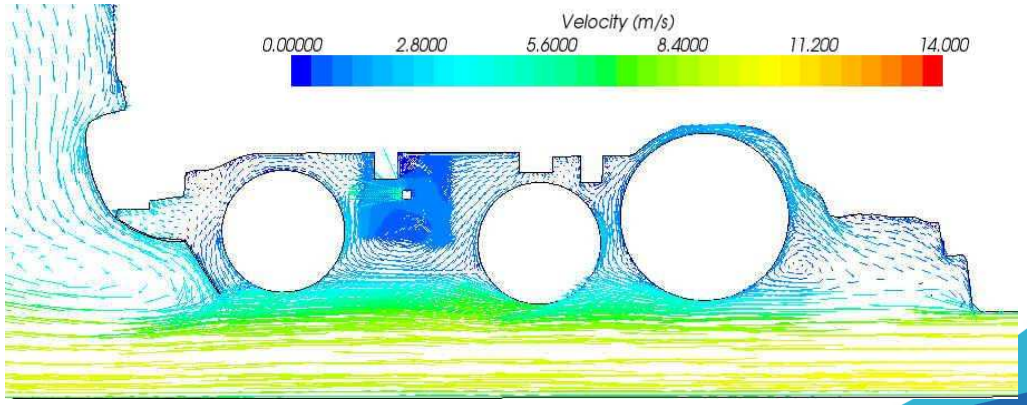
Section A-A



Detail of B



Air flow outside vehicle



Velocity profile near storages area

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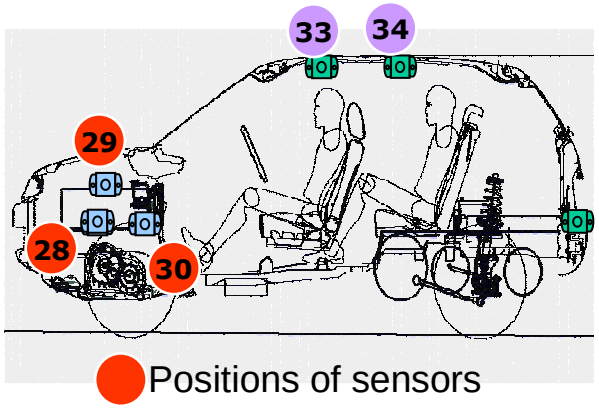
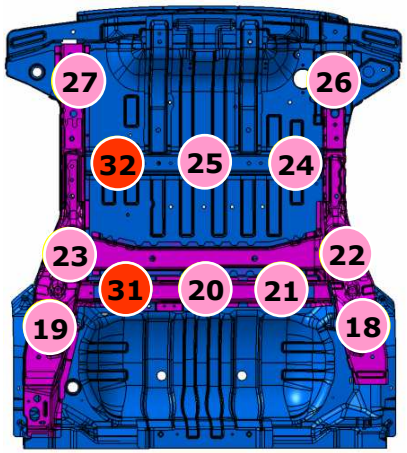
Stop Mode Test Conditions (1)

