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DANGEROUS GOODS PANEL (DGP)

MEETING OF THE WORKING GROUP OF THE WHOLE

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Agenda Item 2: Development of recommendations for amendments to the *Technical Instructions* for incorporation in the 2007/2008 edition
2.8: Part 8 - Provisions Concerning Passengers and Crew

FUEL CELL CARTRIDGES

(Presented by R. Richard)

1. INTRODUCTION

Micro fuel cells are expected to be introduced into the consumer marketplace in the very near future. Fuel cells have been used for decades aboard spacecraft and are a promising technology to someday be commercialized for automobiles. But the first commercial introduction of fuel cells to consumers is envisioned in 2005 with high tech electronic equipment such as laptop computers and hand-held devices that perform multiple tasks such as communications, computing and advanced video. Many companies are planning to produce fuel cell powered equipment that operates on methanol or methanol/water solutions. Fuel cells that operate on other fuels are expected to be available in the future.

Fuel cell developments now underway will result in small power units for use in consumer products such as cell phones and laptops which are currently powered by lithium ion batteries or other rechargeable batteries. Fuel cells have the advantage of being able to provide consumers with convenient, on-demand power anytime, anywhere, without the need to plug the device into an electrical outlet and have the potential to provide much longer run-times for portable consumer electronics.

A recent study projects that nearly 22% of all hand-held electronic devices with rechargeable power packs could be powered by Methanol Fuel Cells (MFCs) by 2011. Various companies have announced plans to start commercializing laptops powered by MFCs in 2005. Significant military applications of MFC are projected as early as 2006. Once fuel cartridges become readily available, it is expected that consumers will be able to purchase replacement cartridges at convenient locations (e.g. airport kiosks), allowing users to extend their runtime on demand.

Fuel Cell Systems:
How they work:

Fuel cells convert fuel and oxygen (from ambient air) into electricity through an electrochemical process without the need for combustion of the fuel. Protons and electrons are split at the fuel cell's anode and then combined at the cathode to produce electricity and water. The fuel is not burned, but rather is

converted into electricity through an electrochemical process. Fuel cells can convert fuel directly into electricity as long as fuel and air are supplied. This eliminates the need for "recharging" but necessitates the carrying of replacement fuel cartridges. These small replaceable and disposable fuel cartridges are installed into the fuel cell of the consumer device on an as needed basis. Using fuel supplied by a cartridge, the MFC produces electricity to power the consumer product by reacting oxygen and methanol inside the fuel cell.

In practice, a consumer will insert a small methanol fuel cartridge into a fuel cell power system to provide power, as illustrated in Figure 1. The consumer may choose to carry multiple fuel cartridges or buy additional units when needed, but there will be no need to carry electrical cords or adapters. Additionally, the consumer may remove and replace cartridges while the equipment's system is running.



Figure 1: Illustration of How a Consumer Would Operate a Consumer Product

Fuel cells vs. Batteries:

Fuel cells are similar to batteries in that they provide electrical power to portable products, but there are important differences.

Energy Storage:

MFCs do not store energy in the same way as rechargeable batteries. Fuel cell cartridges store energy for MFCs and are designed to avoid leakage or any other harmful situation. MFCs are designed to be safer than rechargeable batteries, which need many protective measures to avoid external short circuits, over charge, or over load.

Run Time:

MFCs provide higher total energy for a given size or weight, compared to batteries. Additionally, once the fuel is consumed, the fuel cartridge can be replaced while the system is running to continue to provide power. An MFC will continue to provide power as long as fuel and air are supplied.

Self-Discharge:

MFCs do not store energy internal to the cell and do not self-discharge during storage or periods of not being used. Batteries, on the other hand, tend to lose energy when stored (self-discharge). MFC systems can be stored indefinitely.

Short Circuit:

Unlike batteries, fuel cell cartridges are not susceptible to short circuits or the dangerous buildup of heat.

Fuel Cell Cartridge Design

Once fuel cartridges become readily available consumers will be able to purchase replacement cartridges at convenient locations. Methanol fuel cartridges for consumer portable electronics will have a maximum methanol capacity of 200 ml, but smaller fuel cartridges will be sold to power products such as cell phones. These cartridges will also be non-refillable by the consumer, so empty cartridges will be disposed of, or recycled.

