CSA Standards

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CSA Standards HPRD1-2009

Temporary Interim Requirement For

Pressure Relief Devices For Compressed Hydrogen Vehicle Fuel Containers

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HPRD1 Hydrogen Service Suitability

5.6 General Hydrogen Service Suitability

5.6.1 General.

The purpose of this test is to demonstrate suitability of pressure relief devices in hydrogen service. The pressure relief devices will be selected to be in compliance with Section 5.1 and representative of normal production.

NOTE: This series of performance tests may not guarantee that all cases and conditions of service will be validated; it is still incumbent on the designer/builder to carefully screen materials of construction for their intended use.

Test Method. The general hydrogen service suitability test sequence will be performed on nine devices.

a) Nine pressure relief devices are to be subjected to at least 250 hours of hydrogen exposure at 95°C (203oF) or the Accelerated Life *Test Temperature* defined in Section 5.3.3, whichever is lower. The devices shall be placed in an oven or liquid bath with the temperature of the specimen(s) held constant within ± 1°C (± 1.8°F) throughout the test. The gaseous hydrogen pressure in the pressure relief device for the duration of the test shall be 125 percent of the manufacturer's specified service pressure ±7 bar (±100 psi).

b) The nine pressure relief devices shall then be subjected to 10,000 hydrogen cycles between not less than 80 percent of the manufacturer's specified service pressure and not more than 25 percent of the manufacturer's specified service pressure. The test setup must start with the dead volume of the device exposed to hydrogen at not less than 80 percent of the manufacturer's specified service pressure at -40°C ± 1°C (-40oF ± 2°F) . Prior to cycling, the samples shall be cooled to -40°C ± 1°C (-40oF ± 2°F). The cycling rate shall not exceed ten cycles per minute and the hydrogen test temperature cannot be greater than -39°C (-38oF) at any time during the test. If the hydrogen test temperature exceeds -39°C (-38oF) the cycle rate of the test must be reduced.

The hydrogen pressure cannot be removed from the pressure relief device for more than four hours between tests.

c) The nine pressure relief devices shall then be subjected to five cycles of hydrogen between 150 percent of the manufacturer's specified service pressure ±7 bar (±100 psi) and 25 percent of the manufacturer's specified service pressure ±7 bar (±100 psi) at ambient temperature. The cycling rate shall not exceed ten cycles per minute.

d) Following these tests, each pressure relief device shall meet the requirements of Section 5.9 *Leakage* and Section 5.10 *Bench Top Activation*.

R&D Project Requested by HPRD1 TAG

- September 2009 RFQ issued by NREL
- Awarded to Powertech November/December 2009
- R&D Objective
  - Validation of proposed test method for hydrogen service suitability and confirm that proposed test method will identify non-conforming product
- Rationale:
  - No existing component level standardized method to evaluate suitability for hydrogen service
- TASKS
  - Conduct draft test using 70MPa hydrogen PRD's
  - Conduct draft test using surrogate PRD's manufactured of materials expected to have poor performance in a hydrogen environment
  - Conduct Post test metallurgical evaluation
  - Issue final report to CSA PRD1/HPRD1 TAG

HPRD1 Hydrogen Service Suitability Validation Testing

- Powertech contracted to validate the test methodology of the Hydrogen Hydrogen Service Suitability Test in HPRD1
- Testing will include:
  - 3 “good” PRD designs
    - one eutectic designs
    - one glass-bulb design 700bar PRDs
    - One same as “bad” deisgn but with SS316
  - 1 “bad” PRD design (expected to demonstrate failure mode)
    - Custom design
    - Carbon Steel with UTS of 950 MPa (yield to tensile ratio less than 0.9)
    - Simple piston design with a eutectic puck not exposed to service gas
    - Wall thickness equivalent to burst pressure of production design

HPRD1 Hydrogen Service Suitability Validation Testing

- May 2010
  - Custom built designs validated for pressure rating and stress ratio
  - Testing program initiated
  - Preliminary results will be provided to HPRD1 TAG
- June 2010
  - Anticipate final testing results report
- August 2010
  - HPRD1 TAG review and incorporation of results into the HPRD1 document

Open Topics

- PRD Reliability
  - Statistical analysis of the historical records of PRD failures
  - Validation of HPRD1 Model and Test for Long Term Creep
  - Modified form of the HPRD1 Benchtop Activation Design Qualification Test for Use in PRD Activation Reliability Testing

  Other Topics under consideration:

  - Corrosion Resistance Design Qualification
    - Replacement of the salt spray test for under vehicle exposure only
    - Based on cyclic exposure (temperature, humidity and salt exposure)
    - Implemented in HGV2, HPRD1 And HGV 3.1

Future Topics

- Other Topics under consideration:
  - Corrosion Resistance Design Qualification
    - Replacement of the salt spray test for under vehicle exposure only
    - Based on cyclic exposure (temperature, humidity and salt exposure)
    - Implemented in HGV2, HPRD1 And HGV 3.1

- Ozone Exposure
  - Addition of test for exposure for elastomeric materials only
  - Proposal is to harmonize with the European CNG requirements (ECE R110): ISO 1431/1, ASTM D1149, or equivalent test methods
  - Implemented in HGV2, HPRD1 And HGV 3.1

THANK YOU!