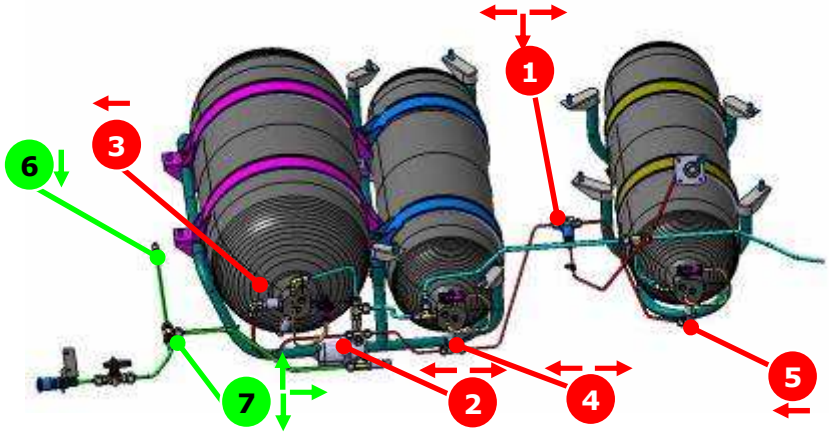
- Positions of hydrogen sensor

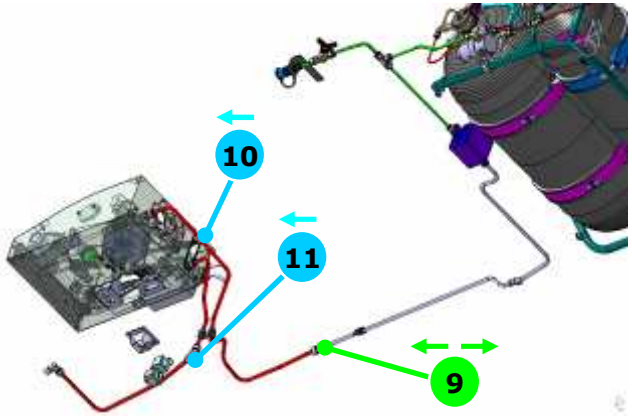




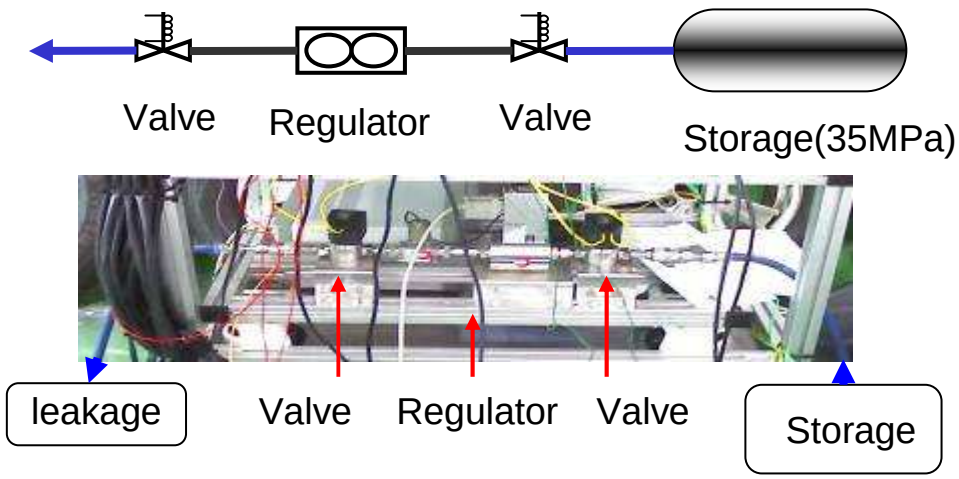
Positions of sensors (under flower)

- Expected hydrogen leaking points :
  - High(5)/low(4) pressure lines and engine room(2)





Stop Mode : Test Conditions (2)



Hydrogen leakage device

Single failure conditions test

- Conditions of hydrogen leaking flow
  - 10 NL per minute : low leaking mode
  - 40 NL per minute : max. leaking mode before activation of excess flow valve
  - 131 NL per minute : leaking limit in FMVSS 301

Hydrogen Leakage Test Results

- Driving Mode
  - Diffused rapidly due to wind flowing outside vehicle
  - Sensors did not detect leaking hydrogen except sensors near leaking area

- Stop Mode
  - Leaking hydrogen may enter into vehicle through holes on the bottom if hydrogen leaks underneath the body
  - Leaking hydrogen may enter into vehicle through running HFCV system if hydrogen leaks in engine room ➔ Preventive measure needed
  - Hydrogen continued to leak for about 10 seconds before shutdown after 2 % hydrogen was detected

  ➔ There were some area where hydrogen up to 4 % was detected before shutdown. But concentration dropped below 4 % within one minute

- Conclusions
  - Optimization of number of sensors and their locations is needed for effective detection depending on vehicle structure

  ➔ 2-3 sensors out of 5 sensors may be removed in case of HFCV SUV
  - Interior sensors should be considered for detecting hydrogen entering from outside

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Rear Impact Test (Fuel System Integrity)

