SGS 4 - 14

Localized Fire Protection Considerations

Working together to improve Road Safety!

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Canada

H2 release from burning vehicle

Bonfire test of tank using LPG burner

Wood bonfire test of tank

Diesel fuel fire test of tank

Localized Fire Studies

This presentation reports on studies performed by Powertech Labs Inc. of Vancouver, Canada under the following Transport Canada contracts:

- High Pressure Cylinder – Lessons Learned Study
  - Completed March 31, 2007
- Localized Fire Protection Considerations
  - Complete Fall 2008

CNG Vehicle Fire Experience

- **Single largest cause of CNG vehicle tank failures is fire**
  - Since 1980 some 40 failures from all causes - 13 by fire
  - Since 2000 some 21 documented CNG failures – over 50% by fire

    (other failure causes are being corrected over time)
- **Fire failures caused by:**
  - Absence of any PRD
  - Use of pressure-activated PRDs
  - Use of PRDs in solenoid valve (slow reaction time)
  - Localized fire source
- **PRD problems being (absence of PRDs, or use of designs that require pressure-activation) largely corrected**
  - Localized fire now single leading cause of fire failures

CNG Vehicle Fire Issues – Localized Fire Examples

- December 2007 (Korea) rupture of OEM transit bus tank
  - Fire on tank end opposite PRD
- March 2007 (Seattle) rupture of Honda OEM car tank
  - Fire from passenger compartment burned through back seat and impinged on tank sidewall (remote from PRD location)
- November 2005 (Bordeaux) rupture of OEM transit bus tank
  - Fire through roof vent impinged on tank sidewall (remote from PRD location)
- May 2003 (Saarbrucken) rupture of OEM transit bus tank
  - Fire on tank end opposite PRD

Pressure Relief Devices

- The response time and reliability of PRDs has increased dramatically since the mid-1990s; however,
  - In bonfire tests, PRDs typically activate only when they are in the fire
  - PRDs only activate outside of a fire when the heat is intense and in close proximity (within cms)
- The 1.65m bonfire test length currently specified in standards is purely arbitrary
  - No automotive or technical rationale

Transport Canada Study Objectives

- Review existing research on vehicle fires
- Summarize localized fire test conditions on-board vehicles
- Defined a localized fire test procedure
- Construct and test a localized fire test apparatus
- Propose changes to installation codes that would prevent localized fire effects

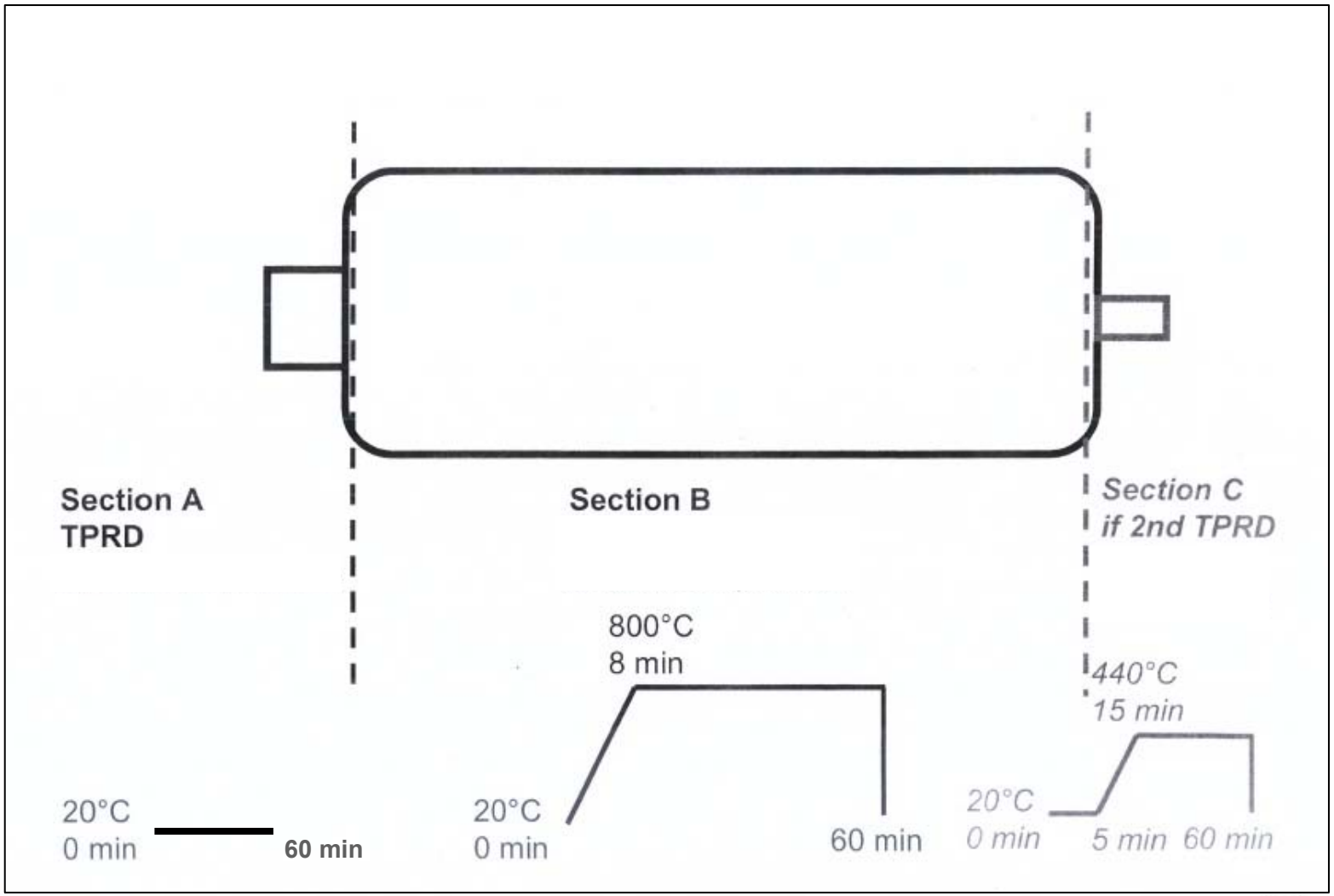
Review of Existing Research on Vehicle Fires

