



WORKING PAPER

**DANGEROUS GOODS PANEL (DGP)
MEETING OF THE WORKING GROUP OF THE WHOLE**

Atlantic City, United States, 4 to 8 April 2011

Agenda Item 2: Development of recommendations for amendments to the *Technical Instructions for the Safe Transport of Dangerous Goods by Air* (Doc 9284) for incorporation in the 2013-2014 Edition

2.4: Part 4 — Packing Instructions

2.8: Part 8 — Provisions Concerning Passengers and Crew

INTERNATIONAL ELECTROTECHNICAL COMMISSION SPECIFICATION FOR MICRO FUEL CELLS USING WATER REACTIVE FUELS

(Presented by Fuel Cell and Hydrogen Energy Association (FCHEA))

SUMMARY

This paper provides information on a new IEC Specification for micro fuel cell safety using water reactive fuels.

Action by the DGP-WG is in paragraph 3.

1. INTRODUCTION

1.1 The *Technical Instructions for the Safe Transport of Dangerous Goods by Air* (Doc 9284) allows fuel cell systems, fuel cell cartridges and fuel cell powered devices to be transported by air and to be carried on board passenger aircraft and to be carried by passengers as checked baggage with fuel cells and fuel cell cartridges using the following types of fuels:

- a) flammable liquids
- b) corrosive substances
- c) liquefied flammable gas
- d) water reactive substances (carry-on only)
- e) hydrogen in metal hydride

1.2 The Technical Instructions make conformance to International Electrotechnical Commission (IEC) Publicly Available Specification (PAS) 62282-6-1 Fuel cell technologies — Part 6-1: Micro fuel cell power systems – Safety, mandatory for fuel cell systems, cartridges and fuel cell battery interaction under the provisions for dangerous goods carried by passengers or crew, Part 8;1.1.2 t). Similar requirements are also applicable to cargo transport on passenger aircraft of fuel cell cartridges and fuel cell systems when transported under packing instructions for fuel cell cartridges contained in equipment in Part 4 of the Technical Instructions.

1.3 IEC Publicly Available Specification (PAS) 62282-6-1 Fuel cell technologies –Part 6-1: Micro fuel cell power systems – Safety covers specifically the following fuel types:

- a) methanol or methanol and water solution (or methanol clathrate compound)
- b) formic acid and water solution (<85% formic acid by weight)
- c) hydrogen stored in hydrogen absorbing metal alloy
- d) borohydride compounds (water reactive solid fuels must have at least 70% borohydride compounds); (borohydride compounds include sodium or potassium borohydride, or a combination of both)
- e) butane (at least 75% butane by mass)

Other specific formulations must be certified to meet IEC PAS 62282-6-1 using a method allowed by IEC PAS 62282-6-1 called “Equivalent Level of Safety” whereby the differing formulation must be evaluated as to their ability to yield levels of safety equivalent to those prescribed by the Specification. Such a process may be less straightforward than following a published specification that allows for additional international peer review and consensus building. For this reason, among others, the industry has chosen to publish a new specification to include a broader scope of water reactive substances that produce hydrogen.

1.4 The fuel cell industry has investigated and developed fuel cell fuels using a variety of hydrogen producing water reactive substances that meet the definitions in Part 8 of the Technical Instructions (i.e. “Water Reactive Substances”) but do not meet the specific formulations covered by IEC PAS 62282-6-1. In order to have a published document available to cover new fuel cell technologies being introduced into the market sooner than a revision to the existing standard can be published, the fuel cell industry has worked within the International Electrotechnical Commission to publish a new Specification, IEC PAS 62282-6-150. The purpose of this paper is to bring this new specification to the attention of the Working Group and ask for consideration of using this new specification as adequate proof of safety for certification of fuel cell cartridges and fuel cell devices using water reactive substances and ask for its inclusion in Part 8 and Part 4 of the Technical Instructions.

1.5 As changes like these are made to update the standards and specifications that cover fuel cell cartridges, fuel cells and fuel cell powered devices, the fuel cell industry will continue to keep the Dangerous Goods Panel apprised.

2. OVERVIEW OF IEC PAS 62282-6-150

2.1 Scope

- a) applies to fuel cells and fuel cell cartridges that use water reactive fuels producing hydrogen when activated by an aqueous solution.
- b) only applies to low voltage (<60 V d.c.) and low power (<240 VA) devices.
- c) only applies to solid water reactive fuels consisting of mixtures, alloys, compounds or chemical hydrides of the following materials:
 - 1) sodium
 - 2) magnesium
 - 3) borohydride compounds (sodium or potassium borohydride or a mixture)
 - 4) silicon
 - 5) silicon dioxide
 - 6) iron
 - 7) nickel
 - 8) cobalt
- d) only Division 4.3 water reactive compounds or formulations with no subsidiary risk are allowed.
- e) hydrogen must be the only gas evolved by the system.
- f) Compounds or formulations not permitted for transport by air are not allowed.

