105/69/CD

COMMITTEE DRAFT (CD)

IEC/TC or SC: TC 105	Project number IEC 62282-5 Ed. 1.0	
Title of TC/SC: Fuel cell technologies	Date of circulation **2004-03-19**	Closing date for comments **2004-06-18**
Also of interest to the following committees -	Supersedes document 105/21/NP - 105/27/RVN	
Functions concerned: ☒ Safety ☐ EMC	☒ Environment ☐ Quality assurance	
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Title:
Fuel cell technologies - Part 5: Portable fuel cell appliances - Safety and performance requirements

(Titre) :

Introductory note

INTERNATIONAL ELECTROTECHNICAL COMMISSION

6XXXX-1

Portable Fuel Cell Systems

Part 1: Generators

FOREWORD

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International Standard IEC XXX has been prepared by subcommittee XX, of IEC technical committee XX:

The text of this standard is based on the following documents:

FDIS	Report on voting
XX/XX/FDIS	XX/XX/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until _____. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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Portable Fuel Cell Systems

Part 1: Generators

1 SCOPE

This standard covers construction, marking and test requirements for ac and dc type portable fuel cell power systems. These fuel cell systems are movable and not fastened or otherwise secured to a specific location. The purpose of the portable fuel cell system is to produce useable power.

This Standard applies to ac and dc type portable fuel cell power systems, with a rated output voltage not exceeding 600 V ac, or 850 V dc for commercial, industrial, and residential indoor and outdoor use in non-hazardous areas.

This Standard does not apply to portable fuel cell power systems that are:

a) Permanently connected (hard wired) to the electrical distribution system;

b) Permanently connected to a utility fuel distribution system;

c) Exporting power to the grid;

d) For propulsion and auxiliary power of road vehicles;

e) Micro fuel cell systems.

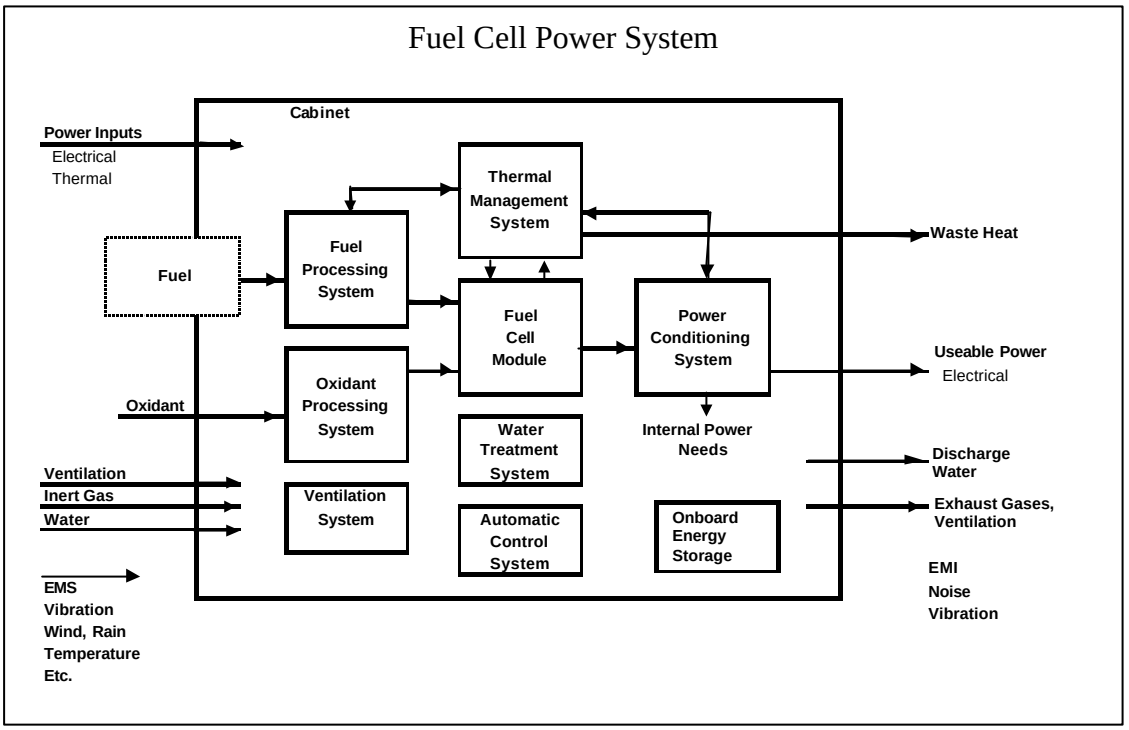
Fuels considered within the scope of this standard are:

- Natural Gas
- Liquefied Petroleum Gas, such as Propane and Butane
- Liquid Alcohols e.g. Methanol, Ethanol
- Gasoline
- Diesel
- Kerosene
- Hydrogen
- Metals
- Chemical Hydrides

This standard does not preclude the use of similar fuels provided the unique hazards are addressed through additional requirements.

This standard covers portable fuel cells using Oxygen from air.

Portable Fuel Cell Power Systems



1.1 System Boundary

The overall design of a portable fuel cell power system anticipated by this standard shall form an assembly of some or all of the following systems, integrated as necessary, to perform designated functions, as follows*:*

FUEL PROCESSING SYSTEM - meters and processes incoming fuel supply for use within the portable fuel cell power system.

OXIDANT PROCESSING SYSTEM - meters, conditions, processes and may pressurize (blowers or turbochargers) incoming oxidant supply for use within the portable fuel cell power system.

THERMAL MANAGEMENT SYSTEM - provides cooling and heat rejection to maintain thermal equilibrium within the portable fuel cell power system.

POWER CONDITIONING SYSTEM- conditions output power of the fuel cell to meet the specifications of the output system.

AUTOMATIC CONTROL SYSTEM - the assembly of components that maintains the portable fuel cell power system control parameters within the manufacturer's specified limits without manual intervention.

FUEL CELL MODULE - assembly including a FUEL CELL STACK which electrochemically converts chemical energy to electric energy and thermal energy intended to be integrated into a vehicle or power generation system.

FUEL SUPPLY SYSTEM – shall be either integral to the portable fuel cell power system, or supplied through a removable and refillable container assembly. The system must be full functional from the internal fuel storage without external connections. There should be a current connection and might be a replenishment port with. The replenishment port must be different from standard gas bottles**.** The fuel supply external to the system enclosure and supplied through a non-permanent fuel connection falls outside the scope of this standard.

ONBOARD ENERGY STORAGE SYSTEM – an internal energy source intended to aid or complement the fuel cell module in providing power to internal or external loads.

VENTILATION SYSTEMS – a system intended for the movement of air and its replacement with fresh air by artificial means, for example fans, and applied to the internal volume of the portable fuel cell system.

WATER TREATMENT SYSTEMS - provides for treatment and purification of recovered or added water for use within the fuel cell power system.

1.2 Equivalent Level of Safety

These requirements are not intended to prevent the design and construction of a portable fuel cell power system not specifically prescribed in this standard, provided that such alternative has been considered in testing and listing the portable fuel cell power system. In considering alternative designs or construction the materials or methods used shall be evaluated as to their ability to yield equivalent performance to that prescribed by this standard.

This Standard does not cover requirements of pressurized or non-pressurized fuel supply containers upstream of the appliance gaseous or liquid fuel supply connector that are not integral to the portable fuel cell power system.

1.3 General Statements

All pressures in this standard are considered to be gauge pressures, unless otherwise specified.

2 NORMATIVE REFERENCES

IEC 60079-10 Electrical apparatus for explosive gas atmospheres - Part 10: Classification of hazardous areas

IEC 60079-15, Electrical apparatus for explosive gas atmospheres - Part 15: Type of protection 'n'.

IEC 60079-20 Electrical apparatus for explosive gas atmospheres - Part 20: Data for flammable gases and vapours, relating to the use of electrical apparatus

IEC 60695

IEC 61340-2-1 Electrostatics - Part 2-1: Measurement methods - Ability of materials and products to dissipate static electric charge.

IEC 60529 Degrees of protection provided by enclosures (IP Code)

IEC 60364-4-41 Electrical installations of buildings - Part 4-41: Protection for safety - Protection against electric shock.

IEC 61032 Protection of persons and equipment by enclosures - Probes for verification

IEC 61140 Protection against electric shock - Common aspects for installation and equipment

IEC 60884-1 Plugs and socket-outlets for household and similar purposes - Part 1: General requirements.

IEC 60664-1 Insulation coordination for equipment within low-voltage systems - Part 1: Principles, requirements and tests.

IEC 62040-1-2 Uninterruptible power systems (UPS) - Part 1-2: General and safety requirements for UPS used in restricted access locations.

IEC 62040-1-1 Uninterruptible power systems (UPS) - Part 1-1: General and safety requirements for UPS used in operator access areas

IEC 60439-1 Low-voltage switchgear and controlgear assemblies - Part 1: Type-tested and partially type-tested assemblies.

IEC 60364-5-54, second edition 2002 – 2006, electrical installations of buildings – part 5-54: selection and erection of electrical equipment – earthing arrangements, protective conductors and protective bonding conductors.

IEC 60695-11-10 Fire hazard testing - Part 11-10: Test flames - 50 W horizontal and vertical flame test methods

IEC 60695-11-20 Fire hazard testing - Part 11-20: Test flames - 500 W flame test methods.

IEC 60695-2-13 Fire hazard testing - Part 2-13: Glowing/hot-wire based test methods - Glow-wire ignitability test method for materials.

IEC 60695-2-11 Fire hazard testing - Part 2-11: Glowing/hot-wire based test methods - Glow-wire flammability test method for end-products.

IEC 62109-1 Electrical Safety of Static Inverters and Charge Controllers For Use In Photovoltaic Power Systems.

IEC 61779-4 Electrical apparatus for the detection and measurement of flammable gases – Part 4: Performance requirements for Group II Apparatus indicating a volume fraction up to 100-percent lower explosive limit

IEC 61779-6 Electrical apparatus for the detection and measurement of flammable gases – Part 6: Guide for the selection, installation, use and maintenance of apparatus for the detection and measurement of flammable gases.

IEC 60730-1 Electrical equipment of non-electric controls for household and similar use (1995).

IEC 60730-2-5 Automatic electric controls for domestic use – Part 2- 5: Automaticelectrical controls for electrical burner control systems.

IEC 60730-2-9 Automatic electric controls for domestic use – Part 2-9: Particular requirements for temperature sensing controls

IEC 61000-6-1 Electromagnetic compatibility - Part 6-1: Generic standards - Immunity for

IEC 61000-6-3 Electromagnetic compatibility - Part 6-3: Generic standards - Emission standard for residential, commercial and light industrial environments

IEC 61000-6-2 Electromagnetic compatibility - Part 6-2: Generic standard - Immunity for industrial environments

IEC 61000-6-4 Electromagnetic compatibility - Part 6-4: Generic standard - Emission standard for industrial environments.

IEC 61000-3-2 : Limits for harmonic currents emissions [equipment input current < 16 A per phase]

IEC 61000-3-3 Section 3: Limitation of voltage fluctuations and flicker in low-voltage supply systems for equipment with rated current < 16 A.

IEC 61882 Hazard and operability studies (HAZOP studies) - Application guide

IEC 61511-3 Functional safety - Safety instrumented systems for the process industry sector - Part 3: Guidance for the determination of the required safety integrity levels.

IEC 60812 Analysis Techniques for System Reliability-Procedure for Failure Mode and Effects Analysis (FMEA).

IEC 62109-1 Electrical Safety of Static Inverters and Charge Controllers For Use in Photovoltaic Power Systems.

IEC 60034 - Rotating Electrical Machines

ISO TS 16528 Boilers and pressure vessels -- Registration of codes and standards to promote international recognition.

ISO 16110 Hydrogen generators using fuel processing technologies

ISO 15156-1, Petroleum and Natural Gas Industries – Materials for use in H2S – Containing Environments in Oil and Gas Production – Part 1: General Principles for Selection of Cracking Resistant Materials.

IEC 60950-1 Information technology equipment - Safety - Part 1: General requirements

IEC 60335-1 Household and similar electrical appliances - Safety - Part 1: General requirements

3 DEFINITIONS

The following definitions apply in this Standard:

Allowable working pressure - maximum pressure, specified in gauge pressure by the manufacturer, of a component or system to which it has been certified to according to the relevant code or directives

Note- Reliefs are set to protect at (or below) this value

Controlled environment— a temperature-controlled, indoor location such as a computer room, office, or factory floor that is relatively free of conductive contaminants such as carbon dust and the like.

Electrical enclosure - A part of the equipment intended to limit access to parts that may be at HAZARDOUS VOLTAGES or HAZARDOUS ENERGY LEVELS or are in TNV CIRCUITS.