- Fire test studies of liquid-fuelled vehicles provided supporting time and temperature data
  - Considered gasoline vehicles, fire initiation conditions (e.g.crash-induced fires), fire dimensions, flame intensity/temperature, fire propagation behavior
  - Localized fire can occur due to gasoline pool fire, passenger compartment fire, tire fire
- Limited studies available involving hydrogen vehicles
  - Confidential OEM test data was provided, giving time and temperature profiles for compartments containing hydrogen tanks
- All above data used to support the development of a localized fire test procedure

OEM Vehicle Fire Data

- From data, concluded that tanks would typically experience the following:
  - High temperature in the centre section (800°C)
  - Medium temperature at one end (440°C)
  - Low temperature at the opposite end (ambient)
- Medium temperatures would only start developing at one end some 5 minutes after heating of centre
- PRDs typically located at one end of a tank – is it the right end in a fire?

Proposed Localized Fire Test – Temp/Time Profiles



Localized Fire Test Method

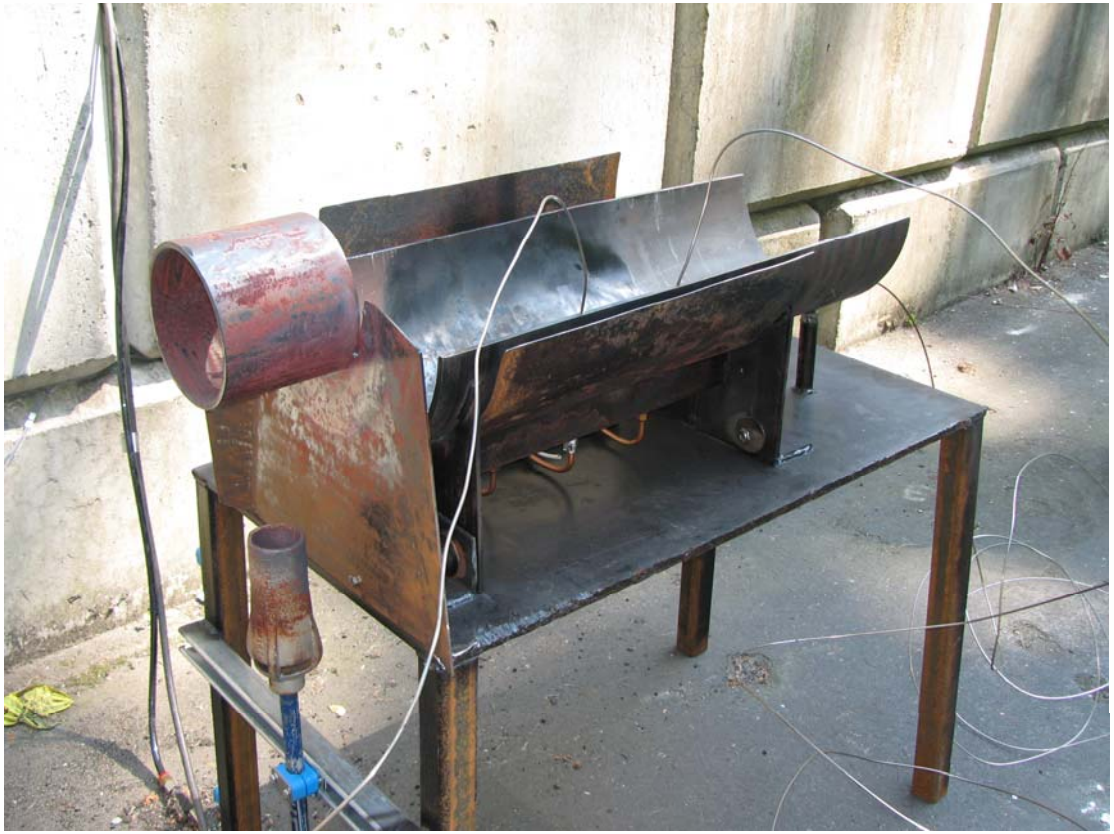
- Need a repeatable method that achieves and maintains certain constant temperatures within a given time
- “Hot plate” test method developed
  - Tank centre sits in contact with a curved steel “cradle” (high temperature)
  - One tank end sits in contact with separate steel “cradle” (medium temperature)
  - Opposite tank end in open air (low temperature)
- Central cradle heated by oxy-LPG flame & end cradle heated by separate LPG torch
  - Oxy-LPG required to heat steel to 800°C within 8 minutes

