Ref No: I16-125
Gas Products No. 396
Date: November 7, 2016

Announcing: Reaffirmation of Technical Information Letter CSA R-18 Portable fuel cell power systems
Class No: 2725 05, POWER GENERATORS - Portable Fuel Cell Power Systems
To purchase the Standard, visit us at www.shop.csa.ca

Who is affected?
Manufacturers of portable fuel cell power systems.

What do you do?
1. This publication outlines certification revisions that do not affect your currently certified product designs.
2. Please contact CSA technical staff if you have questions or need information concerning this publication and how it applies to you.
3. If you would like to arrange for an evaluation of new products to the revisions, initiate a certification project by contacting our Client Services Centre at 1-866-797-4272. Please supply appropriate supporting documentation*. If testing is needed, we will inform you of the samples required.

*which includes technical information, company name, address, factory locations and CSA file number or master contract number (if assigned), and any other relevant documentation.

Introduction:
Should this T.I.L. not be incorporated into the standard within five (5) years, it may be withdrawn and certifications will be cancelled.
T.I.L CSA R-18 is reaffirmed.
The reference standards for components as stated in the T.I.L. are updated to show their current edition.

For technical questions on this Informs
Contact Gregory Chirdon
by phone 704.552.2919, fax 704.552.0683 or e-mail gregory.chirdon@csagroup.org
ATTACHMENT 1

TECHNICAL INFORMATION LETTER CSA R-18

CSA Group

Product Group: Fuel Burning and Handling Equipment
Issued By: Brij Aggarwal

EQUIPMENT: Portable fuel cell generating systems.

ITEM: Interim Certification Requirements - Portable Fuel Cell Power Systems

REFERENCES Refer to section 1.2.2.

Background

This Technical Information Letter (T.I.L.) covers requirements for certification of portable fuel cell generating systems. Due to the demand by manufacturers to offer a certification program to cover portable fuel cell generating systems, CSA International is pleased to offer the following certification requirements.

Scope:

This T.I.L. contains construction, marking and test requirements for ac and dc type portable fuel cell power systems with a rated output voltage not exceeding 600 V, for commercial, industrial, and residential indoor and outdoor use in non-hazardous locations, in accordance with the Rules of the Canadian Electrical Code, Part 1, as appropriate and shall be used in conjunction with CSA Standard C22.2 No. 107.1.
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PART 1

CONSTRUCTION

1.1 SCOPE

1.1.1 This Technical Information Letter (T.I.L.) contains construction, marking and test requirements for ac and dc type proton exchange membrane (PEM) portable fuel cell power systems with a rated output voltage not exceeding 600 V, for commercial, industrial, and residential indoor and outdoor use in non-hazardous locations, in accordance with the Rules of the Canadian Electrical Code, Part 1, as appropriate.

1.1.2 This T.I.L. does not apply to portable fuel cell power systems that are

a. Permanently connected (hard wired) to the electrical distribution system;
b. Indoor Portable Fuel Cell Power Systems that are connected to a fuel utility distribution system
c. Electric power interactive or that export power to the grid;
d. Micro fuel cell power units for devices; or
e. Fuel cell systems for propulsion

1.1.3 Fuels considered within the scope of this T.I.L. are:

(1) Natural Gas
(2) Liquefied Petroleum / Propane Gases
(3) Liquid Alcohols e.g. Methanol, Ethanol
(4) Gasoline
(5) Diesel
(6) Kerosene
(7) Hydrogen
(8) Chemical Hydrides

1.1.4 These requirements are not intended to prevent the design and construction of a portable fuel cell power system not specifically prescribed in this T.I.L., provided that such alternative has been considered in testing and certifying 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 T.I.L.

1.2 GENERAL REQUIREMENTS AND REFERENCE PUBLICATIONS

1.2.1 General requirements

a) Portable fuel cell power systems shall comply with the requirements of CSA Standard C22.2 No. 107.1, Clauses 1 to 6 and 9 to 11 as applicable and the additional requirements contained in this Technical Information Letter.
b) Portable fuel cell power systems equipped with fuel burning features which allows the production of carbon monoxide, shall be certified for outdoor use only.

