

December 20, 2011

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UL 2262A

OUTLINE OF INVESTIGATION
FOR
BOROHYDRIDE FUEL CARTRIDGES WITH INTEGRAL FUEL PROCESSING
FOR USE WITH PORTABLE FUEL CELL POWER SYSTEMS OR SIMILAR
EQUIPMENT

Issue Number: 2

DECEMBER 20, 2011

Summary of Topics

This is the second issue of the Outline of Investigation for Borohydride Fuel Cartridges with Internal Fuel Processing For Use With Portable Fuel Cell Power Systems or Similar Equipment.

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INTRODUCTION

1 Scope

1.1 These requirements cover disposable borohydride compound fuel cartridges with integral fuel processing for use with portable fuel cell power systems or similar equipment that use gaseous hydrogen from the cartridge. The fuel contained within the cartridge consists of a sodium or potassium borohydride formulation, or a mixture of these formulations, which have been shown to be UN Class 8 (Corrosive) materials. The compounds, in liquid state are processed through a chemical reaction within the cartridge that results in hydrogen gas (for use as a fuel) and borate solution (waste material stored in the cartridge until disposal).

1.2 These requirements also cover cartridges that contain fuel consisting of UN Class 4, Division 4.3 (Water Reactive) borohydride compounds. The compounds, in solid state, are processed with the addition of water resulting in a chemical process that results in hydrogen gas (for use as fuel) and borate solution (waste material stored in the cartridge until disposal).

1.3 These requirements cover cartridges for use in portable fuel cells systems, but do not cover cartridges for use in equipment intended to be brought on board passenger aircraft.

1.4 The fuel cell cartridges covered by these requirements are for use in ambient temperatures that do not exceed 50°C (121°F) and whose internal pressures do not exceed 100 psig.

1.5 Federal regulatory requirements pertaining to the shipment of fuel cartridges are outside the scope of this Outline of Investigation.

2 Units of Measurement

2.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

3 References

3.1 Any undated reference to a code or standard appearing in the requirements of this Outline of Investigation shall be interpreted as referring to the latest edition of that code or standard.

4 Glossary

4.1 For the purpose of these requirements, the following definitions apply.

4.2 CATALYST – A substances such as a metal salt or acid that facilitates the production of hydrogen from the borohydride fuel.

4.3 CLASS 8 (CORROSIVE) – Materials classified in accordance with the UN Recommendations on the Transport of Dangerous Goods Model Regulations as Class 8.

4.4 CLASS 4, DIVISION 4.3 (WATER REACTIVE) – Materials which when exposed to water result in production of flammable gases are classified in accordance with the UN Recommendations on the Transport of Dangerous Goods Model Regulations as Class 4, Division 4.3.

4.5 FUEL – Any solution of sodium or other borohydride compounds with water and/or other specified additives, which is used to produce hydrogen through a chemical reaction between the borohydride compounds and water.

4.6 FUEL (CLASS 4, DIVISION 4.3) – Solid borohydride compounds that with the addition of water and other additives are used to produce hydrogen through a chemical reaction between the borohydride compounds and water

4.7 FUEL BY-PRODUCTS – Consists of borate solutions resulting from the production of gaseous hydrogen within the cartridge.

4.8 FUEL COMPONENTS – Various separate materials that the fuel is comprised of including solid borohydride compounds, water and additives.

4.9 FUEL PROCESSING CHAMBER – Chamber within fuel cartridge that contains the catalyst and where the chemical reaction that results in the production of hydrogen takes place.

4.10 IMPERMISSIBLE LIMITS:

IMPERMISSIBLE LEAKAGE OF FUEL – A release of fuel, fuel components, fuel by-products from the fuel cartridge that is visible and accessible.

IMPERMISSIBLE LEAKAGE OF HYDROGEN GAS – An unintended release of hydrogen gas from its containment system in the fuel cartridge that can result in a hydrogen concentration greater than 25% LFL. See 8.3.

4.11 RUPTURE – A tearing or breaking apart of an object due to a buildup of pressure, an impact, or other force or mechanism applied to the object.

4.12 TOOL – A screwdriver, coin, key, or any other object that is usable to operate a screw, latch, or similar fastening means.

4.13 VALVE – Component that controls the movement of hydrogen, fuel or fuel components.

CONSTRUCTION

5 General

5.1 Features of the product intended to limit the exposure of fuel and fuel components to users or inhibit the amount of fuel, or fuel components that can be leaked under normal and abnormal conditions shall be judged based on the design and corroborating evidence in the form of valid calculations, technical references and internal test data when determining the product's compliance to this Outline of Investigation.