Energy hazard—a hazard considered to exist at any exposed live part of a power supply if, between the exposed live part and an adjacent exposed live or unenergized metal part of different polarity, there exists a potential of 2 V or more and either an available continuous power level of 240 VA or more, or a reactive energy level of 20 J or more.

Hazardous Area – an area in which an explosive gas atmosphere is present, or is expected to be present, in quantities such as to require special precautions for the construction, installation and use of apparatus.

Live part—a metal or other conductive part that has a voltage difference with respect to ground or any conductive part in normal use.

Micro Fuel Cell Systems– fuel cell power systems and fuel containers 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. These DC units power or recharge consumer electric devices.

Operator access area—an area for which under normal operating conditions

(a) access is gained without the use of a tool; or

(b) the means of access is deliberately provided to the operator; or

(c) the operator is instructed to enter regardless of whether or not tools are needed to gain access.

In this Standard, the terms "access" and "accessible", unless qualified, relate to operator access as defined above.

Portable Fuel Cell System – movable, not fastened to a specific location, capable of being moved by the user(s).

Reserve mode—UPS delivering ac power output current with the utility disconnected and the power conversion portion receiving power from either a fully charged battery bank or an external dc source of supply when the UPS is used with a remote battery.

Safety circuit—a circuit that is relied upon to prevent a hazard.

Secondary circuit—a circuit that has no direct connection to a primary circuit and derives its power from a transformer, converter, or equivalent isolation device located within the power supply.

SELV - Voltage not exceeding 42 V between conductors and between conductors and earth, the no load voltage not exceeding 50 V.

When SELV is obtained from the supply mains, it is be through a safety isolating transformer or a converter with separate windings, the insulation of which complies with double insulation or reinforced insulation requirements.

Service personnel—trained persons having familiarity with the construction and operation of the power supply and the risks involved.

Thermal Equilbrium Conditions – Thermal Equilibrium Conditions are indicated by changes in temperature of not more than 3EC, between 2 readings, 15 minutes apart.

Tool—a screwdriver, coin, key, or any other object that may be used to operate a screw, latch, or similar fastening means.

Wet cell battery—a storage battery that has provision for the addition of water or electrolyte or for the external measurement of electrolyte specific gravity.

4 REQUIREMENTS

4.1 Material Compatibility

All parts and all substances shall be suitable for the range of temperatures and pressures to which subjected during expected usage; and resistant to the reactions, processes and other conditions to which they are exposed during expected usage.

Any part that is exposed directly to liquid fuel, moisture, condensate etc., as well as fasteners used to attach any part that must be adjusted or removed for servicing, shall be corrosion-resistant and suitable for the application.

Ferrous materials used in the construction of the outside casing, and in an outside cabinet which is the sole enclosure of current-carrying parts, shall be adequately protected against corrosion.

Non-ferrous cabinets, enclosures and outside portions of casings may be employed without special corrosion protection.

Asbestos or asbestos-containing material(s) shall not be used in the construction of a portable fuel cell power system.

4.1.1 Polymeric and Elastomeric Components

Polymeric and elastomeric piping, tubing and components shall be permitted under the following conditions:

a) Materials shall be demonstrated to be suitable for the combined maximum operating temperatures and pressures and compatibility with other materials and chemicals they will come in contact within service and during maintenance. Adequate mechanical strength shall be demonstrated through 8.25, the Ultimate Strength test (covers both tests).

b) Plastic or elastomeric components shall be protected from mechanical damage within the enclosure. Shielding may be used as appropriate to protect components against failure of rotating equipment or other mechanical devices housed within the unit.

c) Any compartment enclosing plastic or elastomeric components used to convey flammable gases shall be protected against the possibility of overheating. A control system shall be provided to terminate fuel flow before temperatures reach a point minimum of 10 K below the lowest HDT of the materials used in the fuel conveying components.

d) Plastic or elastomeric materials used to convey flammable gas shall be conductive to avoid static build-up if conveying dry gases. Materials must have a maximum resistance of 1 mega ohm when tested in compliance with IEC 61340-2-1.

Fuel connection devices constructed of copper alloys, such as brass or bronze, shall be resistant to season cracking in accordance with the applicable requirements of ISO 15156-1.

4.2 Protection Against Mechanical Hazards

Adequate protection shall be provided against accidental contact with all moving parts. All parts that may be contacted during normal usage, adjustment or servicing shall be free from sharp projections or edges.

4.2.1 Mechanical strength

Equipment shall have adequate mechanical strength and shall be so constructed as to remain safe in the meaning of this standard when subjected to handling as may be expected.

4.2.2 Enclosures

Enclosures for electrical equipment shall be formed and assembled so that they will have the strength and rigidity necessary to resist the abuse to which they may be subjected, without increasing their fire and accident hazards due to partial collapse and without reduction of spacing, loosening or displacement of parts or other serious defects.

For applications where the equipment may be exposed to oil, acid fumes, moisture, dust, or other injurious materials in normal operation, the protection afforded to the enclosed components shall be compliant with the applicable IP rating as per IEC 60529. The minimum IP rating should be IP2X.

Enclosures for outdoor applications shall be compliant with the applicable IP rating as per IEC 60529.

Enclosures shall be sufficiently complete to contain or deflect parts that, because of failure or for other reasons, might become loose, separated or thrown from a moving part.

Under conditions of normal use, portable fuel cell power systems shall not become physically unstable. Compliance with this clause is demonstrated in section 8.17.

4.3 Protection Against Toxicity of Fuels

Precautions shall be taken in the design of the portable fuel cell and fuel supply to avoid spillage or unnecessary exposure of personnel to gaseous or liquid fuels, particularly where such fuel may be potentially harmful due to corrosive effects, inhalation or skin absorption.

Such gaseous fuels (or liquid fuels which may produce toxic vapours) shall be stored in sealed containers, with the contents accessible only via couplings which are interactive with the fuel cell supply lines, for example “quick connect” type connectors.

The possible hazards resulting from use of fuels shall be detailed in the operating and storage instructions provided with the generator, together with precautions to be taken when handling the materials, the maximum exposure levels in continuous use, and means to deal with spillage or contamination of personnel.

4.4 Protection Against Explosion Hazards

The fuel cell power system shall be designed and constructed to avoid any credible risk of fire or explosion posed by the fuel cell power system itself or by gases, liquids, dust, vapors or other substances produced or used by the fuel cell power system.

4.4.1 Flammable Atmospheres within the Portable Fuel Cell Power System

Within fuel cell module, compartments with sources of flammable gas or vapour shall be classified and the extent of hazardous areas determined according to IEC 60079-10.

Within areas classified as hazardous the manufacturer shall eliminate ignition sources by ensuring that:

- the installed electrical equipment is suitable for the area classification according to IEC 60079-10,
- the surface temperatures do not exceed 80% of the auto-ignition temperature, expressed in degrees Celsius, of the flammable gas or vapor. See IEC 60079-20 for guidance regarding auto-ignition temperatures of various flammable fluids,
- the potential for static discharge has been eliminated by proper bonding and grounding
- equipment containing materials capable of catalysing the reaction of flammable fluids with air shall be capable of suppressing the propagation of the reaction from the equipment to the surrounding flammable atmosphere.

4.4.2 Normal Operation

The volume within the system enclosure shall fall below 25% of the Lower Flammability Limit (LFL) under normal operating conditions. Where mechanical ventilation is used, a means to confirm operation, and interlock shall be provided to safely shut down the generator upon failure of the ventilation system. Compliance with this requirement is demonstrated in section 8.2.

4.4.3 Abnormal Operation

The extent of a flammable region within the system enclosure created by a limited internal release shall be addressed using a minimum of one of the following techniques.

1. The dilution boundary within the portable fuel cell power system produced under normal operation or by a limited internal release shall be classified using IEC 60079-10. All equipment within this dilution boundary shall be suitable for the classification including: the potential for static discharge, surface temperatures, and the flame suppression of catalytic reactors.

2. A reliable means shall prevent the accumulation of flammable fuel above 25% of the lower flammability limit (LFL) within the portable fuel cell power system. Where detection is used, the system must be compliant with the provisions of 4.9, and the control circuit and logic must be compliant with the requirements outlined in section 4.9.3. Localized volumes within the generator may momentarily exceed 25% LFL of the fuel, however, this transient condition must not pose a safety hazard to the surrounding environment.

Where a flammable gas sensor is provided to comply with section 4.4.3(2), it shall be located downstream of the stack ventilation discharge.
A sensor shall comply with IEC 61779-4. The sensor shall be set to shut off the generator system to ensure the discharge air stream flammable gas concentration does not exceed 50% of the LFL. Compliance is demonstrated in section 8.21. The portable generator shall remain inoperable upon flammable gas sensor activation. Only qualified personnel shall perform service and re-activation after flammable gas sensor activation. In IEC 61779-6 guidance can be found regarding installation and maintenance of gas sensors.

4.4.4 Fuel processing components

For Fuel cell power system components carrying fluids, in which flammable or explosive gas volumes are intentionally produced to conduct a controlled oxidation reaction (e.g. combustion, catalytic partial oxidation, and catalytic combustion), the manufacturer shall comply with the applicable requirements from ISO 16110.

4.4.5 Purging

Means shall be provided to purge those systems of the portable fuel cell power system where, for safety reasons, it requires a passive state after shutdown or prior to initialization as specified by the manufacturer. A suitable purge system, utilizing a medium specified by the manufacturer such as but not limited to nitrogen, or air or steam in a non-hazardous situation within the intended use, meets the intent of this provision.

If safety can be secured by procedures other than the purge, purging is not required.

4.5 Protection Against Electric Shock

4.5.1 General

Except where specifically permitted for functional reasons, accessible conductive parts of equipment shall not be hazardous live in normal condition, nor be or become hazardous live in any reasonably foreseeable single fault condition. Appliances shall be constructed and enclosed so that there is adequate protection against accidental contact with live parts.

The electrical equipment shall provide protection of persons against electric shock from:

a) Direct contact.

b) Indirect contact.

c) Both direct and indirect contact through the use of SELV (safety extra-low voltage).

4.5.2 Protection against direct contact

For each circuit or part of the electrical equipment, protection shall be achieved through the use of enclosures or the insulation of live parts. Where these measures are not practical, alternative measures for protection may be applied such as barriers, placing out of reach, and using obstacles (see IEC 60364-4-41).

4.5.2.1 Protection by enclosures

Live parts shall be located inside enclosures that provide protection against direct contact of at least IP2X or IPXXB (see IEC 60529)

Where the top surfaces of the enclosure are readily accessible, the minimum degree of protection against direct contact provided by the top surfaces shall be IP4X or IPXXD (see IEC 60529).

Test probe B of IEC 61032 is applied without appreciable force, the appliance being in every possible position except that appliances normally used on the floor and having a mass exceeding 40 kg are not tilted. Through openings, the test probe is applied to any depth that the probe will permit and is rotated or angled before, during and after insertion to any position. If the opening does not allow the entry of the probe, the force on the probe in the straight position is increased to 20 N. If the probe then enters the opening, the test is repeated with the probe in the angled position.

Opening an enclosure (i.e. opening doors, lids, covers, and the like) shall be possible only under one of the following conditions:

a) The use of a key or tool.

b) The disconnection of live parts inside the enclosure before the enclosure may be opened i.e. interlocking the door.

c) Opening without using one of the protection techniques described in a) or b) shall be possible only when all live parts are protected against direct contact to at least IP2X or IPXXB (see IEC 60529).

4.5.2.2 Protection by insulation of live parts

It shall not be possible to touch live parts or live parts protected only by lacquer, enamel, ordinary paper, cotton, oxide film, beads, or sealing compound except self-hardening resins, with the probe.

Live parts protected by insulation shall be completely covered with insulation that can only be removed by destruction. Such insulation shall be capable of withstanding the mechanical, chemical, electrical, and thermal stresses to which it can be subjected under normal service conditions. Heat-resistant, moisture-absorption-resistant insulating material, such as phenolic composition, porcelain, cold moulded composition, that will withstand the most severe conditions likely to be met in service shall be used for the support of bare, live parts and for barriers used to obtain required spacings (as specified in 4.5.13) and shall comply with the test specified in 8.13 Insulating Material.

4.5.3 Protection against indirect contact

4.5.3.1 General

Protection against indirect contact is intended to prevent hazardous conditions in the event of an insulation failure between live parts and exposed conductive parts. Protection against indirect contact shall be achieved by:

a) Measures to prevent the occurrence of a hazardous touch voltage; or

b) Automatic disconnection of the supply before the time of contact with a touch voltage can become hazardous.