- Goal : Verification of fuel system integrity

- Test Vehicle
  - Mock up fuel cell vehicle

BIW of HFCV

SUV

Mounted storages

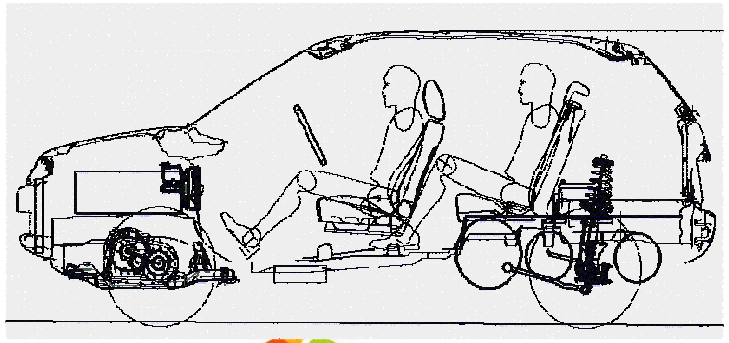
Sample vehicle

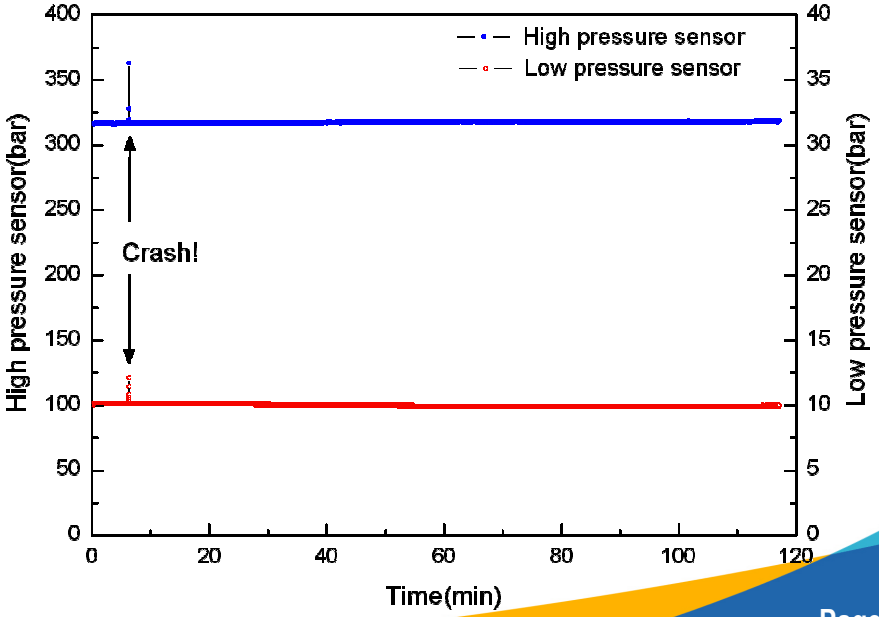
- Test Conditions
  - KMVSS article 91(FMVSS 305) : 48 km/h rear impact test
  - Filled with helium 90 % of normal working pressure
  - During the crash, opened storage valve (severe condition)
  - After crash test, evaluate hydrogen discharge

Rear Impact Test Results : Hydrogen Discharge

Side View	
Top View	

- After impact, no hydrogen discharge
  - High pressure sensor : 30 MPa
  - Low pressure sensor : 1 MPa





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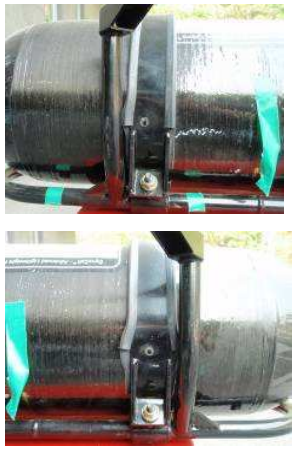
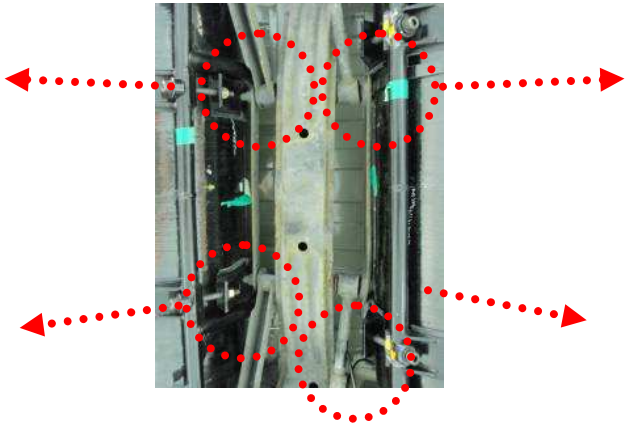
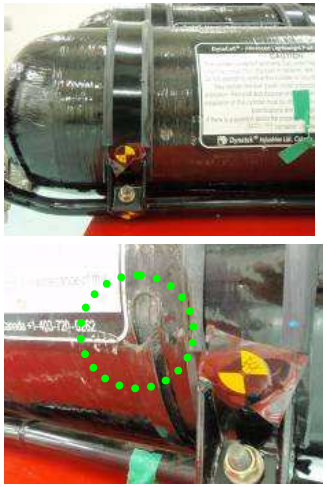
Rear Impact Test Results : Verification Test of Storage

- Verification Test of Storage
  - Storage was damaged due to deformation of suspension during impact
  - Verification test of damaged storage ➔ No noticeable degradation





Under body rear suspension



Damaged carbon fiber layers of storage

Verification test of damaged storage
➔ Passed after 11,250 cycling tests at 103 MPa

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Summaries

- Hydrogen Leakage Test (Single Failure Conditions)
  - Optimization of number of sensors and their locations is needed for effective detection depending on vehicle structure
  - In this particular model of HFCV SUV, some sensors are redundant
  - Interior sensors should be considered for detecting hydrogen entering from outside

- Rear Impact Test (Fuel System Integrity)
  - Exterior of storage was damaged due to deformation of suspension during impact
    ➔ No noticeable strength degradation after endurance test
  - No malfunction in other storage components
  - Impact absorbing structure should be devised

Thank you very much for your attention !

Acknowledgement

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