1.2.2 Reference Publications

This T.I.L. refers to the following publications and where such reference is made it shall be to the edition listed below, including all amendments published thereto.
**CSA Standards**

C22.2 No. 0.8  Safety Functions Incorporating Electronic Technology  
C22.2 No. 0.15  Adhesive labels  
C22.2 No. 0.17  Evaluation of Properties of Polymeric Materials  
C22.2 No. 24  Temperature Indicating and Regulating Equipment  
C22.2 No. 77  Motors with inherent Overheating Protection  
C22.2 No. 88  Construction and Test of Industrial Heating Equipment  
C22.2 No. 107.1  Power Conversion Equipment  
C22.2 No. 108  Liquid Pumps  
C22.2 No. 113  Fans and Ventilators  
C22.2 No. 139  Electrically Operated Valves  
C22.2 No. 145  Motors and Generators for Use in Hazardous (Classified) Locations  

B51  
CSA 8.3-2015  
CSA 2.6-2016 • ANSI Z83.8-2016  
CSA 6.3-2007 • ANSI Z21.18-2007 and Addenda CSA 6.3a-2010 • Z21.18a-2010, and CSA 6.3b-2012•Z21.18b-2012(reaffirmed 2012)  
E60730  
LC 1/CSA 6.26  

**American Petroleum Institute**

API RP 941  Steels for Hydrogen Service at Elevated Temperatures and Pressures in Petroleum Refineries and Petrochemical Plants  

**ASME Standards**

ASME B1.20.1--2013  Pipe threads, General Purpose (Inch)  
ASME B31.1-2013  Power Piping  
ASME B36.10M-2015  Welded and Seamless Wrought Steel Pipe  

**ASTM Standards**

ASTM A90/A90M  Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings  
ASTM B504  Standard Test Method for Measurement of Thickness of Metallic Coatings by the Coulometric Method  
ASTM B487  Standard Test Method for Measurement of Metal and Oxide Coating Thickness by Microscopical Examination of a Cross Section  
<table>
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<td>ASTM B858-06</td>
<td>Standard Test Method for Ammonia Vapour Test for Determining Susceptibility to Stress Corrosion Crack in Copper Alloys</td>
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<td>Standard Classification System for Rubber Products in Automotive Applications</td>
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<td>ASTM D4000-16</td>
<td>Standard Classification System for Specifying Plastic Materials</td>
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<td>ASTM E779-10</td>
<td>Standard Test Method for Determining Air Leakage Rate by Fan Pressurization</td>
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<td>Standard Test Method for Determination of the Susceptibility of Metallic Materials to Gaseous Hydrogen Embrittlement</td>
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<tr>
<td>ASTM F1940-07a</td>
<td>Standard Test Method for Process Control Verification to Prevent Hydrogen Embrittlement in Plated or Coated Fasteners</td>
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<tr>
<td>ASTM G129-00</td>
<td>Standard Practice for Slow Strain Rate Testing to Evaluate the Susceptibility of Metallic Materials to Environmentally Assisted Cracking</td>
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<tr>
<td>ASTM G142-98</td>
<td>Standard Test Method for Determination of Susceptibility of Metals to Embrittlement in Hydrogen Containing Environments at High Pressure, High Temperature, or Both</td>
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**American Water Works Association Standards**

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<tr>
<td>ANSI/AWWA B100-16</td>
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<td>AWWA C511-07</td>
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**Compressed Gas Association Standards**

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<th>Standard Number</th>
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<tr>
<td>CGA V-9-12</td>
<td>Compressed Gas Cylinder Valves</td>
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**CSA America Standards**

Manually Operated Gas Valves for Appliances, Appliance Connector Valves and Hose End Valves

Gas Appliance Pressure Regulators

ANSI Z21.21-2015/CSA 6.5-2015
Automatic Valves for Gas Appliances

Connectors for Gas Appliances

ANSI Z83.8-2016•CSA 2.6-2016
Gas Unit Heaters, gas packaged heaters, gas utility heaters and gas-fired duct furnaces