4.5.3.2 Measures to prevent the occurrence of a hazardous touch voltage

Measures to prevent the occurrence of a hazardous touch voltage include the use of class II equipment or by equivalent insulations (see IEC 61140), electrical separation (see IEC 60364-4-41) and the design of the supply system such that its neutral point is either insulated from or has a high impedance to earth so that an earth fault will not result in a hazardous touch voltage.

4.5.3.3 Automatic disconnection of the supply

Automatic disconnection of the supply of any circuit affected by the occurrence of an insulation failure is intended to prevent a hazardous condition resulting from a touch voltage (see IEC 60364-4-41).

4.5.4 Protection by the use of SELV

4.5.4.1 General

SELV (safety extra-low voltage) may be used to protect persons against electric shock from direct or indirect contact. All accessible parts are not considered to be live if it is supplied at safety extra-low voltage.

An accessible part is not considered to be live if the part is supplied at safety extra-low voltage, provided that:

a) for a.c., the peak value of the voltage does not exceed 42,4 V,

b) for d.c., the voltage does not exceed 42,4 V,

or

– the part is separated from live parts by protective impedance. If protective impedance is used, the current between the part and the supply source shall not exceed 2 mA for d.c., its peak value shall not exceed 0,7 mA for a.c. and

4.5.5 Selection of Electrical Components and Equipment

Electrical components and equipment shall be suitable for the area classification in which they are used, based on IEC 60079-10 (see also section 4.4.1). Electrical components such as switches that are subjected to turning moments in normal operation or servicing shall be fastened securely and prevented from turning by means other than friction between surfaces, if turning could result in reduction of the spacings specified in 4.5.13, or in an infringement of other requirements of this Standard. A lock washer shall not be considered acceptable for devices that require turning moments for their operation.

4.5.6 Fuses

Fuses shall be of a type that is non-replaceable without the use of tools (e.g. soldered-in type) if the circuits protected by the fuses extend beyond the fuel cell power enclosure. If there are no circuits extending beyond the enclosure, the fuses may be of a readily replaceable type. If the fuse can be contacted externally, a fully touch proof fuse holder shall be used.

4.5.7 Securing of parts

Screws, nuts, washers, springs or similar parts shall be secured so as to withstand mechanical stresses occurring in normal use if loosening would create a hazard, or if CLEARANCES or CREEPAGE DISTANCES over SUPPLEMENTARY INSULATION or REINFORCED INSULATION would be reduced to less than the values specified in 4.5.13.

Bare live parts (including conductors) shall be fixed to their bases or mounting surfaces so that they will be prevented from turning or shifting so as to reduce the spacings required by 4.5.13. Friction between surfaces is not an acceptable means of preventing the turning of live parts, but a suitable lockwasher will be acceptable if properly applied.

Compliance is checked by inspection, by measurement and by manual test.

For the purpose of assessing compliance:
- it is assumed that two independent fixings will not become loose at the same time; and
- it is assumed that parts fixed by means of screws or nuts provided with self-locking washers or other means of locking are not liable to become loose.

A component shall be secured to the base or surface so that it will be prevented from rotating or shifting in position as the result of normal stresses, if such movement might result in a reduction of spacings below the minimum acceptable values (see 4.5.13, Creepage and Clearances).

4.5.8 Current-Carrying Parts

Current-carrying parts shall have adequate mechanical strength and current-carrying capacity for the service, and shall be nonferrous or stainless steel except that in SELV circuits, the material is not specified.

The securement of contact assemblies shall be such as to ensure the continued alignment of contacts.

Misalignment of male and female connectors, insertion of a multipin male connector in a female connector other than one intended to receive it, and other manipulations of parts that are accessible without the use of a tool shall not result in a hazardous condition.

4.5.9 Internal Wiring

The space within enclosures of equipment shall provide ample room for the distribution of wires and cables required for the proper wiring of the equipment to prevent overheating and damage to the insulation. The wire connections and wires between parts of equipment shall be protected or enclosed. Wireways shall be smooth and entirely free from projections, burrs, and sharp edges that may cause abrasion of the insulation on the conductors.

Bare conductors shall be so supported that spacings will be maintained as required by 4.5.13.

Wiring other than that of printed circuits shall consist of wire of a type or types that are suitable for the particular application when considered with respect to:

a) Conductor size (consideration shall be given to the effects of vibration, impact, and handling for wires smaller than 1,5 mm²);

b) Temperature and voltage to which the wiring is liable to be subjected;

c) Exposure to oil, grease, or other substance liable to have a deleterious effect on the insulation;

d) Exposure to moisture; and

e) Other conditions of service to which the wire is liable to be subjected.

All wiring joints shall be provided with insulation equivalent to that of the conductors themselves unless they are held securely and rigidly so that the spacings required by 4.5.13 are maintained.

Cords and insulated conductors, either single or bunched, or cabled, when passing through openings in sheet metal walls shall be effectively protected by suitable bushings or well-rounded surfaces against which the cords or conductors may bear.

Conductors identified by green or the colour combination green/yellow shall be used only for grounding or bonding connections.

Electrical connections which need be broken to service any controls shall be made in such a manner that they may be disconnected and reconnected without breaking a soldered connection and without breaking or cutting the wire(s).

4.5.10 Cord-Connected Portable Fuel Cell Power Systems

Portable fuel cell power system intended to be cord-connected at the input shall be provided with a suitable length of cord having an additional conductor for grounding non-current-carrying conductive parts. The cord shall have an ampacity at least equal to the marked input in amperes and shall be of the hard-usage type, damp/wet type except as required by other clauses of this Standard.

The supply cord shall terminate in a suitable attachment plug that conforms to IEC 60884-1 and has a:

- Voltage rating suitable for the voltage marked on the portable fuel cell power system;
- Current rating of not less than125 percent of the marked input current.

4.5.11 Strain relief

Strain relief shall be provided so that stress on a supply cord, as determined by the test specified in 8.12, or twisting of the cord will not be transmitted to the connections inside the portable fuel cell power system. Appliances provided with a supply cord, and appliances intended to be permanently connected to fixed wiring by a flexible cord, shall have a cord anchorage. The cord anchorage shall relieve conductors from strain, including twisting, at the terminals and protect the insulation of the conductors from abrasion. At least one part of the cord anchorage is securely fixed to the appliance, unless it is part of a specially prepared cord.

At the point at which a supply cord passes through an opening in a wall, barrier, or the overall enclosure, there shall be a bushing or the equivalent that is secured in place and that has a smooth, well-rounded surface against which the cord may bear.

A bushing of the same material as that moulded integrally with the supply cord shall be acceptable if the built-up section is not less than 1,6 mm thick at the point at which the cord passes through the enclosure.

It shall not be possible for a flexible cord to be pushed through the cord-entry hole, if such displacement is liable to:

a) Subject the cord to mechanical injury;

b) Expose the cord to a temperature higher than that for which the cord is recognized;

c) Reduce the spacings (such as from bare live parts to a metal strain relief clamp) below the values specified in 4.5.13.

4.5.12 Terminals and Electrical Connections

Connections to external circuitry shall be:

a) Fixed to their mountings without possibility of self-loosing,

b) Constructed in such a way that the conductors cannot slip out from their intended location.

4.5.13 Creepage and Clearances

Appliances shall be constructed so that the clearances, creepage distances and solid insulation are adequate to withstand the electrical stresses to which the appliance is liable to be subjected. Guidance in determining appropriate creepage and clearance distances is specified in IEC 60664-1.

Exemption: An anode and cathode of the same cell are not subject to these clearance and creepage requirements.

In case of explosive gas atmospheres, as determined by IEC 60079-10, the Clearances, creepage distances and separations between conductive parts at different potentials shall also comply with section 7 of IEC 60079-15.

4.5.14 Grounding and Bonding

4.5.14.1 Portable Stand-by Fuel Cell Power Systems

For portable standby fuel cell power systems with an output supplied by either

a) an internal AC (inverter equipped fuel cell) power supply, or

b) the electrical distribution system,

an internal transfer switch shall make and break all current carrying, neutral, and ground conductors

such that:

1. When the unit is supplying power from its internal AC source, the neutral to the load shall be transferred to the neutral established for the internal source and disconnected from the distribution system neutral.
2. When the unit is supplying power directly from the electrical distribution system, the neutral to the load shall be transferred to the neutral provided by the distribution system and disconnected from the internal power supply neutral.
3. The Receptacle Grounding Terminal shall be connected to the fuel cell equipment frame.

4.5.14.2 Portable Stand-Alone Fuel Cell Power Systems

The frame of a portable generator shall not be required to be grounded and shall be permitted to serve as the grounding electrode under the following conditions:

a) The generator supplies only equipment mounted on the generator, cord-and-plug-connected equipment through receptacles mounted on the generator, or both, and

b) The non-current-carrying metal parts of the equipment and the equipment grounding conductor terminals of the receptacles are bonded to the generator frame.

4.5.14.3 Uninteruptible Power Systems

Shall meet the provisions of IEC 62040-1-2 and IEC 62040-1-1 as applicable.

4.5.15 Separation of Circuits

Insulated conductors (internal wiring, including wires in a terminal box or compartment) that operate at different voltages shall comply with at least one of the following:

a) Be segregated by internal barriers;

b) Be segregated from each other;

c) Be segregated by grounded shielding;

d) Have all conductors insulated for the highest voltage; or

e) Have either conductor (or the group of conductors for that voltage) insulated for twice the highest voltage.

Insulated conductors shall be separated by internal barriers or shall be segregated from bare live parts at a voltage higher than that for which the conductors are insulated.

Segregation or separation of insulated conductors may be accomplished by clamping, routing, or an equivalent means that ensures permanent separation.

If an internal barrier is used to provide separation between the wiring of different circuits it shall be of adequate mechanical strength and reliably held in place and constructed in accordance with the requirements of clause 5.4.3 from IEC 60439-1.

Barriers of insulating material shall be not less than 0,70 mm thick, if of electrical grade paper and, when located between conductors and bare live parts of different circuits, shall comply with 4.5.2.2.

Openings in barriers for wires and closures for unused openings shall present a smooth surface wherever an insulated conductor may be in contact with it.

Grounded shielding, when used, shall be subject to investigation to determine compliance with the requirements of the IEC *60364-5-54, second edition 2002 – 2006, electrical installations of buildings – part 5-54: selection and erection of electrical equipment – earthing arrangements, protective conductors and protective bonding conductors*, as appropriate.

4.5.16 Protection of Receptacles

An output receptacle shall be protected by an overcurrent device rated or set at not more than the rating of the receptacle unless:

a) The circuit is not capable of delivering current in excess of the rating of the receptacle under any conditions of loading; or

b) Electronic protection is provided that cannot be defeated by a single fault.

4.6 Protection Against Fire Hazard

4.6.1 General

This clause specifies requirements intended to reduce the risk of ignition and the spread of flame, both within the equipment and to the outside, by the appropriate use of materials and components and by suitable construction.

External parts of non-metallic material, parts of insulating material supporting live parts including connections, and parts of thermoplastic material providing supplementary insulation or reinforced insulation, shall be sufficiently resistant to heat if their deterioration could cause the appliance to fail to comply with this standard. This requirement does not apply to the insulation or sheath of flexible cords or internal wiring. Compliance is checked by subjecting the relevant part to the ball pressure test of IEC 60695-10-2.

The test is carried out at a temperature of 40 °C +/– 2 °C plus the maximum temperature rise determined during the test of clause 8.4, but it shall be at least
– 75 °C +/– 2 °C, for external parts;
– 125 °C +/– 2 °C, for parts supporting live parts.

4.6.2 Flammability

Components and materials inside the fuel cell generator enclosure shall be so constructed or shall make use of such materials, that propagation of fire and ignition is minimized. This may be demonstrated through the selection of materials meeting FV 0, FV 1 or FV 2 when tested in accordance with IEC 60695-11-10, IEC 60695-11-20.

Exemptions:

Membranes, or other materials within a single fuel cell or stack which comprise less than 10 percent of its total mass, are considered to be of limited quantity and are permissible without flammability ratings. If the stack total mass is less than 200 g, stack materials are considered to be of limited quantity and are permissible without flammability ratings.

Components shall be protected against overheating under fault conditions. Where it is not practical to protect components against overheating under fault conditions, the components shall be mounted on materials of FLAMMABILITY CLASS V-1 or better. Additionally, such components shall be separated from material of a class lower than FLAMMABILITY CLASS V-1by at least 13 mm of air, or by a solid barrier of material of FLAMMABILITY CLASS V-1.