Design Concept:

In general, fuel cartridges are comprised of an internal fuel chamber, coupled with an internal valve, control unit, front cover and outer jacket. The cartridge is not merely a methanol container since it has a control mechanism and a specially designed valve. Fuel cartridges incorporate a valve that will open to allow the methanol out only when mated with the consumer electronic equipment. Fuel cartridge valves and connectors will normally be closed and will self-seal if removed from the fuel cell system. This prevents a partially used cartridge from leaking.

The 200 ml Quantity Limit:

200 ml represents the quantity of methanol needed for 10 hours of run time in a laptop computer. Cartridges larger than 200 ml may in the future be purchased for use in larger equipment than those sold to consumers.

Flammability Concerns:

Pure methanol has a flash point of approximately 11°C. Methanol's auto-ignition temperature is 385°C. Fuel cartridges for MFCs are engineered to safely hold any concentration of methanol fuel and will protect against inadvertent release much better than commercially available methanol containers (e.g. plastic bottles).

Short Circuit Concerns:

There is no short circuit hazard with fuel cartridges. If an external short were to occur with a fuel cell or equipment, it is less likely there an over current scenario would result because the fuel cell is designed with a power control system. A fuel cell control system will detect a short circuit from the low power output, and deactivate the fuel cell system. If too much load is placed on a methanol fuel cell, the potential decreases and power output drops to zero, effectively turning off the fuel cell. The control system is designed to shut down reactant flows in the event of a fuel cell overload or extended short circuit.

Transportation Issues:

The UN Model Regulations on the Transport of Dangerous Goods and the ICAO TI include provisions covering the fuel cell cartridges contained in equipment on the basis of the entry "Dangerous Goods in Machinery, UN3366, but this does not cover the consumer article referred to as a fuel cartridge containing methanol. Direct methanol fuel cell powered equipment and methanol fuel cartridges may presently be transported as cargo using the methanol, UN 1230 entry. The TI provides limited quantity and consumer commodity exceptions for shipments of methanol. The US plans to request that the UN Sub-Committee designate a specific entry for fuel cell cartridges. The TI does not contain passenger or crew member

exceptions in Part 8 that could be used for methanol fuel cell cartridges or equipment containing fuel cell cartridges.

Performance tests:

The fuel cell industry is developing standards to minimize the probability of leakage, require the cartridges to be designed and constructed so that they can meet rigorous performance requirements so that the methanol fuel cartridges are appropriately and safely transported. This proposal has the support of the US Fuel Cell Council (U.S.-based trade association for the fuel cell industry), the Methanol Institute (the trade association of the methanol industry), and the Japanese Electrical Manufacturers Association (JEMA).

The methanol fuel cell industry has been working with the International Electrotechnical Commission (IEC), Underwriters Laboratories, Inc. (UL), and the UN Committee of Experts on the Transportation of Dangerous Goods to develop appropriate performance tests. The objective is to impose a set of performance requirements that will result in a high level of safety and consistency in their manufacture. As the safety codes and transportation requirements evolve, further regulatory work and provisions will be needed from the different transportation modal agencies so that fuel cell powered equipment can be shipped to customers and retail sellers like battery powered equipment is today. It is envisioned that passengers and crew members will want to use fuel cell powered equipment and carry replacement cartridges with them aboard commercial aircraft. The efforts involved in developing performance standards include:

Underwriters Laboratories, Inc. (UL): The fuel cell industry is working with UL to develop a commercial safety code (UL 2265) for the design and manufacture of methanol fuel cell cartridges. The US Consumer Product Safety Commission is participating in this effort. It is expected that UL 2265 will be completed near or soon after the end of 2004. Fuel cell powered electronic devices will in addition need to comply with existing UL 60950, the standard for information technology devices such as computers.

International Electrotechnical Commission (IEC): The fuel cell industry and UL are working with the IEC to develop international standards (IEC TC 105) for performance, safety and interchangeability of methanol fuel cell personal electronics and fuel cartridges. IEC 60950 for information technology devices will also be applicable.

Conclusion:

The United States intends to propose that a passenger and crew member exception for fuel cell cartridges and equipment containing fuel cell cartridges be introduced in the 2007-2008 TI. The exception would allow passengers and crew members to carry a specific number of spare cartridges and equipment containing cartridges (such as laptop computers, cell phones and personal electronic planners) on their person and in checked baggage. The US intends to limit the quantity of flammable liquid in the cartridges to 200 ml. The working group is requested to consider the information provided and to provide comments on the US objective.

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