CAN1-8.3-2015
Thermoplastic Hose and Hose Couplings for Conducting Propane and Natural Gas

**IEC Standards**

IEC 60079-0
Explosive Atmospheres – Part 0: General Requirements

IEC 60079-10-1
Explosive Atmospheres – Part10-1: Classification of Areas – explosive gas atmospheres

IEC 60079-20-1
Explosive Atmospheres –Part 20-1: Material characteristics for gas and vapour classification – Test Method and Data

**ISA Standard**

ISA 60079-29-1
Explosive atmospheres – Part 29-1 : Performance requirements of detectors for flammable gases

**FM Standard**

FM7400-98
Liquid and Gas Safety Shutoff Valves

**National Association of Corrosion Engineers Standards**

NACE TM0284-11
Standard Test Method - Evaluation of Pipeline and Pressure Vessel Steels for Resistance to Hydrogen-Induced Cracking

**SAE Standards**

SAE CRP-008-93
Recommended Methods for Determining Physical Properties of Polymeric Materials Exposed to Gasoline/Methanol Fuel Mixtures

SAE J30-2012
Fuel and Oil Hoses

SAE J1681-2000
Gasoline, Alcohol, and Diesel Fuel Surrogates for Materials Testing

SAE J1747
Recommended Methods for Conducting Corrosion Tests in Hydrocarbon Fuels or Their Surrogates and Their Mixtures with Oxygenated Additives

SAE Report 2000-01-2013
A Rational Approach to Qualifying Materials for use in
Fuel Systems

UL Standards

UL 125-2015  Flow Control Valves for Anhydrous Ammonia and LP-Gas
ANSI/UL 144-2014  LP-Gas Regulators
ANSI/UL 252-2015  Compressed Gas Regulators
ANSI/UL 353-2011  Limit Controls
UL 404-2015  Gauges Indicating Pressure for Compressed Gas Service
UL 536-2014  Flexible Metallic Hose
UL 795-2013  Commercial-Industrial Gas Heating Equipment
UL 842-2015  Valves for Flammable Fluids
ANSI/UL 900-2015  Air Filter Units
UL 1998-2013  Software in Programmable Components
UL 2075  Gas and Vapor Detectors and Sensors

1.3 DEFINITIONS

The following definitions apply in this T.I.L.

Fuel Cell Module:  A fuel cell Module comprises one or more fuel cell stacks defined as “an assembly of two or more electrically connected fuel cells and corresponding separators that electrochemically convert fuel and oxidant to direct electrical current, heat, water and other byproducts”. It is also comprised of cooling plates, piping system, manifolds, power delivery electrical connections, means for monitoring and control, and a supporting structure.

Limited Internal Release:  Potential sources of leakage identified and measured through the risk analysis described in Section 1.16.1. A limited internal release does not apply to catastrophic failures that are beyond the concept of abnormality dealt with in this T.I.L. Catastrophic failure in this context is applied, for example, to the rupture of a process vessel or pipeline, and such events that are not predictable.

Micro Fuel Cell Systems:  Small low-power DC portable fuel cell units that are connected to devices by flexible cords and plug arrangements or other connection means such as termination connectors integrated into the casing of the fuel cell power units. These fuel cell power units also include the associated fuel supply systems. Some examples include: battery replacement systems for laptops, cell phones, hand-held computer systems or small standalone chargers systems, etc.

Operating Pressure, Maximum:  The steady-state gauge pressure at which a part or system normally operates. It shall not exceed the allowable working pressure, and it is usually kept at a suitable level below the setting of pressure-limiting/relieving devices to prevent their frequent functioning.