6 Corrosive, Toxic and Flammable Material Containing Parts

6.1 Corrosive, toxic and flammable materials shall be kept within a closed containment system. The fuel cartridge shall be designed to prevent contact with fuel during fuel cartridge storage, when handling and during use. Polymeric structural or functional parts of the fuel cartridge (i.e. cartridge housing, polymeric interlock or guarding devices, valve bodies, etc.) shall have a minimum flame rating of HB as outlined in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.

6.2 Parts in contact with the fuel, fuel components, and fuel by-products shall be resistant to deterioration from those materials as determined by the applicable tests of Section 9.2 (non-metallic) or 13.2 (metallic). Metallic and non-metallic parts in contact with gaseous hydrogen shall be suitable for hydrogen use. Guidance can be found in Basic Considerations for the Safety of Hydrogen Systems, ISO/TR 15916. Non-metallic parts in contact with gaseous hydrogen, fuel or fuel components shall be suitable for the anticipated temperatures they encounter during use as determine by evaluation of the documentation of the materials and through the applicable elevated temperature tests of Sections 11 and 13. Elastomeric parts shall additionally be evaluated in accordance with 9.1.

6.3 Toxic, corrosive and flammable materials and liquid containing parts and their connections shall have adequate strength to withstand pressures that they are exposed to. Compliance is determined by the differential pressure tests of 12.

6.4 Connections between the fuel cartridges and applicable system and within the fuel cartridge itself shall be sufficiently leak tight as determined by the applicable tests of 11 – 13.

6.5 A filled fuel cartridge shall include provisions for any necessary expansion of fuel due to ambient temperature or pressure variations. Compliance is determined by the tests of Section 13.

6.6 There shall be no fuel and fuel component's leakage during connection and disconnection or during activation of the fuel cartridge. Cartridges shall be designed to prevent misalignment that would result in leakage of impermissible limits as defined in 4.10 during installation and removal of the fuel cartridge.

6.7 The fuel cartridge shall be designed for installation without the use of tools. The design of the fuel cartridge or the combination fuel cartridge and end use fuel cell application shall include features to prevent the inadvertent disconnection of the fuel cartridge during use.

6.8 The fuel cartridge shall be designed to reduce the risk of impermissible leakage of fuel during travel, normal storage, handling and when installed in the fuel cell power unit and when removed from the fuel cell power unit for disposal. Compliance shall be determined by the tests in this Outline.

6.9 The fuel cartridge shall be designed to prevent the uncontrolled mixing of fuel components during transportation, storage and use. The fuel cartridge shall be designed to prevent mixing of components that could result in a hazardous condition (i.e. hazardous heat build up, flammable or poisonous gas or vapor development not anticipated in the normal operation of the product). When components are present that could mix and form a hazardous condition the combination fuel cartridge and end use fuel cell application shall provide at least two independent means to prevent uncontrolled mixing of these components. Examples of these means include but are not limited to: positive activation by the control system; physical removal of an impermeable barrier preventing contact; opening of a normally closed manually controlled valve preventing contact. For at least one of these means for preventing uncontrolled mixing, it shall be necessary for the user to take positive action to remove or deactivate it prior to use. At least one means for preventing uncontrolled mixing of these materials shall be provided during use and storage after use. This means may include active control by system electronics, subject to the FMEA analysis of 7.1.

6.10 The fuel cartridge design shall reasonably prevent the entry of debris that may be present during the storage and usage of the fuel cartridge.

6.11 Accessible valves shall not inadvertently actuate during user handling that would result in fuel leakage. Compliance shall be determined in accordance with the Standard for Protection of Persons and Equipment by Enclosures - Probes for Verification, IEC 61032, and a force of 9.8 N, using test probe 2.

Note: Test Probe 2 is referred to as the IEC articulate finger.

6.12 Pressure relief valves and rupture discs shall be constructed and marked in accordance with the ASME Boiler & Pressure Vessel Code Section VIII Part 1. Pressure relief devices that are outside the scope of ASME shall be suitable for the application as determined by the material requirements of Section 6 and the Start to Discharge test of 14.1.

7 Hazard Analysis

7.1 A Failure Modes and Effects Analysis (FMEA) or equivalent reliability analysis shall be conducted by the manufacturer to identify faults which have safety related consequences and the design features that serve to mitigate those faults. This analysis shall include failures that may result in an impermissible leakage of fuel in accordance with 4.10.

7.2 The Hazard Analysis shall be a consideration for determining specific abnormal tests performed in Abnormal Operations, Section 10.1.