

SGS-10-08

DEVELOPING FIRE TESTS FOR FCV AND HYDROGEN VEHICLES

Glenn Scheffler

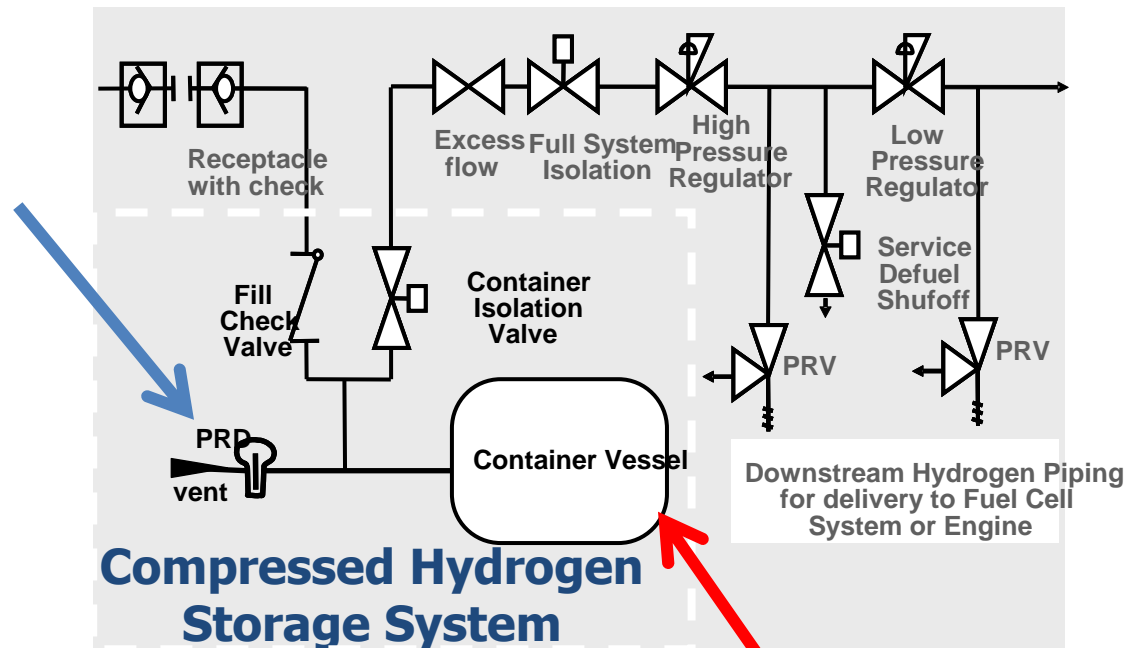
Consultant for the US Department of Energy

August 2010

Compressed Hydrogen Storage System (CHSS)

REQUIREMENT

The PRD needs to activate and vent contents during fires before the hydrogen container is weakened and bursts.



CONCERN

Localized fires can weaken the container before PRDs are activated.

OVERVIEW

- Transport Canada and NHTSA conducted research on localized fire test:
 - Phase I: Study on current fire safety standards for containers; vehicle fire characterization, localized fire profile and test procedures.

 - Phase II: Refined/simplified the test procedures and study on mitigation technology.

- The research data is being used by industry to formulate localized fire test requirements and procedures.
 - Defining the test article
 - Establishing the test conditions
 - Conducting the test

LOCALIZED FIRE TEST

Defining the Test Article

Two options are provided to the manufacturer for flexibility:

1. Generic (Non-specific) Vehicle Installation

- Allows only shields and features that are attached to the vessel or system
- Size of fire set to 250mm long, covering the full diameter
- Direction and location of fire set to maximize distance from PRD(s).

2. Vehicle-specific Installation

- Allows for thermal shields and features that are part of the vehicle
- Vehicle features may require reduction in generic fire size.
- Direction and location of fire based on the vehicle

LOCALIZED FIRE TEST

Establishing Test Conditions

- Vehicle fire tests conducted
 - By JARI and US manufacturers
 - Passenger vehicles, SUVs, and vans tested

- Different fires origins investigated
 - Passenger compartment
 - Trunk
 - Wheel wells
 - Pool fires beneath vehicle

- Representative localized fire test conditions were established based on data provided.