Parts of insulating material supporting current-carrying connections, and parts of insulating material within a distance of 3 mm of such connections, are subjected to the glowwire test of IEC 60695-2-11. However, the glow-wire test is not carried out on parts of material classified as having a glow-wire ignition temperature according to IEC 60695-2-13 of at least:

– 775 °C, for connections which carry a current exceeding 0,2 A during normal operation;
– 675 °C, for other connections, provided that the test sample was no thicker than the relevant part.

When the glow-wire test of IEC 60695-2-11 is carried out, the temperatures are:

– 750 °C, for connections which carry a current exceeding 0,2 A during normal operation;
– 650 °C, for other connections

Parts that withstand the glow-wire test of IEC 60695-2-11, but which, during the test, produce a flame that persists for longer than 2 s, are further tested as follows. Parts above the connection within the envelope of a vertical cylinder having a diameter of 20 mm and a height of 50 mm are subjected to the needle-flame test of annex E. However, parts shielded by a barrier that meets the needle-flame test of annex E are not tested. The needle-flame test is not carried out on parts of material classified as V-0 or V-1 according to IEC 60695-11-10, provided that the test sample was no thicker than the relevant part.

4.6.3 Openings in equipment

The risk of ignition caused by small metallic objects, such as paper clips or staples, shall be reduced by measures to minimize the likelihood of such objects entering the equipment and bridging bare conductive parts between which the voltage is not limited in accordance with 4.5.4. Acceptable measures include:

a) providing openings that do not exceed 1 mm in width regardless of length; or

b) providing a screen having a mesh with nominal openings not greater than 2 mm between centre lines and constructed with a thread or wire diameter of not less than 0,45 mm;

c) or providing internal barriers.

Additionally, where metallized parts of a plastic barrier or ENCLOSURE are within 13 mm of parts of circuits where the available power is greater than 15 VA, one of the following requirements applies:

a) access by a foreign metallic object shall be limited in accordance with the above acceptable measures even though the available power meets the limits of 4.5.4; or

b) there shall be a barrier between the bare conductive parts and the ENCLOSURE; or

c) fault testing shall be carried out to simulate bridging along a direct path between a bare conductive part and the nearest metallized part of a barrier or ENCLOSURE that is within 13 mm of the bare conductive part.

NOTE Examples of metallized plastic barriers or ENCLOSURES include those made of conductive composite materials or that are electroplated, vacuum-deposited, painted or foil lined. *Compliance is checked by inspection and measurement and, where appropriate, by test. If simulated fault testing is carried out, no ignition of the metallized barrier or ENCLOSURE shall occur.*

Openings in the vertical sides of an enclosure of a portable fuel cell power system shall not allow intrusion of objects or material that would cause injury to persons or malfunction of equipment that would result in a shock or energy hazard.

Portable fuel cell power systems with opening at the enclosure bottom shall comply with the applicable requirements of section 4.6.2 of IEC 60950-1.

4.7 Protection against Temperature Hazard

Components working at high temperature shall be effectively shielded or separated to avoid overheating of their adjacent materials and components.

4.7.1 Surface temperatures

The maximum temperature of any surface(s) that may be contacted by personnel performing regular and routine service while the portable fuel cell power system is in operation shall not exceed the limit(s) given in IEC 60335-1, clause 11. Appliances and their surroundings shall not attain excessive temperatures in normal use.

Compliance is checked by determining the temperature rise of the various parts under the conditions specified in clause 8.3

4.7.2 Component temperatures

The maximum temperature of any component shall not exceed the limit(s) given in IEC 60335-1, clause 11.

Compliance is checked by determining the temperature rise of the various parts under the conditions specified in clause 8.4.

4.7.3 Wall, Floor and Ceiling Temperatures

The temperatures on walls, floor and ceiling adjacent to a portable fuel cell system shall not exceed 50C above ambient temperature under the test conditions of 8.5.

4.8 Protection against electromagnetic disturbances

The portable fuel cell generator shall have an adequate level of immunity to electromagnetic disturbances so that it can operate correctly in its intended environment. In addition, the equipment shall not generate electromagnetic disturbances above the levels appropriate for its intended places of use.

As applicable, the generator shall comply with IEC 61000-6-1 and IEC 61000-6-3 for residential, commercial and light industrial environments. If the portable fuel cell generator is intended to be used in industrial environments, the following standards shall be referenced:

IEC 61000-6-2; IEC 61000-6-4; IEC 61000-3-2; and IEC 61000-3-3 as applicable

4.9 Functional Safety and Reliability

4.9.1 General

The manufacturer shall ensure that:

all foreseeable hazards, hazardous situations and events associated with the hydrogen generators throughout their anticipated lifetime have been identified,

the risk for each of these hazards has been estimated derived from the combination of probability of occurrence of the hazard and of its foreseeable severity as per IEC 61882, and IEC 61511-3 as applicable.

- the two factors which determine each one of the estimated risks (probability and severity) have been eliminated or reduced as far as possible through the design (inherently safe design and construction),
- the necessary protection measures in relation to risks that are not eliminated have been taken (provision of warning and safety devices),
- users are informed of any additional safety measures that they may be required to implement.

The manufacturer shall demonstrate that the necessary protection measures in relation to risks that are not eliminated have been taken by performing a safety and reliability analysis intended to identify failures that have significant consequences affecting the system performance and/or safety.

4.9.2 Failure Modes and Effects Analysis

A Failure Modes and Effects Analysis (FMEA) or equivalent reliability analysis intended to identify failures which have significant consequences affecting the system performance and/or safety, shall be performed in accordance with IEC 60812. This analysis will result in a table of critical failure modes for the power system in question. The set of protection parameters will provide the definition of the necessary functionality of the safety circuit.

4.9.3 Safety Control Circuits

Automatic electrical and electronic controls shall be designed and constructed so that they are safe and reliable, in conformance to IEC 60730-1.

Manual controls shall be clearly marked and designed to prevent inadvertent adjustment and activation.

Protective devices, such as relays, switches and transformers, that have been separately tested and recognized or certified for their intended or equivalent usage by a nationally-recognized testing agency shall be exempt from this a component failure analysis when applied within their certified parameters, e.g. automatic electrical burner control systems shall comply with IEC 60730-2-5. Catalytic oxidation reactors shall comply as applicable with IEC 60730-2-5.. The design of a safety-control circuit shall be such that electrical failure of an individual functional part (not in the safety-control circuit itself) will either:

a) interrupt the intended function under its control, or

b) allow completion of an operational cycle, but will fail to start or will lock out on the subsequent cycle.

5 CONSTRUCTION

5.1 Fuel Supply

The fuel connection device connecting the fuel supply and the system shall be suitable for its application.

Where necessary, means shall be provided to allow for a ground connection during refueling. The replenishment port on non-standard fuel tanks must be incompatible with standard fuel storage connections**.**

Where the fuel supply is resident within the portable fuel cell system from either an integral, or removable and refillable container assembly (pressurized or non-pressurized), the fuel container shall meet applicable national regulatory requirements.

Means shall be provided to secure fuel containers from becoming dislodged while in use or stored on the portable fuel cell power system. Lateral movement shall not exceed an amount that results in a hazardous condition. The cylinder or any portion thereof shall not become dislodged from its retention means when a lateral force equal to the full weight of the cylinder is applied in any direction at the center of the vertical height of the cylinder.

Any integral compressed gas fuel container shall include a connection fixture that will not allow the flow of gas until a positive gas seal has been achieved.

5.2 Fuel Processing Systems

5.2.1 General Requirements

Fuel processing system shall be able to withstand stress due to the shock, vibration and temperatures anticipated during normal usage.

Fuel processing system shall not cause any hazard due to impact if dropped during transportation.

Fuel processing system shall be resistant to corrosion under the expected operating conditions.

5.2.2 Burners and Reactors

The caulking, welding or other parts shall have no defects which may affect the function of the burner, or reactor.

The burner head shall not have any deformation which may affect the combustion.

The burner shall be mounted properly at the prescribed position and its position relative to the nozzle, combustion chamber, electrical ignition device, safety device, etc. shall be maintained securely. The burner shall not move or detach during normal operation.

The burner shall be mounted at a location where it does not heat or damage other portions of the equipment.

The term “Burner” generally refers to a combination of a pilot and main burners. When a pilot burner is not provided, “burner” means a main burner. A “Pilot burner” is a burner used for the ignition of the main burner and burns without turndown while the main burner is firing.

5.2.3 Ignition

Prior to ignition, any remaining gas in the combustion chamber shall be automatically purged with a volume of air more than four times that of the chamber.

Ignition of the burner shall be able to be monitored by a flame monitor or temperature detector.

The flame monitor or temperature detector shall be fixed so that its relative position to the burner will not change during normal operation.

If ignition of the burner has not been detected by the flame monitor or temperature detector after a series of prescribed ignition operations, the fuel supply to the burner shall be shut off automatically. In this case, the ignition operation shall be locked out and a manual reset shall be required for further operation.

When the flame monitor or temperature detector senses flame outage, the fuel supply to the burner shall shutdown within the control manufacturer's specified flame failure response time. The flame failure response time is the period of time between flame outage and the action to shut off the gas supply.

The ignition heater shall be affixed so that its position will not change easily. Maintenance parts, such as the ignition heater, shall be easily replaceable.

5.2.4 Electrodes

The electrodes shall be located so that as not to contact the yellow flame during normal operation.

The electrodes shall be affixed so that the gap between the electrodes will not change during normal operation.

Live parts of high voltage circuits shall be separated by sufficient air clearance which is greater than the gap between the electrodes, or effective insulation means shall be provided to prevent sparkover during the ignition operation.

Effective electrical insulation covering shall be provided over live parts which may be touched inadvertently by an operator during normal operation.

5.3 Battery Supplies

5.3.1 General Requirements

A battery shall be so located and mounted that the terminals of cells will be prevented from coming in contact with the terminals of adjacent cells, or with the metal parts of the battery compartment, as the result of shifting of the battery.

If transformer isolation is not provided between the ac input circuit of the portable fuel cell power system and the battery circuit:

a) The battery terminals shall be guarded to reduce the likelihood of unintentional contact with the battery terminals; and

b) The marking specified in Clause 7.5 shall appear adjacent to the batteries.

A battery that requires the addition of water shall have a means to determine the fluid level.

5.3.2 Battery Compartments

Battery compartments shall be suitable for the service and resistant to potential leakage.

A polymeric enclosure or compartment housing a wet cell battery, such as a lead-acid storage battery, shall be resistant to corrosion by acids or alkalis, as applicable.

The enclosure or compartment housing a wet cell battery, such as a lead-acid storage battery, shall be constructed so that spillage or leakage of the electrolyte from the volume of one battery container will be contained within the enclosure and prevented from:

a) Reaching the outer surfaces of the portable fuel cell power system where contact with the user is possible;

b) Contaminating adjacent electrical components or materials; and

c) Bridging required electrical spacing.

A metal case or container of a battery, such as an alkaline battery, shall be insulated or spaced away so as not to contact uninsulated live parts of the portable fuel cell power system if such contact may result in a short circuit.

An enclosure or compartment housing batteries having metal containers or cases that are conductively connected to a battery electrode shall be such that the batteries are insulated or spaced from each other, or otherwise physically arranged, to prevent short-circuiting of part or all of the battery supply after installation in the portable fuel cell power system.

5.3.3 Vented Wet Cell Batteries

Vented wet cell batteries may be integral with the portable fuel cell power system, provided all the following conditions are met:

a) The enclosure or compartment housing the batteries is vented;

b) Arcing parts such as the contacts of switches, circuit breakers and relays are not located in the battery compartment; and

c) The battery compartment does not vent into compartments with enclosed spaces that contain arcing parts.

d) Where a hazard may be present through system orientation or positioning, instructions shall be provided and the fuel cell shall be marked.

The requirements of section 5.3.3 do not apply to sealed cell or valve regulated batteries.

5.3.4 Ventilation of battery compartments

If vented wet cell batteries are housed in an enclosure or compartment, the minimum ventilation rates shall comply with the requirements of section 4.4.1. For reference in establishing minimum ventilation rates, see Annex A.

5.4 Inverters

Inverters shall comply with the applicable requirements of IEC 62109-1

5.5 Pressure Equipment and Piping

5.5.1 General

Special consideration shall be given to the following aspects:

- overstressing from inadmissible free movement or excessive stresses and strains being produced, e.g. on flanges, connections, bellows or hoses; overstressing can be avoided by means such as support, constraint, anchoring, alignment and pre-tension;
- rupture events (sudden movement, high-pressure jets, etc.);
- condensation during start-up and/or use occurring inside enclosures for gaseous fluids which could cause damage from water hammer, vacuum collapse, corrosion and uncontrolled chemical reactions; in such case means shall be provided for drainage and removal of deposits from low areas and for access during cleaning, inspection and maintenance;
- where explosive, flammable, or toxic fluids are contained in the piping, appropriate precautions shall be taken in the design and marking of sampling and take-off points.