In general, all of the design, construction, marking and testing requirements are stronger than the corresponding requirements in IEC PAS 62282-6-1. The limits for leakage and emissions are more limiting. This results in more rigorous analysis and testing and requires additional detail to give guidance to the manufacturer and the testing personnel. This paper is intended to summarize the differences between IEC PAS 62282-6-1 and IEC PAS 62282-6-150. Since IEC PAS 62282-6-150 is a stand-alone document, additional text drawn from IEC 62282-6-100 has been added to provide clear guidance to the manufacturers and to those doing the analysis and testing of the fuel cell cartridges, fuel cell devices and their components.

2.2 General requirements

2.2.1 The general requirements of IEC PAS 62282-6-150 are essentially identical to the requirements of IEC PAS 62282-6-1 with additional requirements drawn from new work on IEC 62282-6-100 covered by another Working Paper being brought to the Working Group during these meetings. The general requirements include:

- a) A Failure Modes and Effects Analysis must be performed by the manufacturer and measures must be taken to prevent any credible risk of leakage, fire or explosion.
- b) No ignition sources are permitted where fuel is present or could be released.
- c) Flammable, toxic or corrosive materials must be kept within a closed containment system such as piping or a closed reservoir.

2.3 **Specific requirements**

2.3.1 Specific requirements for valves, piping, materials, resistance to corrosion, resistance to mis-connection, ignition sources, temperature limits, electrical and electronic components, and enclosures are essentially identical to the requirements for the same components and aspects of IEC PAS 62282-6-1. Fuel cartridges must be suitable for use from $-40\text{ }^{\circ}\text{C}$ to $+70\text{ }^{\circ}\text{C}$. The fuel cartridge must also be capable of holding 95 kPa internal gauge pressure plus normal working pressure at $22\text{ }^{\circ}\text{C}$ or two times the gauge pressure of the fuel cartridge at $55\text{ }^{\circ}\text{C}$, whichever is greater. Requirements to prevent mixing of incompatible materials are included where “Two independent means for preventing inadvertent or uncontrolled mixing of these materials shall be provided during transportation and storage prior to use”. Requirements for batteries now requires compliance with the applicable standards: IEC 60086-4, IEC 60086-5, IEC 62133, IEC 62281.

2.4 **Requirements drawn from IEC 62282-6-100**

2.4.1 Consistent with the changes made to move from IEC PAS 62282-6-1 to IEC 62282-6-100; design, construction, marking and testing requirements were strengthened and clarified throughout the standard and the limits for leakage and emissions were made more limiting. This results in more rigorous analysis and testing and requires additional detail to give guidance to the manufacturer and the testing personnel.

2.5 **Summary table of differences between limits in IEC PAS 62282-6-1 and IEC PAS 62282-6-150**

2.5.1 This table includes not only the changes, but also the most important testing limits for both IEC PAS 62282-6-1 and IEC PAS 62282-6-150. All of the relevant limits have been included for completeness. To note the changes, read from left to right on the same line. This summary is provided for the information of the Working Group. For the specific language, please refer to the documents directly. Copies of these documents will be provided upon request.

	IEC PAS 62282-6-1	IEC PAS 62282-6-150
Borohydride System Limits versus water reactive system limits	<p>No hazardous liquid leakage</p> <p>Hydrogen limits apply if hydrogen is generated.</p> <p style="padding-left: 40px;">0.016 g/h hydrogen limit from a single source.</p> <p>System cannot build up a 25% flammable mixture in 10 m³ volume with 1 air change per hour.</p>	<p>No hazardous liquid or solid fuel leakage</p> <p>Hydrogen limits:</p> <p style="padding-left: 40px;">Cartridge – Bubble tight</p> <p style="padding-left: 40px;">Internal reservoir – Bubble tight</p> <p style="padding-left: 40px;">Device off - 0.0032 g/h total</p> <p style="padding-left: 40px;">Device on - 0.8 g/h total, 0.016 g/h from a single source</p> <p>Connection - Bubble tight</p> <p>Water immersion testing ensures cartridge integrity following type testing.</p> <p>Operating, device off <i>and breathing zone</i> Emissions Limits for: Formaldehyde, CO, CO₂, and volatile organic carbon compounds.</p>

3. ACTION BY THE DGP-WG

3.1 The DGP WG is asked to add citations to IEC PAS 62282-6-150 in the Technical Instructions for the Safe Transport of Dangerous Goods by Air at Part 8, 1.1.2 t) 4) and t) 8), Provisions for Dangerous Goods Carried by Passengers or Crew, and in Part 4, Packing Instructions 496 for fuel cell cartridges contained in equipment.

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