Hot Plate Design – Test

Hot Plate Design - Features

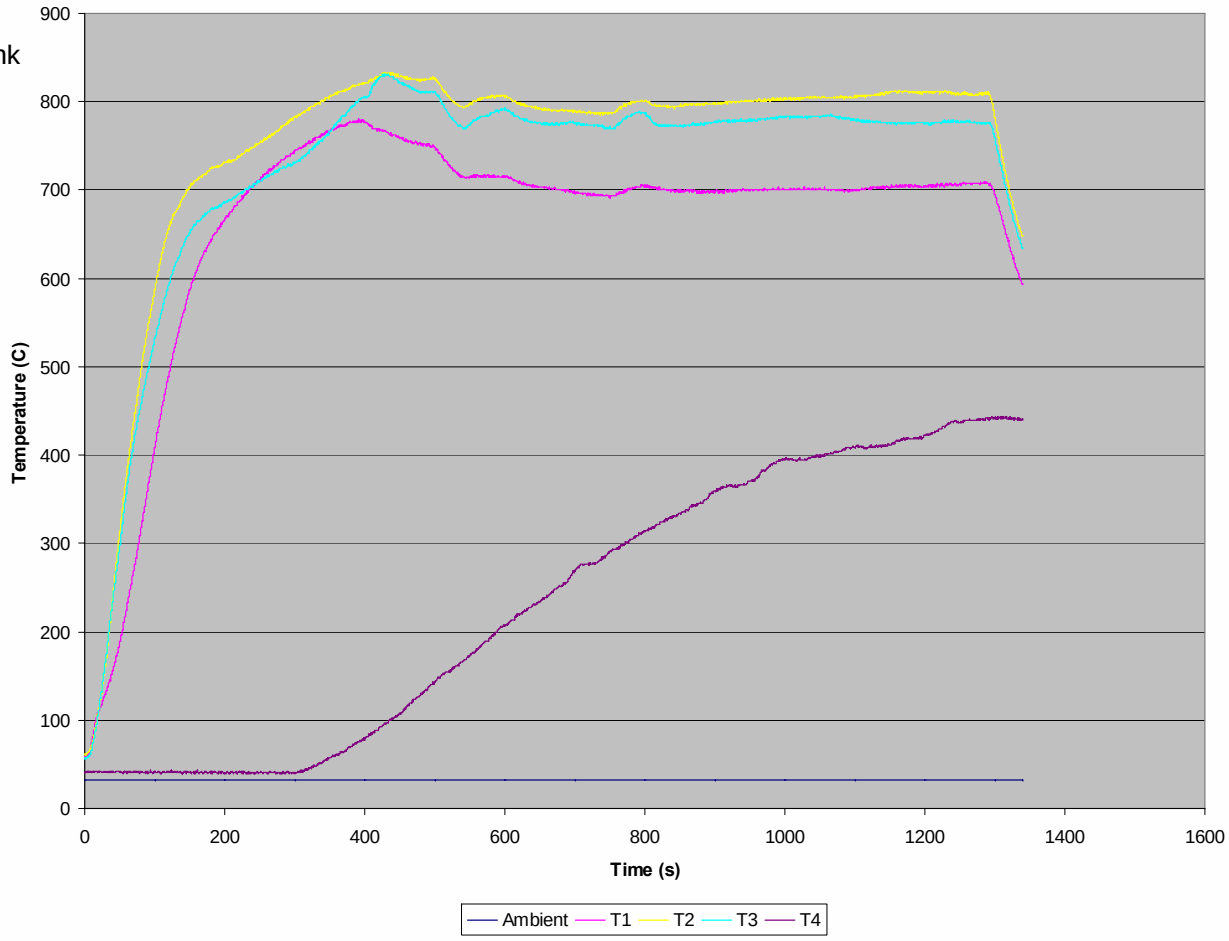
- Steel cradle provides temperature control vs use of open flames or hot gases
  - Hot gas temperatures easily affected by thermal mass of tank
  - Temperature control +/- 5ºC has been demonstrated
  - Keeps the temperature away from the ends
- Valve/PRD end can be tested in either medium temp or low temp position
- Hot plate" not only method that can be used - any test method that meets the temperature/time profile is acceptable
  - The temperature/time profile assures consistent test results between Test Labs

