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Microportable Fuel Cell Safety
An Overview of IEC TC105 WG8

Presentation to ICAO
April 18, 2005
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Outline

- IEC TC105 WG8 scope
- Standard structure and content
- Timeline
- Summary

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IEC TC105 WG8 Scope

- An international safety standard for micro portable fuel cells
  - This consumer safety standard covers fuel cell power systems and fuel cartridges that are wearable or easily carried by hand, providing dc outputs that do not exceed 60 V d.c. and power output of 240 VA.
  - This Standard also covers compatible and separately transported fuel cartridges for these fuel cell power systems.
  - This standard establishes requirements for micro fuel cell systems and cartridges to ensure their safe operation during normal use, reasonably foreseeable misuse and transport.
- Requirements comply with IEC 60950, a consumer electronics standard

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Standard Structure

- The body of the standard is written for methanol fuel and direct methanol fuel cells (DMFC)
  - Additional safety requirements for reformed methanol fuel cells (RMFC) are in an appendix
- Additional appendices will be added for other fuel technologies
  - Formic acid
  - Chemical hydrides
  - Metal hydrides
  - Butane

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Safety Philosophy

- Set the criteria to uphold safety
  - Emissions and leakage limits are set using established international regulations, recommendations and no observable effect data
  - Uses the most restrictive values for the limits
- Test types designed to address the foreseeable usage and misuse conditions
  - Altitude simulation test
  - Vibration test
  - Temperature cycling test
  - Drop test
  - Compressive loading (crush) test
  - External short-circuit test
  - Surface and exhaust gas temperature test
  - Long-term storage test
  - Internal pressure test
  - Connection cycling test
  - Emission Test

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Safety Criteria

- No fuel leak
  - Defined as less than 0.26 g instantaneous or 0.13 g/hr continuous
    - Assumed 1 m^3 room with only 0.5 ACH to represent stringent temporary storage conditions
    - Meets the no observable effect limit for a 10 kg child
      - ? More stringent than the US CPSC 25 lb reference child limit
  - Long term storage limit for a cartridge in external packaging set to 0.001 g/hr to stay below 25% LEL in a small area with zero ACH
- Emissions limits during usage are a function of room volume and ACH
  - 1 m^3 is the free space available in a sports car with 2 passengers
  - 10 ACH is the estimated minimum rate for comfort in a small space
  - Standard will require a warning to operate the fuel cell in a well ventilated area

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Emissions Limits

- Included all potential methanol FC emissions
- Used regulatory limits for all but formaldehyde
- Used UN recommended limit for "specially sensitive groups" for formaldehyde
  - Limit used in this standard is 30 times more stringent than regulatory limit for formaldehyde

Table 7.5 Operating Emissions Limits

	Concentration Limit	Volume and Air Exchange Rate	Emission Rate Limit (1.0 m^3 and 10 ACH)
Water	Unlimited		
Methanol	260 mg/m3	1 m^3 @ 10 ACH	2600 mg/hr
Formaldehyde	0.01 mg/m3	1 m^3 @ 10 ACH	0.1 mg/hr
CO	32.5 mg/m3	1 m^3 @ 10 ACH	325 mg/hr
CO_2	6.5 g/m3	1 m^3 @ 10 ACH	65000 mg/hr
formic acid	6.5 mg/m3	1 m^3 @ 10 ACH	65 mg/hr
methyl formate	130 mg/m3	1 m^3 @ 10 ACH	1300 mg/hr

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Altitude Test

- To simulate the effects of high altitude
  - Test samples shall be stored at a pressure of less than 68 kPa for 6 hours
- Passing Criteria
  - No methanol leakage, no fire and no explosion

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Vibration Test

- To simulate the effects of normal transportation vibration
  - A sinusoidal waveform with a logarithmic sweep between 7 Hz (peak acceleration of 1 gN) and 200 Hz (peak acceleration of 8 gN) and back to 7 Hz traversed in 15 minutes.
  - This cycle shall be repeated 12 times for a total of 3 hours for each of three mutually perpendicular mounting positions of the test samples.
- Passing Criteria
  - No methanol leakage, no fire and no explosion