PEM (Proton Exchange Membrane/Polymer Electrolyte) Fuel Cell:  A fuel cell that employs solid positive ion exchange resin membrane as the electrolyte

Working Pressure, Maximum Allowable  The maximum gauge pressure at which a part or system may be operated in accordance with the provisions of this T.I.L. It is the pressure used in determining the setting of pressure-limiting/relieving devices installed to protect the part or system from accidental over-pressuring.
1.4 CONSTRUCTION

1.4.1 General Requirements

a. All parts and all substances shall be:

1. Suitable for the range of temperatures and pressures to which they will be subjected during expected usage; and

2. Resistant to the reactions, processes and other conditions to which they will be exposed during expected usage.

b. Any part, such as a component, control or similar device that does not meet the requirements of applicable national standards may be judged suitable for a particular application.

c. All parts that require regular or routine maintenance or servicing, as defined in 1.16.1-k, such as inspection, lubrication, cleaning, replacement or similar function shall be reasonably accessible.

d. Joints when used in heat transfer surfaces shall be substantially continuous and of a type to provide permanent joining of parts. Joints when used in positive pressure zones shall be tight and shall not depend for its mechanical strength or tightness on cement or other sealing material(s). Such joints shall be either welded, brazed, threaded, lock-seamed, machined and bolted, or of rigid flanged construction tightly bolted together and enclosing gaskets or shall have a rigid pressed, machined slip or equivalent construction.

A machined slip joint shall neither be constructed entirely of sheet metal nor depend upon friction of the joint itself for strength. Such a joint shall be constructed so that making and breaking the connection will not alter the effectiveness of the joint.

e. Adequate protection shall be provided against accidental contact with all moving parts.

f. All parts that may be contacted during normal usage, adjustment or servicing shall be free from sharp projections or edges.

g. 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 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.

1.4.2 Flammable Atmospheres

The integrated systems of the portable fuel cell power system shall be assembled and installed so as to prevent ignition of flammable atmospheres within the portable fuel cell power system.

1.4.2.1 Surface Temperatures

Surface temperatures of components used in classified areas shall not exceed 80% the ignition temperature of the specific gas or vapor as described in IEC 60079-20.
1.4.2.2 Normal Operation

The extent of a flammable region within system enclosure created or produced under normal operation shall fall below 25% of the Lower Flammability Limit (LFL). 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 2.10.

1.4.2.3 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.

a) The dilution boundary within the portable fuel cell power system produced by a limited internal release shall be classified using IEC 60079-10 or CFD analyses. 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. Guidance in the selection of appropriate electrical equipment can be found in CSA E60079 – 0 and related series. Alternatively, the area may be classified and protected according to the requirements of the Canadian Electrical Code, Part 1, Section 18.

b) 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 section 1.7.1, and the control circuit and logic must be compliant with the requirements outlined in section 1.15 Safety Analysis. 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.

   i) Where a flammable gas sensor is provided to comply with section 1.4.2.3(b), it shall be located downstream of the stack ventilation discharge.

   ii) The reliable means shall be set to shut off the generator system to ensure the discharge airstream flammable gas concentration(s) do not exceed 25% of the LFL(s). Compliance is demonstrated through the Flammable Gas Accumulation Tests (Section 2.10).

   iii) The portable generator shall remain inoperable upon flammable gas sensor activation. Only the factory shall perform service and re-activation after flammable gas sensor activation.

1.4 Fuel Supply

1.4.3.1 This T.I.L. 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.

1.4.3.2 Cylinders containing hazardous compressed gases shall comply with the requirements of CAN/CSA B339 Cylinders, Spheres and Tubes for the Transportation of Dangerous Goods and/or the Boiler, Pressure Vessel, and Pressure Piping Code, CSA B51

1.4.3.3 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 25.4 mm at the retention means, and 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 centre of the vertical height of the cylinder.

1.4.3.4 Any integral compressed gas fuel container shall be equipped with a cylinder valve compliant with the applicable requirements in CGA V-9, Standard for Compressed Gas Cylinder Valves and include a connection fixture that will not allow the flow of gas until a positive gas seal has been achieved.
1.5 MATERIALS

1.5.1 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 protected against corrosion by one of the coatings appropriate to the thickness of the part as outlined in Table I (Minimum Corrosion Protection of Ferrous Materials Used in the Construction of Fuel Cell Power Systems for Outdoor Installation) and the notes applicable thereto, or by other metallic or nonmetallic coatings or materials which have been shown to give equivalent protection.