5.5.2 Pressure Vessels and Piping

The design and construction of both rigid and flexible components carrying fluids under high pressure, including pipes and fittings, shall be compliant with applicable national pressure equipment codes. Guidance in equivalency can be found in ISO TS 16528.

5.6 Unpressurized Vessels

Unpressurized vessels, such as tanks and similar containers, shall be of stainless steel, cast iron, aluminum, plastic, reinforced plastic, ceramic, or other material especially suited to the application for which the tank or container is intended.

5.7 Piping Systems

5.7.1 General Requirements

All piping materials, thread compounds, and thread tapes shall not be degraded through interaction with the system constituents. Unions, when used in gas lines, shall be appropriately constructed and if a packing is used it shall be resistant to the action of gases.

For liquid fuel piping, a filter shall be provided upstream of the fuel controls.

5.7.2 Hoses

Hose used for liquid fuels shall be suitable for the application. Compatibility includes absence of corrosion of the hose material, no unacceptable breakdown of physical properties, and no unacceptable contamination of the fuel. Fuel dwell times for contamination testing shall be based on worst-case normal operating and normal and emergency shutdown conditions. Faulted shutdown conditions need not be considered.

Hose used for liquid fuels shall be used within the maximum working pressures and temperatures for normal, abnormal, emergency, and faulted operating and shutdown conditions of the fuel cell power system.

5.8 Fuel Controls and Equipment

The provisions of this section apply to all gas controls associated with the metering, processing, and conveying incoming fuel supply for use within the portable fuel cell power system.

5.8.1 Automatic Gas Valves

Flammable gas supplied to the portable fuel cell power systems shall pass through at least two automatic valves, in series, each of which serves as an operating valve and a safety shutoff valve. Additionally:

a) Electrically-operated safety shutoff valves shall be of a type that will close upon current failure.

b) The valve closing time of safety shutoff valves shall not exceed 1 second.

c) Automatic valves shall comply with IEC 60730-2-17.

5.8.2 Regulators

The gas pressure regulator shall be equipped with a vent limiter or a vent line.

5.9 Air/Fluid-Handling Equipment

5.9.1 Process Control Equipment

Process control equipment and monitoring devices, such as sensors, indicators and transmitters, shall comply with the applicable sections of the IEC 61779-4 or other nationally recognized standard as appropriate for the application.

5.9.2 Filters

Air filters shall be of a type suitable for the application and shall be reasonably accessible for inspection and replacement. The air velocity through a filter shall not exceed the filter manufacturer's recommended air velocity.

5.9.3 Liquid Fuel Filters

Liquid fuel filters shall be designed by the manufacturer as a pressure part, suitable for the maximum working pressure of the adjacent fuel system.

Liquid fuel filters and their filter media shall be compatible with the fuel used.

5.10 Air/Fluid-Moving Equipment

When air/fluid moving equipment is used for the purpose of preventing the accumulation of flammable fuel within an enclosure, such equipment must be capable of providing sufficient ventilation to maintain the local atmosphere within the enclosure below 25% LFL as required by section 4.4.1.

5.10.1 Motors

Electric motors shall be designed for continuous duty and shall be provided with overload protection in accordance with the applicable sections of IEC 60034, parts 1 through 26, as applicable.

5.10.2 Electric Motors for Use in Hazardous areas

Electric motors, when for use in hazardous areas, shall comply with the applicable protection techniques described in the IEC 60079 series.

5.10.3 Fuel Pumps

Fuel pumps shall be designed for the specific fuel and for the pressures and temperatures to which it may be subjected under normal operating conditions. Fuel pumps shall be provided with the following:

a) Pressure relief devices that limit both inlet and outlet piping pressure to less than the design pressure of the piping. If the shut-off head of the fuel pump is less than the pressure rating of the piping, relief valves are not required. Relief valve discharge shall be recycled to the fuel tank or routed to a safe place.

b) An automatic shut-down on high discharge pressure.

c) Suction and discharge lines shall be adequately protected from damage due to vibration.

d) Shaft seals compatible with the pumped fluids, temperatures, and pressures expected in normal and abnormal operation and during normal and emergency shutdowns.

e) Motors, bearings, and seals suitable for the expected duty cycles.

6 INSTRUCTIONS

6.1 Instructions

Instructions to be referred to as the operation and maintenance manual shall be provided with the portable fuel cell power system. Instructions related to product safety shall be provided in printed form. This manual shall contain clearly defined, legible and complete instructions for at least the following:

a) Directions that the area surrounding the portable fuel cell power system must be kept clear and free of combustible materials, gasoline and other flammable vapors and liquids.

b) Where requiring air for combustion or ventilation, instructions not to block or obstruct air openings on the portable fuel cell power system, air openings communicating with the area in which the portable fuel cell power system is installed, and the required spacings around the portable fuel cell power system that provide clearances to secure and discharge required air.

c) Instructions for starting and shutting down the portable fuel cell power system. These instructions shall pictorially illustrate and locate all components.

d) The following statement: Do not use this portable fuel cell power system if any part has been immersed or flooded with water. Immediately call the manufacturer or manufacturer's representative to inspect the portable fuel cell power system and to replace any functional part that has been affected.

e) Specifications for the frequency of filter change or cleaning and the dimensional size and type of filter for replacements. These instructions shall contain directions for removal and

replacement of filters and pictorially illustrate and locate all components supplied by the manufacturer referred to in the instructions for removal and replacement of filters.

f) Recommended methods for periodic cleaning of necessary parts.

g) When a means to neutralize condensate is provided, instructions and a schedule for maintenance, if required.

h) Instructions for lubrication of moving parts, including type, grade and amount of lubricant.

i) Instructions for examining the portable fuel cell power system installation to determine that:

j) Any intake or exhaust openings are clear and free of obstructions.

k) A list of replacement parts and the source where such parts are available.

l) The necessity and minimum frequency for examinations and also, when required shall specify the periodic inspection of the portable fuel cell power system by qualified service personnel.

m) Where a hazard may be present through system orientation or positioning, instructions shall be provided and the fuel cell shall be marked.

n) Documentation of all hazardous chemicals contained within the fuel cell system with a description of the hazard and instructions for remedial action should the user or service personnel be contaminated.

o) Clearances to combustible materials

p) An enumeration of all regular and routine maintenance items to be performed on the equipment.

q) Manufacturer’s or distributor’s name, address, and telephone number.

r) The following statement for fuel cell power systems intended only for indoor use:

CAUTION: FOR INDOOR USE ONLY

s) The following statement for fuel cell power systems intended only for outdoor use:

CAUTION: FOR OUTDOOR USE ONLY

6.2 User's Information Manual

A user’s information manual shall be provided for a portable fuel cell power system. The manual shall be provided in the official language of the countries of expected use.

The user's information manuals shall be formatted to provide easy-to-follow procedures. Instructions related to product safety shall be provided in printed form. Illustrations should be used to identify portable fuel cell power system components, dimensions and clearances, assembled components, and connection points as needed to make the instructions clear. Illustrations should also be used to identify the location of user serviceable components and illustrate correct methods for performing service procedures.

When text is shown in quotation marks, it shall appear in the user’s information manual exactly as shown.

Each user’s information manual should be divided into appropriate chapters or sections, and should include a table of contents and clearly marked page numbers.

The user's information manual shall contain the following safety information:

6.3 Front Cover:

The front cover shall present the user(s) with only the most important safety instructions. The front cover or, in the absence of a cover, the first page of the manual shall bear the following safety precautions boxed as shown:

WARNING:

FIRE OR EXPLOSION HAZARD

Failure to follow safety warnings exactly could result in serious injury, death or property damage.

– Do not store or use gasoline or other flammable vapors and liquids in the vicinity of this or any other appliance.

The letters used for the boxed warnings above shall be boldface type having a minimum uppercase height of 3.05 mm. The minimum vertical spacing between lines of type shall be 1.17 mm. Lowercase letters shall be compatible with the uppercase letter size specification.

The boxed warning above shall contain the following additional statement when the fuel cell power system is intended only for indoor use:

- FOR INDOOR USE ONLY

The boxed warning above shall contain the following additional statement when the fuel cell power system is intended only for outdoor use:

- FOR OUTDOOR USE ONLY

The front cover shall include a statement informing users that they must read all instructions in the manual, and must keep all manuals for future reference.

6.4 Safety Section

A safety section shall be included near the front of the manual to present portable fuel cell power system users with a listing of potential hazards and safety related instructions for a particular portable fuel cell power system. Statement of the following shall be included in the safety section with references to specific section or page of the manual:

a) Directions that the area surrounding the fuel cell must be kept clear and free of gasoline and other flammable vapors and liquids.

b) Where requiring air for cooling or ventilation, instructions not to block or obstruct air openings on the portable fuel cell power system, air openings communicating with the area in which the portable fuel cell power system is being used, and the required spacings around the portable fuel cell power system that provide clearances to secure and discharge required air.

c) Instructions for starting and shutting down the portable fuel cell power system. These instructions shall pictorially illustrate and locate all user interface components.

d) The following statement: "Do not use this portable fuel cell power system if any part has been under water. A flood-damaged portable fuel cell power system is extremely dangerous. Attempts to use the portable fuel cell power system can result in fire or

explosion. The manufacturer or manufacturer's representative should be contacted to inspect the portable fuel cell power system and to replace all fuel controls, control system parts, electrical parts that have been wet.

e) Specifications for the frequency of filter change or cleaning and the dimensional size and type of filter for replacements. These instructions shall contain directions for removal and replacement of filters and pictorially illustrate and locate all components supplied by the manufacturer referred to in the instructions for removal and replacement of filters.

f) Where a hazard may be present through system orientation or positioning, instructions shall be provided and the fuel cell shall be marked.

g) Documentation of all hazardous chemicals contained within the fuel cell system with a description of the hazard and instructions for remedial action should the user or service personnel be contaminated.

h) Recommended methods for periodic cleaning of necessary parts.

1) Instructions for examining the portable fuel cell power system to determine that:

2) Instructions for examining the portable fuel cell power system to determine that any intake or exhaust openings are clear and free of obstructions.

3) There are no obvious signs of deterioration of the fuel cell.

6.5 In-Text Safety Information:

In-text safety instructions should refer to or incorporate safety precautions from the front cover and from the safety section of the manual. Potentially hazardous situations described in the manual require that additional safety precautionary statements be created.

7 LABELLING

7.1 General

All marking materials shall be suitable for application to surfaces upon which applied. Each appliance shall carry an indelible data plate which is visible during operation.

7.2 Marking

The equipment shall be plainly marked, in a permanent manner, in a place where the details will be readily visible after installation, with the following:

a) Manufacturer's or distributor's name and location, trademark, trade name, or other recognized symbol of identification;

b) Catalogue, style, model, or other type designation;

c) Rated input voltage(s), if applicable;

d) An indication whether the equipment is rated for ac or dc, or both, and, when necessary, the input and output frequency;

e) Number of phases, except for equipment obviously intended for single-phase use only;

f) Rated output voltage;

g) Output in amperes, volt-amperes, or watts;

h) The month and year of manufacture (date coding, serial numbers, or the equivalent may be used);

i) Range of ambient temperatures (minimum and maximum) within which the portable fuel cell power system is intended to operate;

j) Type of fuel;

k) Fuel supply pressures (minimum and maximum) to the portable fuel cell power system;

l) Orientation, if applicable

The polarity of the output leads shall be plainly marked unless the portable fuel cell power system is provided with a polarized termination.

The required voltage and current rating of customer replaceable fuses and other fuses that provide current limitation for compliance with this Standard, shall be marked in the vicinity of the fuse.

7.3 Warnings

Warning signs shall be appropriately placed to identify electrical hazards, contents from drain valves, hot components and mechanical hazards. Preference should be given to the use of standard symbols given in ISO 3864:1984 Safety colors and safety signs.

Control devices, visual indicators, and displays (particularly those related to safety) used in the man-machine interface shall be clearly marked with regard to their functions either on or adjacent to the item. Preference should be given to the use of standard symbols given in IEC 60417 and ISO 7000.

8 TYPE TESTS

All measurements shall be done with rated power, voltage, current, frequency. Multi-voltage portable fuel cell power systems shall be tested at the voltage(s) that produce the highest temperatures.

8.1 LEAKAGE TEST FOR LIQUID FUELED SYSTEMS

The procedures of this section shall be performed, when applicable, following purging as required in Clause 4.4.5.

The system, shall comply with 8.1.1 following exposure to a cumulative operating period at the maximum stable operating temperature for the lesser of 720 hours, or 10% of the system operating design life.