Vehicle Fire Test Configurations

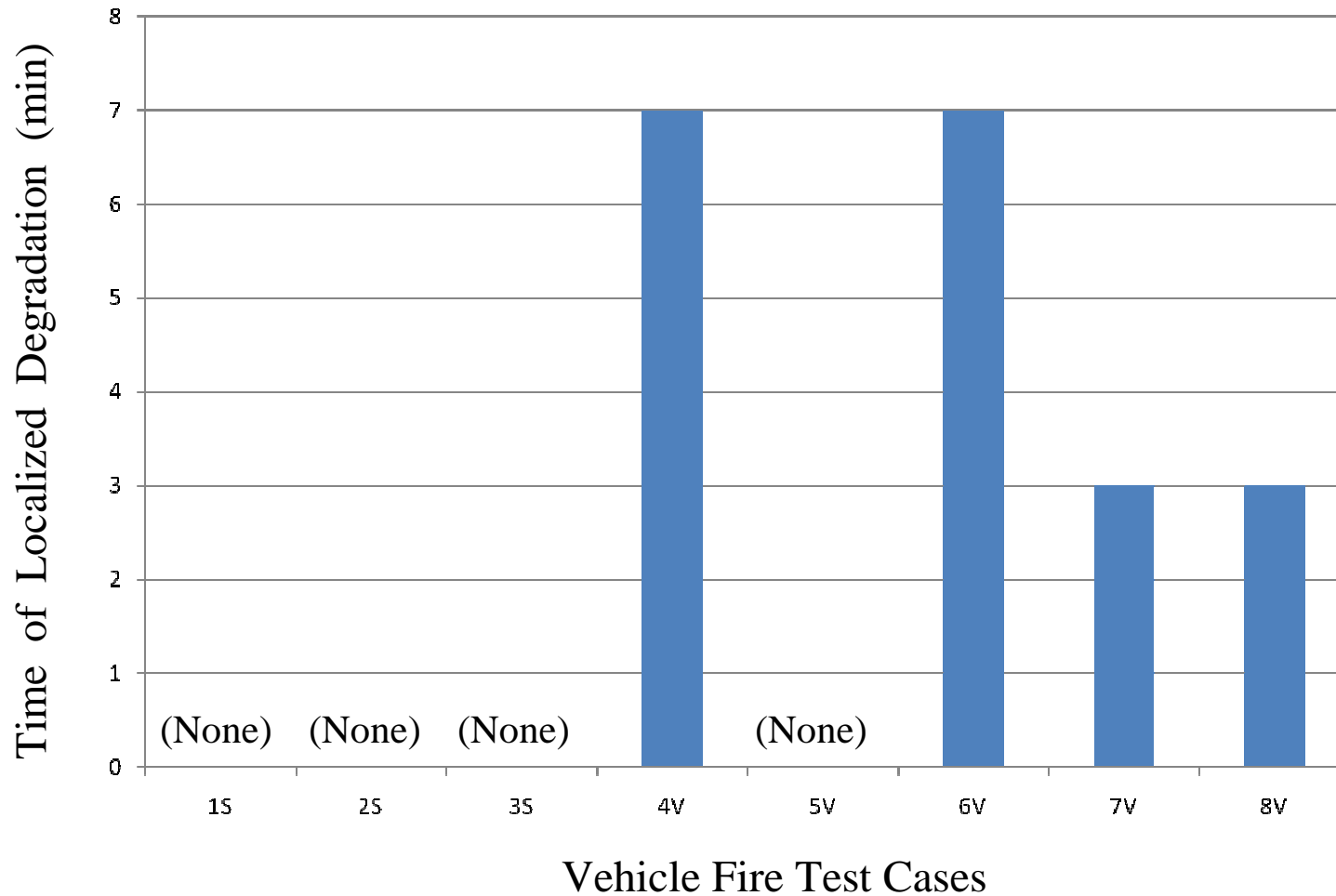
Case Number	Vehicle Type	Window Position	Fire Initiation Location	Container Location In Vehicle
1S	Sedan	Open	Cabin	In Trunk
2S	Sedan	Open	Trunk	In Trunk
3S	Sedan	Closed	Tire	In Trunk
4V	Van	Open	Cabin	Under Front Floor
5V	Van	Open	Cabin	Under Rear Floor
6V	Van	Close	Cabin	Under Front Floor
7V	Van	Close	Cabin	Under Rear Floor
8V	Van			