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Temperature Cycling Test

- To simulate the effects of low temperature and high temperature exposure and the effects of extreme temperature change
  - Cycle between 2 hours at 55°C and 2 hours at -40°C 10 times with 30 minutes transition time between temperatures
- Passing Criteria
  - No methanol leakage, no fire and no explosion

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Drop Test

- To simulate the effects of an inadvertent drop
  - The test sample shall be dropped onto a horizontal hardwood surface
  - Height of drop reflects foreseeable handling
    - from 75 cm high for a fuel cell power unit or system for desktop devices
    - from 100 cm high for a fuel cell power unit or system for handheld devices
    - from 150 cm high for a fuel cell cartridge
- Passing Criteria
  - No methanol leakage, no fire and no explosion

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Compressive Loading (Crush) Test

- To simulate the effects of the forces reasonably encountered due to being stepped on
  - A fuel cell power system to be compressed by a steady force of 25 kg for 5 sec.
  - A fuel cell cartridge to be compressed by a steady force of 100 kg for 5 sec.
- Passing Criteria
  - No methanol leakage, no fire and no explosion

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External Short Circuit Test

- To simulate the effects of an external short circuit on a fuel cell power system
  - Short-circuit system by connecting the positive and negative terminals of the micro fuel cell power unit with copper wire having a maximum resistance load of 0.1 ohm for 5 minutes.
- Passing Criteria
  - No methanol leakage, no fire and no explosion

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Surface & Exhaust Gas Temp. Test

- To ensure no risk of burn injury caused by contact with the fuel cell system enclosure or exhaust gas
  - Measure the temperature of the bare surface of micro fuel cell power system operating at rated output
  - Measure the temperature of exhaust gas within 1 cm of the exhaust vent of micro fuel cell power system operating at rated output
- Passing Criteria
  - No burn
  - May replace "no burn" with a maximum temperature
    - Debate is between 60°C maximum versus 60°C rise
      - Latter is language in IEC standards

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Long-Term Storage Test

- To simulate the effects of long term storage at elevated temperature on a fuel cell cartridge
  - Store fuel cartridges for 28 days in an air circulation type oven with the temperature kept at 50°C
- Passing Criteria
  - No methanol leakage, no fire and no explosion

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Internal Pressure Test

- To simulate the effect of a high internal pressure in a fuel cell cartridge
  - Pressurize a fuel cell cartridge to an internal pressure which equals two times the vapor pressure of the fuel normally contained in the cartridge at 60°C for 1 min.
- Passing Criteria
  - No methanol leakage, no fire and no rupture

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Connection Cycling Test

- To simulate the effects of mating and unmating of the fuel cartridge to the fuel cell power unit
  - Fuel cartridges shall be repeatedly mounted and dismounted from micro fuel cell power unit
    - One thousand cycles for a fuel cell power unit
    - Ten cycles for a fuel cell cartridge
- Passing Criteria
  - No methanol leakage, no fire and no explosion after final cycle

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Emission Test

- To ensure the concentration of hazardous emission gases (CO, CO_2, methanol, formaldehyde, formic acid and methyl formate) shall be under safe limits
  - Operate the fuel cell system at rated power in a fixed volume with controlled airflow
  - Analyze gases collected in sorbent tubes by gas chromatography
  - Calculate emission rates
- Passing Criteria
  - Emissions are below limits in Table 7.5
    - Limits are at or below international safety regulations

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Timeline

- CD (Committee Draft): July 2005
- CDV (Committee Draft for Vote): March 2006
- The standard will cover Direct Methanol Fuel Cells
  - Other fuel cell technologies will be included as appendices
    - Reformed methanol
    - Formic acid
    - Chemical hydride
    - Metal hydride
    - Butane
  - Any micro portable technology appendix not meeting the March 2006 timing will wait until a revised standard is issued
- Each technology would need ICAO approval before being allowed on passenger aircraft

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Summary

- IEC TC105 WG8 is developing a safety standard for fuel cell systems and cartridges that are wearable or easily carried by hand
- Leak and emissions limits are set at or below internationally recognized safe levels
- Comprehensive set of type tests defined
  - Includes tests covering possible conditions on passenger aircraft
- Committee Draft for vote in March 2006
- Batteries cannot meet the increasing power demand of portable electronics
  - Fuel cells will fill this need
  - People will want to carry these devices on aircraft

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