8.1.1 Method of Test

Liquid fueled systems must be tested with their proper fuel for final leak testing as specified by the manufacturer.

Prior to the performance of the test, it shall be established which liquid carrying parts, through interconnection, are subject to the same internal pressure during normal operation of the power system. These parts shall comprise an individual test section, which then shall be pressurized separately and, when deemed necessary, isolated from the rest of the power system by any convenient means.
A suitable pressurizing system, capable of safely providing fuel at 1.5 times the maximum operating pressure of the system, shall be connected to the parts to be tested as an individual test section. The pressurizing system shall be provided with a flow measurement device capable of measuring the fluid flow to the system. Standard revenue fuel meters are acceptable for this purpose, if they are capable of withstanding the test pressure or are located upstream of the pressurizing system and protected by a suitable relief valve. The pressurizing system shall also be equipped with an accurate pressure gauge calibrated prior to the test with a total uncertainty less than 5% of the test pressure in accordance with the ISO/IEC GUIDE TO THE EXPRESSION OF UNCERTAINTY IN MEASUREMENT (GEUM).
This test shall be conducted at ambient temperature of 20EC to 30EC.

The test section shall be isolated by any convenient means. System isolation leakage during the test shall be eliminated.

High point vents shall be provided, where practical, for the purpose of venting any air, vapor, or gas in the test section. If high point vents are not practical, the test section may be evacuated using suitable vacuum pumps such at the total gas volume of the system is less than .001 liter prior to the introduction of the test fluid. If the system cannot tolerate these high vacuums, high point vents shall be provided for testing purposes.

Any functional part(s) shall be caused to assume the open position so the required test pressure is exerted on all parts of the test section.

The test fluid shall be introduced gradually into the test section. The test section shall be gradually pressurized using the pressurizing system, while venting any air or gas or vapor present from all high points of the test section, unless the pre-test vacuum option is used.

The test section shall be pressurized and held at 1.5 times its maximum operating pressure after filling is complete for at least one hour while inspecting all external surfaces of the system for any sign of liquid leakage. All external surfaces of the parts that convey liquid fuels shall be made visible to check for leakage, or provisions shall be made to capture and route leakage down-slope to a suitable tell-tale. If all external surfaces of the parts that convey liquids cannot be made visible, the test shall be held for a minimum of three hours.

No liquid leakage is allowed. The test section shall be monitored for pressure decay and signs of visible liquid leakage for at least one hour. Pressure relief devices capable of interrupting the test shall be defeated for the purpose of this test. All external surfaces of the parts that convey liquid shall be made visible to check for leakage, or provisions shall be made to capture and route leakage down-slope to a suitable telltale.

8.2 Flammable Fuel Concentration Test

This test shall determine the maximum flammable fuel concentration within the appliance enclosure under normal operation. The system, shall comply with 8.2.1 following exposure to a cumulative operating period at the maximum stable operating temperature for the lesser of 720 hours, or 10% of the system operating design life.

8.2.1 Method of Test

The FUEL CELL System shall be operated within the nominal temperature range until THERMAL EQUILIBRIUM CONDITIONS are achieved. The testing shall be carried out at the barometric pressure at the testing station and in an area free from appreciable draughts.

Measurements shall be made at a sufficient distance from the purge or points of release such that the flammable concentration measured is that of the compartment rather than the source.

The test shall be conducted for at least four measurements. The time interval between measurements shall be not less than 5 min.
The test shall be continued until the final measured value is less than or equal to the mean of the four measurement values.

At the conclusion of the test, the highest measured value shall be compared to the LOWER FLAMMABILITY LIMIT. The test is satisfactory if the highest concentration of flammable gas measured during the test is less than 25% of the LOWER FLAMMABILITY LIMIT.

8.3 Surface Temperatures

The method of test for determining maximum surface temperatures shall be in accordance with IEC 60335-1, clause 11. Surface temperatures shall be measured to determine compliance with clause 4.7.1

8.4 Component Temperatures

The method of test for determining component temperatures shall be in accordance with IEC 60335-1, clause 11. Component temperatures shall be measured to determine compliance with clause 4.7.2.

When no IEC standard exists for the relevant component, when the component is not marked or is not used in accordance with its marking, it is tested under the conditions occurring in the appliance.

NOTE - For automatic controls, the term "marking" includes documentation and declaration as specified in clause 7 of IEC 730.

8.5 Wall, Floor and Ceiling Temperatures

The fuel cell system is placed on the test panels made of wood.

For industrial applications, the manufacturer shall specify the distance between the fuel cell system and the back and sidewalls (and closet door, if applicable) of the test panels.

For residential and commercial applications, the fuel cell system is placed in contact with the test panels with zero clearance.

The fuel cell system is placed on the test panels having the following specifications:

Dull black-painted plywood approximately 20mm thick is used for the test panels.

Temperature rises are determined by means of fine-wire thermocouples. Thermocouples having wires with a diameter not exceeding 0.3 mm are considered to be fine-wire thermocouples.

Thermocouples used for determining the temperature rise of the surface of walls, ceiling and floor of the test corner are attached to the back of small blackened disks of copper or brass, 15 mm in diameter and 1 mm thick. The front of the disk is flush with the surface of the boards.

As far as possible, the fuel cell system is positioned so that the thermocouples detect the highest temperatures.

The fuel cell system shall be operated at maximum power output. After equilibrium temperatures have been obtained, the temperature of the test panels shall be measured and checked whether the requirements of 4.7.3. are met.

8.6 Dielectric Strength

Adequate dielectric shall be interposed between ungrounded current-carrying parts and those external surfaces that can be contacted. When connected in the manner intended to a supply circuit of rated voltage and frequency, the portable fuel cell power system shall be operated until thermal equilibrium conditions are reached. At the conclusion of the operating period specified, the dielectric withstand test outlined below shall be conducted.

If the portable fuel cell power system employs a component, such as a solid-state device, that can be damaged by the dielectric potentials specified in this provision, the point of connection of this component to ground shall be disconnected for the purpose of this test to eliminate the likelihood of component damage while still retaining representative dielectric stress of the circuit.

The test as specified in 8.3.1 may be performed using a DC test potential, using a value equal to 150 percent of the corresponding AC potential specified.

8.6.1 Test Method

The dielectric strength test shall be performed in accordance with IEC 60335-1, clause 16.3.

8.6.2 Humidity Test

The humidity test is carried out for 48 h in a humidity cabinet containing air with a relative humidity of (93 ± 3) %. The temperature of the air is maintained within 1 K of any convenient value t between 20 °C and 30 °C. Before being placed in the humidity cabinet, the appliance is brought to a temperature of t +4/-0?C.

NOTE 1 In most cases, the appliance may be brought to the specified temperature by keeping it at this temperature for at least 4 h before the humidity test.
NOTE 2 A relative humidity of (93 ± 3) % can be obtained by placing a saturated solution of Na_2SO_4 or KNO_3 in water in the humidity cabinet, the container having a sufficiently large contact surface with the air.
NOTE 3 The specified conditions may be achieved by ensuring a constant circulation of the air within a thermally insulated cabinet.

The appliance shall then withstand the tests of clause 8.6.1 in the humidity cabinet or in the room in which the appliance was brought to the prescribed temperature after reassembly of those parts that may have been removed.

8.7 WIND TEST

The procedures of this section apply only to portable fuel cell power systems intended for outdoor use or components of portable fuel cell power systems intended for outdoor use.

The portable fuel cell power system shall start and operate normally, without damage or malfunctioning of any part and without creating a hazardous or unsafe condition, when exposed to winds having nominal velocities up to and including 50 km/h.

8.7.1 Method of Test

A wind, produced by a fan/blower of sufficient capacity to develop a draft having a velocity up to and including 50 km/h, shall be directed against an outer surface of the portable fuel cell power system at the point(s) deemed most critical by the testing agency. The fan/blower shall be located so a uniform wind, covering the entire projected area of the outer surface, is directed horizontally toward the portable fuel cell power system at the specified velocity measured in a vertical plane 45.7 cm from the windward surface of the portable fuel cell power system.

At the discretion of the testing agency, additional tests may be conducted with winds of specified and unspecified velocities directed from other direction(s).

8.8 LEAKAGE CURRENT AT OPERATING TEMPERATURE

At operating temperature, the leakage current of the appliance shall not be excessive.
Compliance is checked by the test of 8.8.1. The appliance is operated under normal operation for the duration necessary to achieve thermal equilibrium conditions.

Protective impedance and radio interference filters are disconnected before carrying out the tests.

8.8.1 Test Method

The leakage current of the appliance shall be determined in accordance with IEC 60335-1, Clause 16.2

8.9 ABNORMAL OPERATION

A portable fuel cell power system shall not become a shock hazard, or a fire hazard because of electrical failure, when operated under each of the following conditions. If a product feature precludes a unit operating for as much as 7 hours, that feature, e.g. fuel supply, may be considered as a time limit for the text duration. Operation shall be without regard to temperatures attained on any part of the portable fuel cell power system:

8.9.1 Test Conditions

a) 7 h* with the output of the portable fuel cell power system short circuited;

b) 7 h* with the rotor of each blower motor locked, one at a time†, with the portable fuel cell power system delivering rated load, when forced ventilation is provided within the appliance;

c) 7 h* with the polarity of the batteries reversed when the battery connector is not polarized or the batteries are user replaceable;

d) 7 h* at maximum available power output, unless a fuse opens;

e) 1 h at 135 percent of the ampere rating of the fuse with the fuse bypassed if a fuse opens during the test specified in Condition -d; and

†If agreeable to the submitter and the testing agency, all fan motors of a portable fuel cell power system having more than one fan motor may be locked simultaneously.

If a protective device opens the circuit during tests -a to -d the test shall be:

a) Terminated, if a non-resettable, non-automatic protector ("one shot") functions;

b) Continued for 7 h, if an automatic-reset protector functions;

c) Continued for 10 cycles using the minimum resetting time (but not faster than 10 operations per min), if a manual-reset protective device other than a molded case circuit breaker functions; or

d) Continued for 3 cycles if the manual-reset protective device is a molded case circuit breaker complying with IEC 60934 (2000-10), Circuit-breakers for equipment (CBE)

If the opening of a component other than a protective device, or the short-circuiting of a component terminates the abnormal operation test, an attempt shall be made to restart the portable fuel cell power system in order to continue the test.

Any protective devices that have not been separately approved shall be the subject of investigation as to their reliability.

Electronic components in the primary and secondary circuits that may create a hazardous condition shall be investigated. Components that may cause a hazard shall be short-circuited or open-circuited one at a time to determine that a hazard will not occur.

Examples are short circuits and open circuits of transistors, diodes, and capacitors (particularly electrolytic capacitors), faults causing continuous dissipation in resistors designed for intermittent dissipation, and internal faults in integrated circuits causing excessive dissipation.

8.9.2 Test Methods

The following test procedure shall be used to determine compliance:

a) Only one fault at a time shall be introduced;

b) The equipment shall be set up as for the normal temperature test except that the

- Enclosure shall be connected to ground through a 3 A fuse; and
- Supply circuit shall be fused at not less than 400 percent of the ampacity of the supply circuit conductors unless otherwise specified by the manufacturer; and

c) The test shall be continued as long as necessary to establish steady-state conditions, or up to the point of interruption of the circuit due to failure of the component or to other consequences of the simulated fault condition, whichever is the shorter.

Multivoltage portable fuel cell power systems with an operator-adjustable voltage selector shall be subjected to a mismatch voltage test with the selector adjusted to the lowest marked voltage and the portable fuel cell power system energized at the highest marked voltage.

Portable fuel cell power systems shall be considered to comply with the requirements above if there is no:

a) Opening of the 3 A ground fuse;

b) Emission of flame or molten metal from the overall enclosure;

c) Resultant openings in the overall enclosure that would expose live or current-carrying parts (see Clause 8); and

d) Breakdown when the dielectric strength test of Clause 8.6 is applied as soon as practical after the test.

8.10 OVERLOAD (CONTROL DEVICES)

Except as excepted below, a switch or relay supplied as part of the equipment shall be capable of making and breaking, for 50 cycles of operation at intervals of 10 s, a current equal to 150 percent of the maximum load current at the actual power factor involved.

The current-interrupting test shall be made at the maximum rated voltage. The open-circuit voltage of the supply circuit shall be not less than 100 percent nor more than 105 percent of the test voltage; except that a higher voltage may be employed if agreeable to those concerned. The current-carrying capacity of the supply circuit shall be such that the closed-circuit voltage with rated current flowing is within ± 2.5percent of the test voltage.