Key Findings from Vehicle Fire Tests

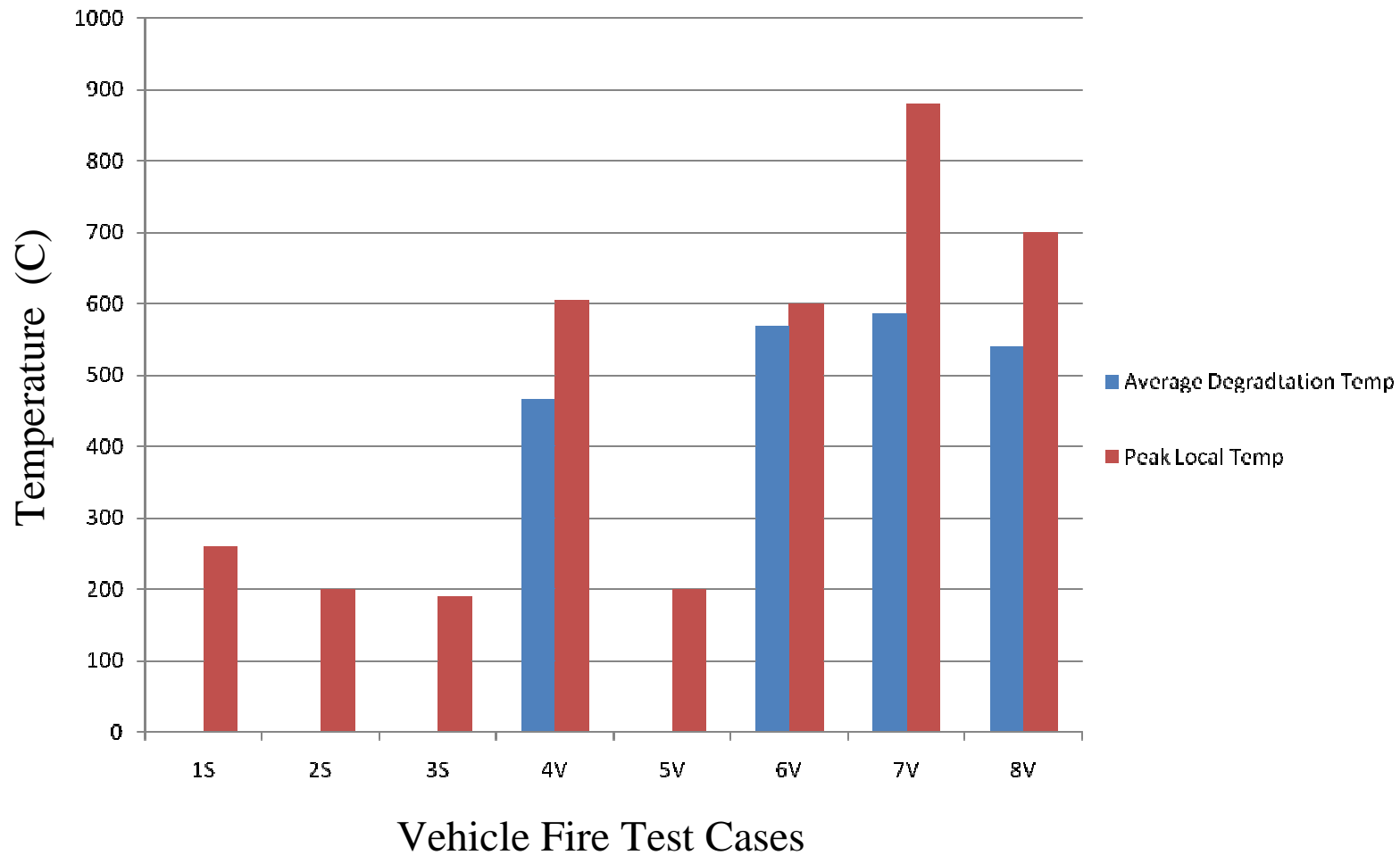
- 1) About 40% of the fires investigated resulted in localized fire conditions before conventional PRDs on end bosses would have activated.
- 2) While vehicle fires often lasted 30-60 minutes, the period of localized fire degradation on the storage containers lasted less than 10 minutes. See figure on next page.
- 3) The average maximum temperature during the localized fire period was less than 570°C with peak temperatures reaching approximately 600°C in 2 cases and 880°C in one case. See figure in two pages.
- 4) The rise in peak temperature near the end of the localized fire period often signaled the transition to an engulfing fire condition.