Localized Fire Test Method - Hot Plate Apparatus



Hot Plate Temperature / Time Profiles

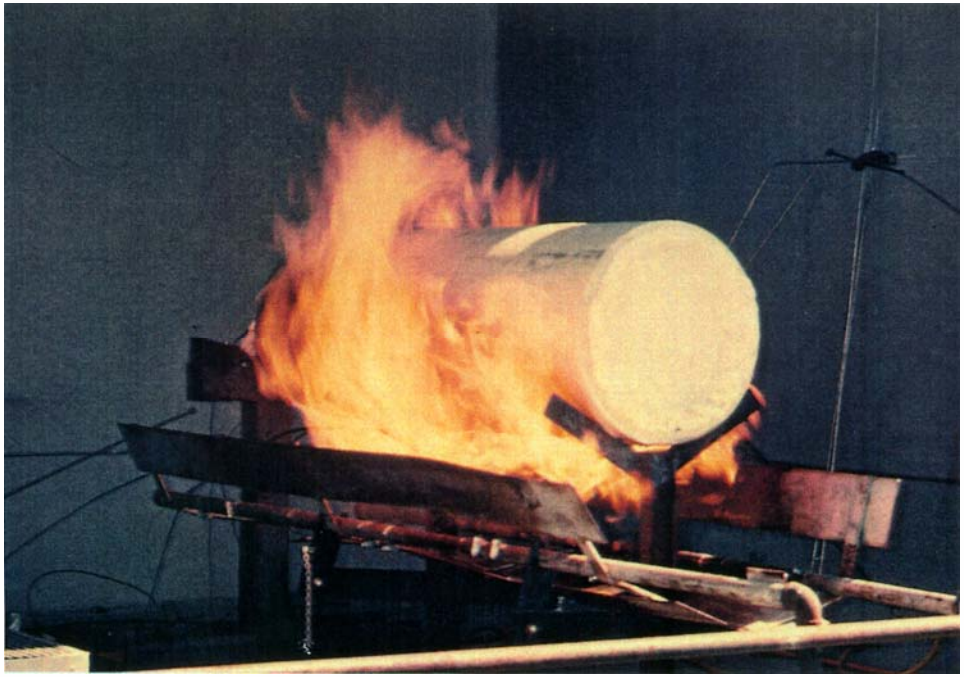
- T1, T2, T3 are temperatures along base of tank centre
- T4 is temperature on one end of tank
- Ambient is temperature at opposite end of tank



Follow-on Study Objectives

- DOT-NHTSA contract signed With Powertech Labs Inc. early September to continue localized fire studies (4 months to completion)
- Objectives:
  - Evaluate fire resistance of various coatings and insulating materials (includes testing on pressurized tanks)
  - Evaluate the use of remote heat sensing technologies to activate PRDs
  - Perform a localized fire test on an OEM fuel system currently protected using a proprietary insulating coating
  - Provide recommendations for standards regarding fire test requirements

Insulating Coatings Studies



Fire test of coating material

Thin low cost insulating materials are available

Bonfire Test of Thermal Protective Coatings (illustrates fire protection method without PRDs)

- 1994 study performed by Powertech on 6m long CNG cylinder
  - 6 mm thick aluminum oxide wrap – 1.65m long fire
  - 45 minutes in fire, composite temperature only reached 100°C

Set-up for bonfire test using LPG burner

Illustrates heat discolouration to wrap

Arigatō!

- Questions?
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