The enclosure of equipment designed for use on a system having one conductor grounded shall be connected during the test through a 3 A fuse to the grounded conductor of the circuit. If a portable fuel cell power system is designed for use on other types of systems, the frame shall be connected through such a fuse to the live pole least likely to arc to ground.

The test cycle shall be one second ON and nine seconds OFF, if the nature of the switch permits the test to be so made.

There shall be no electrical or mechanical failure of the switch nor undue pitting, burning, or welding of the contacts and there shall be no flashover to the enclosure.

As an alternative to the overload test, a switch or relay used to control an internal load may be tested by making and breaking, for 50 cycles of operation at the rate of 6 cycles per minute, the load that it is intended to control with the equipment operating at 110percent of the maximum rated voltage.

8.11 ENDURANCE (CONTROL DEVICES)

A switch or other control device supplied as part of the equipment shall be capable of making and breaking, for 6000 cycles of operation at intervals of 10 s, a current equal to the maximum load current at the actual power factor involved. There shall be no electrical or mechanical failure of the switch nor undue pitting, burning, or welding of the contacts.

The conditions for the endurance test shall be the same as the conditions for the overload test.

8.12 STRAIN RELIEF

The strain relief means required by Clause 4.5.11 shall be subjected to a steady pull of 156 N and a push of 45 N, each applied for 1 min. There shall be no evidence of any stress being imposed on the wiring terminals, splices, or internal wiring.

8.13 INSULATING MATERIAL

When required by Clause 4.5.2.2 insulating material in contact with bare live parts shall withstand the application of an ac voltage of 3000 V for 1 min when placed between two 6.35 mm diameter probes after being conditioned for 96 h in air having a relative humidity of 90 ± 5percent and a temperature of 35 ± 2EC.

8.14 CAPACITOR DISCHARGE (ENERGY AND SHOCK HAZARDS)

If the charge stored in capacitors is accessible in an operator access area and the safety of the operator is assured by an interlock actuated by a door or cover, or by disconnecting a connector (or attachment plug), then the energy stored as determined from the following formula, shall be discharged to a safe level not exceeding 42.4 V peak or dc and it shall not exceed 20 J at 2 s after operation of this interlock or disconnection of the connector:

$$J = 5 \times 10^{-7} CV^2$$

where:

J = energy in joules
C = capacity in microfarads
V = volts

This test shall not be required if the total capacitance in the circuit is not greater than 0.1 µF.

8.15 PROVISION FOR EARTHING

Where applicable, the connection between the earthing terminal or earthing contact and earthed metal parts shall have low resistance.

8.15.1 Test Method

Compliance shall be demonstrated through testing in accordance with IEC 60335-1, clause 27.5

8.16 TANK PRESSURE TEST

All tanks shall withstand a hydrostatic pressure test of 150 percent of the maximum design pressure, unless they are pressure vessels, in which case they shall comply with section 5.5.2.

8.17 STABILITY

Compliance is checked by the following tests, where relevant. Each test is carried out separately. During the tests, containers required for normal use are to contain the amount of substance within their rated capacity producing the most disadvantageous condition. If the portable fuel cell power system is designed to carry spare containers, those containers shall be filled to their rated capacity with the contents of the fluid which it is intended to store. All castors and jacks, if used in normal operation, are placed in their most unfavorable position, with wheels and the like locked or blocked.

a) A portable fuel cell power system shall not overbalance when tilted to an angle of 15 degrees from its normal upright position. Doors, drawers, etc. are closed during this test.

b) A portable fuel cell power system having a mass of 25 kg or more shall not tip over when a force equal to 20 % of the weight of the unit, but not more than 250 N, is applied in any direction except upwards, at a height not exceeding 2 m from the floor. Doors drawers, etc. which may be moved for servicing shall be placed in their most unfavorable position consistent with the user instructions.

c) A portable fuel cell power system shall not overbalance when a constant downward force of 800 N is applied at the point of maximum moment to any horizontal surface of at least 12.5 cm by at least 20 cm, at a height up to 1 m from the floor. Doors, drawers, etc. are closed during this test. The 800 N force is applied by means of a suitable test tool having a flat surface of approximately 12.5cm by 20cm. The downward force is applied with the complete flat surface of the test tool in contact with the portable fuel cell power system; the test tool need not be in full contact with uneven surfaces, e.g. corrugated or curved surfaces.

d) The power generating system shall have the stability during the operating condition on the surface inclined up to 4 degree.

The suitability will be judged by putting the operating systems on the rough concrete surface inclined by 4 degree and turning the facilities on four directions with 90 degree interval. After 30 minutes of no load operation and 30 minutes of full output operation, the systems shall not move more than 10 mm.

Note: But, if the systems are provided with the fixing parts, such as wheel stoppers, wedges, bolts, etc. and the method of fixing is clearly explained, the systems will be exempt from this test.

8.18 IMPACT TEST

The power generating systems shall not have any damages which may affect the mechanical and electrical safety after finishing the test specified below.

The impact shall be applied by spring type impact test equipment in accordance with IEC 60068-2-63.
The springs shall be adjusted so that the hammer can give the impact energy of 1.0±0.05 J to the test objects.
Release mechanism springs shall be adjusted so that sufficient pressure can be generated exactly by holding the release jaws at the engagement position.
The power generating systems shall be tilted until the release jaws engage the slot of hammer shaft.
The impact shall be given so that the release cone hit the target surface of the test object vertically.
Pressure shall be increased slowly so that the release cone touches the release bar, the movement of release bar activates the release mechanism and the cone retreats until hammer can hit the test object.
The test object in non-operating condition shall be fixed firmly and three times of impact shall be given to each weak portion of the enclosure.
The impact shall also be applied to the protection equipment, handles, levers, knobs or similar components, and signal lamps and its covers. But the signal lamps and its covers of which extrusion is below 10 mm or area is below 4 cm^2 will be exempt from the tests. The lamps and its covers will be subject to the tests only when these are liable to be damaged.

Compliance with this section shall then be demonstrated by successfully meeting the requirements of the dielectric strength test, 8.6 and the flammable accumulation, 8.21.

8.19 FREE DROP TEST

The power generating systems shall not have any damages which may affect the mechanical and electrical safety after finishing the test specified below.

Before the test, the power generating systems shall be put in a posture simulating the normal transportation. The facilities shall be dropped down on the concrete surface from the height of 20 cm. The test will be performed once.

Requirements on the handle, knob, grip, lever, etc. and its test shall conform to 22.12 of IEC 60335-1:1991.

Compliance with this section shall then be demonstrated by successfully meeting the requirements of the dielectric strength test, 8.6 and the flammable accumulation, section 8.21.

8.20 ADHESION AND LEGIBILITY OF MARKING MATERIALS

The markings required by this standard shall be clearly legible and durable. Compliance is checked by inspection and by rubbing the marking by hand for 15 s with a piece of cloth soaked with water and again for 15s with a piece of cloth soaked with petroleum spirit.

After all the tests of this standard, the marking shall be clearly legible, it shall not be easily possible to remove marking plates and they shall show no curling.

Notes

1. in considering the durability of the marking, the effect of normal use is taken into account. For example, marking by means of paint or enamel, other than vitreous enamel, on containers that are likely to be cleaned frequently, is not considered to be durable.

2. The petroleum spirit to be used for the test is aliphatic solvent hexane having a maximum aromatics content of 0.1% by volume, a kauri-butanol value of 29, an initial boiling point of approximately 65C, a dry point of approximately 69C and a specific mass of approximately 0.66 kg/l.

8.21 FLAMMABLE GAS ACCUMULATION

This test applies for units that can be used indoors. It does not apply to units that are marked for outdoor use only.

Reliable means (see Section *4.3*) shall be provided to prevent accumulation of flammable gas from reaching 25 percent of the lower flammability limit (LFL) within a tight structure having a volume of 14.2 m^3, and 50% of the lower flammability limit at the system ventilation outlet under simulated leakage conditions,

Note 1: Some examples of fuel leakage conditions are loose fittings or joints, gasket failure, regulator diaphragm failure, cracked or broken fuel cell plate, pressure relief valve activation, and piping or tubing rupture.

Note 2: For the purpose of this standard, approved fuel container rupture is not considered.

8.21.1 Test Set-Up

This test procedure shall verify the functionality of the reliable means provided to prevent accumulation of Fuel gas

The tight structure shall:

a. Be either close-fitting or sealed construction, and exterior walls are covered by a continuous, sealed vapor barrier and gypsum wallboard (drywall) or plywood or similar materials having sealed joints to prevent excessive air infiltration;
b. Have interior length, width, and height measurement each between 2.3 m and 2.6 m, with a total interior volume of 14.2 m^3.

Unless provided as the primary method of protection for the accumulation of fuel gas leakage, any ancillary safety system capable of interrupting the test such as an oxygen depletion sensor, or thermal shut- off shall be bypassed or made inoperable for the duration.

The fuel gas concentration shall be verified by an independent fuel gas analyzer located at the ventilation outlet and a second fuel gas analyzer located within 10 cm of the ceiling of the structure.

8.21.2 Test Method

Simulated leakage shall be introduced to the portable fuel cell power system and room by supplying fuel to the air intake(s) of the system, through a sealed conduit. This is to simulate leakage of a fuel-conveying component (i.e. gas train, fuel cell stack) within the portable fuel cell power system.

a. The portable fuel cell power system shall be operated at idling condition (0 amperes net), at 0.25 ACH, within the room. After 1 minute of operation, a simulated fuel gas leak of 0.5 standard litres per minute shall be introduced, and the flow rate increased in 0.5 slpm increments each minute until a safety device activates.
b. The portable fuel cell power system shall be operated at idling condition (0 amperes net), at 0.5 ACH, within the room. After 1 minute of operation, a simulated fuel gas leak of 0.5 standard litres per minute shall be introduced, and the flow rate increased in 0.5 slpm increments each minute until a safety device activates.

Under each of these conditions, the unit shall operate until a safety device activates., prior to reaching 25 percent of the lower flammability limit (LFL) at the ceiling and 50% of the lower flammability limit (LFL) at the ventilation outlet.

8.22 OXYGEN DEPLETION

The following requirements apply to portable fuel cell power systems that are intended to be used indoors (not marked “FOR OUTDOOR USE ONLY”) and from a fuel supply whose capacity exceeds an amount that is capable of depleting the oxygen content below 18 percent (compare 2.33) of a tight structure having a volume not exceeding 14.1 m^3.

Reliable means shall be provided to prevent depletion of oxygen from reaching 18 percent of the atmosphere operating within a tight structure having a volume of 14.1 m^3. Gas detectors or gas sensors, when used as protection means shall meet the requirements of applicable national standards.

This test procedure shall verify the functionality of the reliable means provided to prevent depletion of oxygen from reaching 18 percent of the atmosphere under normal operation and single fault conditions within a tight structure having a volume of 14.1 m^3.

8.22.1 Test Set-Up

The tight structure shall comply with the provisions of section 8.21.1

Unless provided as the primary method of protection for the depletion of oxygen, any ancillary safety system capable of interrupting the test such as a gas detection sensor, or thermal shut-off shall be bypassed or made inoperable for the duration.

8.22.2 Test Method

The portable fuel cell power system shall be:

a) operated at full rated power, with an ACH of 0.50 within the room.

b) operated at 50 percent of the full rated power with an ACH of 0.25 within the room.

Under each of these conditions, the unit shall operate until the oxygen concentration reaches a steady state, or a safety device activates, prior to reaching 18 percent.

8.23 Emission of Effluents – Closed Room

The following test applies only to portable power systems that may produce carbon monoxide and that are not intended and marked for outdoor use only.

Reliable means shall be provided to prevent the emission of carbon monoxide in excess of 0.02 percent in a room with no air changes occurring during an operating period necessary to

reduce the oxygen content of the room to a quantity equal to 15.1 percent by volume, corrected to 15.5 ^{o}C and 101.3 kPa pressure. Gas detectors or gas sensors, when used as protection means shall meet the applicable requirements of IEC 61779 or equivalent.

Reliable means shall be provided to prevent the emission of carbon monoxide in excess of 0.02 percent in closed room with limited air changes occurring during an operating period necessary to reduce the oxygen content of the room to a quantity equal to 15.1 (is this sure, not >18.0) (even for hydrogen driven fuel cells) percent by volume, corrected to 15.5 ^{o}C and 101.3 kPa pressure. Gas detectors or gas sensors, when used as protection means shall meet the applicable requirements of IEC 61779Any oxygen depletion safety shutoff system shall be bypassed.

The portable fuel cell power system shall be placed in a room constructed so as to prevent infiltration of air. The volume of the room shall be 14.1 m^{3}. Air circulation within the room shall be provided so the atmosphere of the room is evenly mixed and shall not interfere with the operation of the portable fuel cell power system under test. Provision for measuring the average temperature of the room shall also be provided.