Time of Potential Localized Degradation

Based on degradation starting above 300°C on container and ending when end-boss PRDs activate



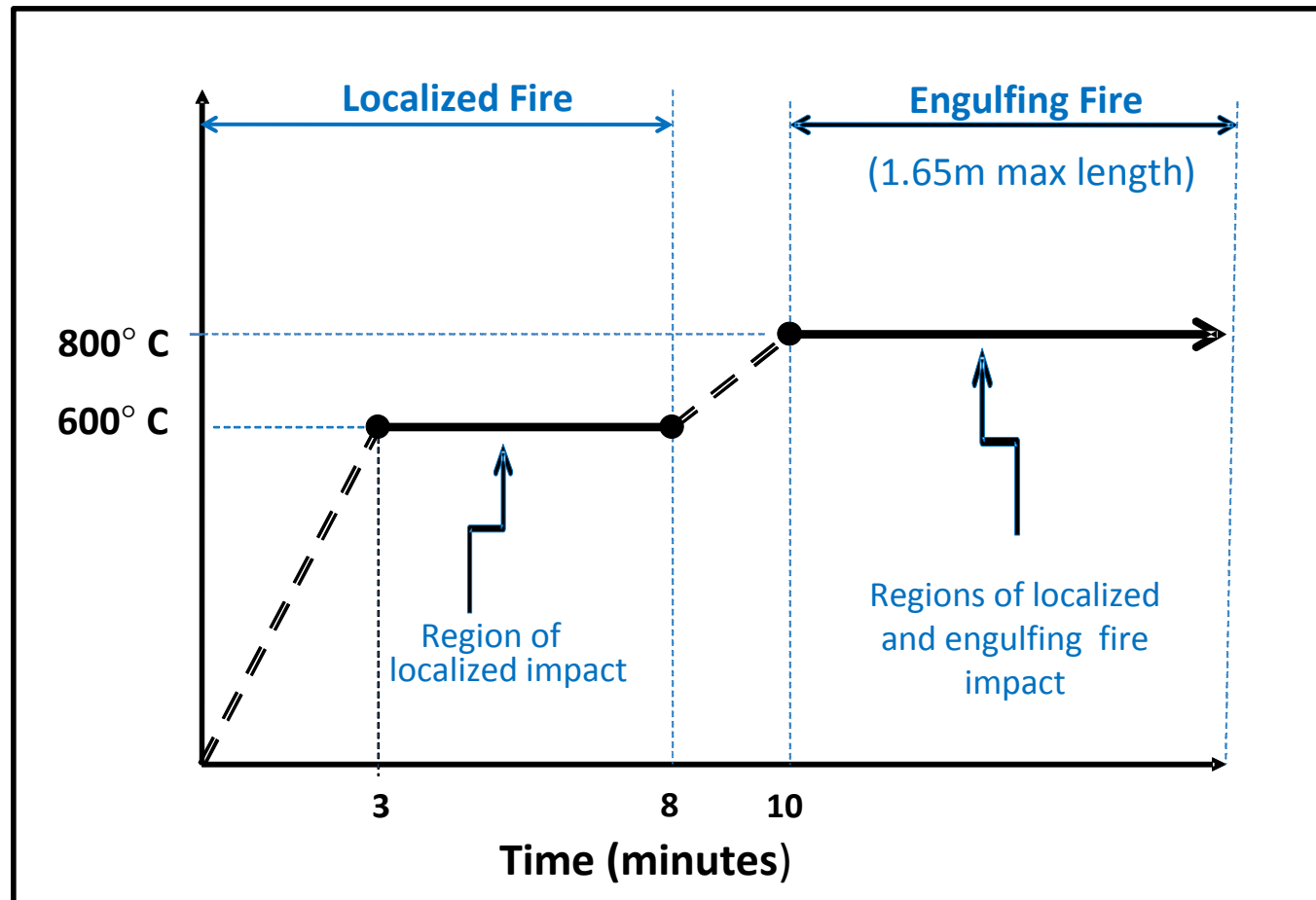
Average and Peak Temperatures During Localized Fire Degradation



Rationale for Constructing the Localized Fire Temperature Profile

- 8-10 minutes of localized fire exposure on the test article required to cover test experience.
- The selection of 600°C as the minimum exceeds the average localized temperature for all test cases.
- Given that test experience indicates the controllability of the fire will be approximately $\pm 100^\circ\text{C}$ in outdoor situations, the peak temperatures expected during the proposed test will also agree favorably with test results.

Minimum Temperature Profile being Considered for the Localized Fire Test



LOCALIZED FIRE TEST

Conducting the Fire Test

- LPG fuel selected for the test burner
 - Fast response
 - Provides controllability and repeatability
- The LPG burner for the localized fire region is lit.
 - The minimum temperature profile is followed.
 - Temperature in regions outside the localized fire are not specified and will vary naturally based on thermal characteristics of the container, thermal shields, and barriers.
- Test continues until the PRD activates. If necessary, the test progresses to the engulfing fire.
- Vessel burst (or significant leak) constitutes failure!

LOCALIZED FIRE TEST

Other Considerations

- The “standard” engulfing fire test is still required if vehicle-specific features are utilized for the new localized fire test.
- Verification needed of the test method.