The portable fuel cell power system shall be operated for fifteen minutes with the door of the room open and the room completely ventilated. The door shall then be sealed and the ventilation stopped. The portable fuel cell power system shall then be operated at its maximum power rating.

During the course of this test, oxygen, room temperature, and carbon monoxide shall be monitored.

When percent oxygen by volume indicates that the total oxygen contained in the room is within + 0.5 percent of that amount contained in the room at a concentration of 15.1 percent by volume at 15.5 ^{o}C and 101.3 kPa pressure, or when the maximum fuel capable of being supplied is consumed, the test shall be terminated.

When percent oxygen by volume indicates that the total oxygen contained in the room is within + 0.5 percent of that amount contained in the room at a concentration of 15.1 percent by volume at 15.5 ^{o}C and at (101.3 kPa) pressure, or when the maximum fuel capable of being supplied is consumed, the test shall be terminated. (This makes an electronic device for oxygen control necessary, for small FC with a great storage is not very likely even without defined room exchange rate

A sample withdrawn at the end of the test shall be analyzed for carbon monoxide.

8.24 Emission of Effluents – Open Room

A portable fuel cell power system capable of producing carbon monoxide shall not produce an average concentration of carbon monoxide in excess of 0.02 percent (200 ppm) in an air-free sample of the effluents when operated in an atmosphere having a normal oxygen supply.

Method of Test

The portable fuel cell power system shall be operated in an open room. During the operational cycle, a sufficient number of effluent samples shall be secured to allow a determination of compliance with this section.

Each effluent sample shall be secured at a point of exhaust discharge of the power system where a uniform sample can be obtained and shall be analyzed for carbon dioxide and carbon monoxide.

When this method of sampling is not practical, the procedure shall be left to the discretion of the testing agency.

8.25 ULTIMATE STRENGTH

The procedures of this section shall be performed last or, when judged feasible, on parts not used for other performance tests specified herein.

A fuel cell module must comply with the ultimate strength requirements of IEC 62282-2.

Any listed or similarly-recognized part(s), when pressure-rated at not less than the maximum allowable working pressure, shall be considered as complying with the applicable provision of this section.

The oxidant and fuel sides of the cell stack may be interconnected and tested simultaneously at the same pressure.

All parts, including joints and connections that convey a liquid shall withstand, without rupture, fracture, deformation or other physical damage, an internal static pressure of not less than $1^1/_2$ times their maximum allowable working pressure.

8.25.1 Method of Test (Liquid)

Prior to conduct of this test, it shall be established which liquid-conveying parts, through (inter)connection, are subjected to the same internal static pressure during normal operation of the portable fuel cell power system. These parts shall comprise an individual test section, which then shall be pressurized separately and, when deemed necessary, isolated from the rest of the portable fuel cell power system by any convenient means. Any non-hazardous liquid, such as water, shall be used as the test medium.

A test section shall be filled with the liquid medium and connected to a suitable hydraulic system, including a pressure-measuring device, capable of sustaining the required test pressure. Care should be taken to liberate any air from the test section.

The test pressure shall be gradually increased so that a uniform gauge pressure of not less than $1^1/_2$ times the maximum allowable working pressure is attained in approximately one minute. This pressure then shall be maintained for 30 minutes during which time no rupture, fracture, deformation or other physical damage shall occur.

All parts, including joints and connections, that convey a flammable liquid shall withstand, without rupture, fracture, deformation or other physical damage the following pressures:

a) For portable fuel cell power systems, or components thereof, subject to a maximum working pressure of, 68,9 Pa an internal static pressure of 5 times (except three times for the fuel cell stack) their maximum operating pressure.

b) For portable fuel cell power systems, or components thereof, subject to a maximum allowable working pressure over 68,9 Pa , but not exceeding 8,61 hPa , the test pressure to be used shall be no less than 1.5 times the produced maximum allowable working pressure.

c) For portable fuel cell power systems, or components thereof, subject to a maximum allowable working pressure exceeding 8,61 hPa, the test pressure shall not exceed a value that produces a hoop (circumferential) stress in the piping or component greater than 50 percent of the specified minimum yield strength of the pipe or component.

8.25.2 Method of Test (Gas)

Prior to conduct of this test, it shall be established which gas-conveying parts, through (inter)connection, are subjected to the same internal pressure during normal operation of the portable fuel cell power system. These parts shall comprise an individual test section, which then shall be pressurized separately and, when deemed necessary, isolated from the rest of

the portable fuel cell power system by any convenient means. Any non-hazardous liquid, such as water, shall be used as the test medium.

The test pressure shall be gradually increased so that a uniform gauge pressure of not less than $1^1/_2$ times the maximum allowable working pressure is attained in approximately one minute. This pressure then shall be maintained for 30 minutes during which time no rupture, fracture, deformation or other physical damage shall occur.

A test section shall be filled with the liquid medium and connected to a suitable hydraulic system, including a pressure-measuring device, capable of sustaining the required test pressure. Care should be taken to liberate any air from the test section.

When liquid cannot be tolerated as the test medium, clean dry air or any inert gas, such as nitrogen or helium, may be used in lieu of the liquid medium. A suitable pressurizing system, capable of supplying the gaseous medium at the required test pressure, and a suitable pressure-measuring device, capable of indicating the required test pressure, shall be connected to the inlet of a test section. The pressure-measuring device shall be located between the pressurizing system and the test section to be pressurized. The outlet of the test section shall be sealed by any convenient means.

The test pressure, when a liquid medium is used, shall be gradually increased or the gaseous medium, when used, shall be gradually admitted to the test section so that a uniform gauge pressure as specified in "a" through "c" above, (except three times the internal static pressure for the fuel cell stack as in "a") is attained in approximately one minute. This pressure shall be maintained for one minute during which time no rupture, fracture, deformation or other physical damage shall occur.

8.26 Steady force tests

8.26.1 10 N

Components and parts, other than parts serving as an ENCLOSURE are subjected to a steady force of 10 N f 1 N.
Compliance criteria are in 4.2.2 and 4.6.3.

8.26.2 30 N

Parts of an ENCLOSURE located in an OPERATOR ACCESS AREA, which are protected by a Cove or door, are subjected to a steady force of 30 N f 3 N for a period of 5 s, applied by means of a straight unjointed version of the test finger to the part on or within the equipment.

Compliance criteria are in 4.2.2 and 4.6.3.

8.26.3 250 N

External ENCLOSURES are subjected to a steady force of 250 N f 10 N for a period of 5 s, applied in turn to the top, bottom and sides of the ENCLOSURE fitted to the equipment, by means of a suitable test tool providing contact over a circular plane surface 30 mm in diameter. However, this test is not applied to the bottom of an ENCLOSURE of equipment having a mass of more than 18 kg.
Compliance criteria are in 4.2.2 and 4.6.3.

8.27 Impact test

A sample consisting of the complete ENCLOSURE, or a portion thereof representing the largest unreinforced area, is supported in its normal position. A solid smooth steel ball, approximately 50 mm in diameter and with a mass of 500 g f 25 g, is permitted to fall freely from rest through a vertical distance (H) of 1,3 m (see figure 4A) onto the sample. (Vertical surfaces are exempt from this test.)

In addition, the steel ball is suspended by a cord and swung as a pendulum in order to apply a horizontal impact, dropping through a vertical distanc e (H) of 1,3 m (see figure 4A) onto the sample. (Horizontal surfaces are exempt from this test.) Alternatively, the sample is rotated 90 deg about each of its horizontal axes and the ball dropped as in the vertical impact test.

The test is not applied to flat panel displays or to the platen glass of equipment (for example, copying machines).

Compliance criteria are in 4.2.2 and 4.6.3.

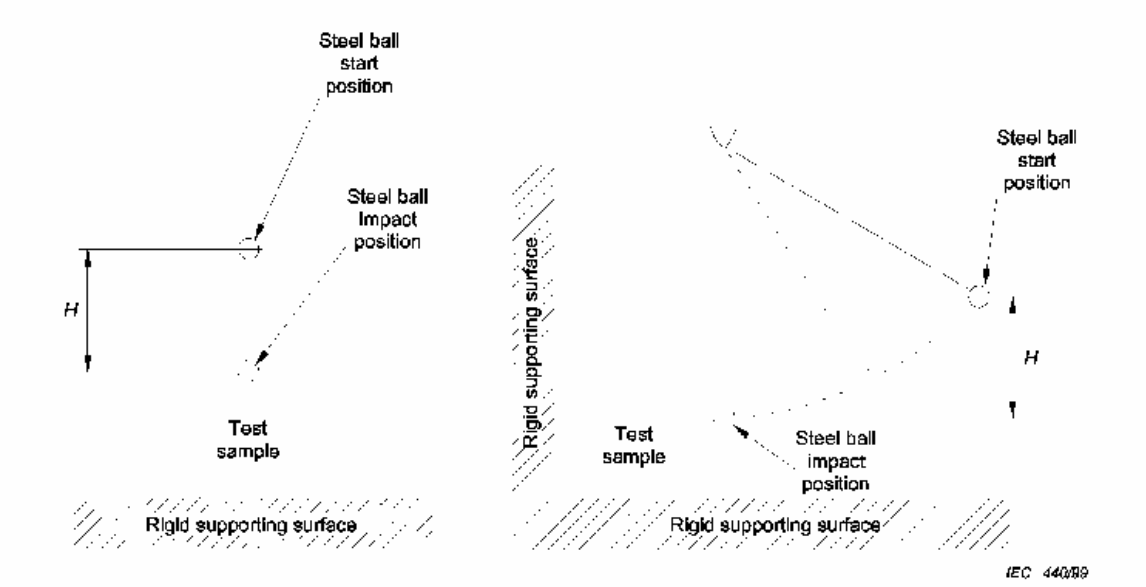


Figure 4A – Impact test using a steel ball

8.28 Drop test

The following equipment is subjected to a drop test:
- HAND-HELD EQUIPMENT;
- DIRECT PLUG-IN EQUIPMENT;
- TRANSPORTABLE EQUIPMENT;
- desk-top equipment having a mass of 5 kg or less that is intended for use with any one of the following:
  - a headset.
  - a cord-connected telephone handset, or
  - another cord-connec ted hand-held accessory with an acoustic function, or

A sample of the complete equipment is subjected to three impacts that result from being dropped onto a horizontal surface in positions likely to produce the most adverse results.

The height of the drop shall be:
- 750 mm + or - 10 mm for desk-top equipment as described above;
- 1 000 mm f+ or - 10 mm for HAND-HELD EQUIPMENT, DIRECT PLUG-IN EQUIPMENT and TRANSPORTABLE EQUIPMENT.

The horizontal surface consists of hardwood at least 13 mm thick, mounted on two layers of plywood each 19 mm to 20 mm thick, all supported on a concrete or equivalent non-resilient floor.

Compliance criteria are in 4.2.1.

8.29 Stress relief test

ENCLOSURES of molded or formed thermoplastic materials shall be so constructed that any shrinkage or distortion of the material due to release of internal stresses caused by the molding or forming operation does not result in the exposure of hazardous parts or in the reduction of CREEPAGE DISTANCES or CLEARANCES below the minimum required.

Compliance is checked by the test procedure described below or by the inspection of the construction and the available data where appropriate.

One sample consisting of the complete equipment, or of the complete ENCLOSURE together with any supporting framework, is placed in a circulating air oven (according to IEC 60216-4-1) at a temperature 10 K higher than the maximum temperature observed on the ENCLOSURE during the test of 4.5.1, but not less than 70 EC, for a period of 7 h, then permitted to cool to room temperature.

With the concurrence of the manufacturer, it is permitted to increase the above time duration.

For large equipment where it is impractical to condition a complete ENCLOSURE, it is permitted to use a portion of the ENCLOSURE representative of the complete assembly with regard to thickness and shape, including any mechanical support members.

NOTE Relative humidity need not be maintained at a specific value during this test.
If the above test is conducted, the compliance criteria of 4.2.1 apply.

Annex A

A) Valve regulated lead acid batteries:

$Q = 11 \times I \times n$

Where Q = Air exchange (ventilation) rate in litres per hour.
I = The maximum current (in Amperes) delivered by the charging equipment during battery gassing, but not less than 25% of the maximum rated output current of the charger in Amperes.
n = Number of cells in series.

B) For vented wet cell batteries:

$Q = 110 \times I \times n$

Where Q = Air exchange (ventilation) rate in litres per hour.
I = The maximum current (in Amperes) delivered by the charging equipment during battery gassing, but not less than 25% of the maximum rated output current of the charger in Amperes.

n = Number of cells in series.

Ventilation for other battery types shall be in accordance with battery manufacturer's specification.