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

Any metallic part that is exposed directly to moisture, condensate, pure (de-ionized) water, liquid fuel, etc., as well as fasteners used to attach any part that must be adjusted or removed for servicing, (1) shall be constructed of an appropriate corrosion-resistant material, such as cast iron, stainless steel, chrome steel or its equivalent, or (2) shall have an appropriate corrosion-resistant coating, such as aluminum, chromium, ceramic, zinc chromate, black oxide, nickel or electro-less nickel, teflon, or its equivalent, as necessary.

Fuel connection devices constructed of copper alloys, such as brass and bronze, shall be resistant to season cracking when tested in accordance with ASTM B 858M using a pH value of 10.0. This test shall be conducted on unplated samples.

1.5.2 Parts constructed of rubber and rubber-like (elastomeric) materials shall be judged with respect to their suitability for the particular application. The acceptability of such materials shall be based on the classification system and associated terminology specified in the Classification System for Rubber Products in Automotive Applications, ASTM D2000, Terminology Relating to Rubber, ASTM D1566, and the Practice for Rubber and Rubber Lattices - Nomenclature, ASTM D1418.

The acceptability of parts constructed of plastic (polymeric) materials shall be based on the classification system and associated terminology specified in the Classification System for Specifying Plastic Materials, ASTM D4000, the Terminology for Abbreviated Terms Relating to Plastics, ASTM D1600 and the Terminology Relating to Plastics, ASTM D883.

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

1.5.4 Components and materials inside the classified gas explosive atmospheres shall be so constructed or shall make use of such materials, that propagation of fire and ignition is minimized. The material flammability shall be such that a sustained fire will not be supported after electrical power and the fuel supply have been removed. This may be demonstrated through the selection of materials meeting V-0, V-1 or V-2 in accordance with CSA Standard CAN/CSA-C22.2 No. 0.17.

Exemptions:

Membranes, or other materials within the fuel cell stack volume which comprise less than 10 percent of the total fuel cell stack mass, are considered to be of limited quantity and are permissible without flammability ratings.

1.5.5 All piping materials, thread compounds, and thread tapes used for liquid fuels shall not cause degradation of the system by interaction of the fuel or compromise their function. Guidance for evaluation can be found in:
Standard SAE CRP-008: Recommended Methods for Determining Physical Properties of Polymeric Materials Exposed to Gasoline/Methanol Fuel Mixtures

Standard SAE J1747: Recommended Methods for Conducting Corrosion Tests in Hydrocarbon Fuels or Their Surrogates and Their Mixtures with Oxygenated Additives

SAE J1681 Gasoline/Methanol mixtures for materials testing

1.5.6 Components in which gaseous hydrogen or hydrogen-containing fluids are processed, as well as all parts used to seal or interconnect the same, shall be sufficiently resistant to the chemical and physical action of hydrogen at the operating conditions. In particular, due account shall be taken of the materials’ resistance to hydrogen embrittlement, corrosion cracking, or any synergism of either one with fatigue, stress corrosion or other types of corrosion so that the components’ mechanical properties necessary for operational safety are not affected within the scheduled lifetime. The following materials are suitable for compliance with this requirement:

  a) Metallic materials such as aluminum, copper, titanium and their alloys and austenitic stainless steels with > 7 % Nickel (for example 304, 304L, 308, 316, 321, 347), shall be considered suitable.

  b) Carbon steels and other stainless steels as per API RP 941.

  c) Non metallic materials such as Polytetrafluoroethylene (Teflon), Polychlorotrifluorethylene (Kel-F), Chloropene rubber (Neoprene), Dacron, Fluorocarbon rubber (Viton), Mylar, Nitrile (Buna-N) and Polyamides shall be considered suitable.

  d) Other materials shall be considered suitable if they are demonstrated to be impervious to hydrogen embrittlement or attack by hydrogen as per the applicable standard(s) below, based on composition, structural form, and environment:

  NACE TM0284-11, ASTM standards G148-97, G142-98, F1940-07a, F519-13, F1624-12, F1459-06, B850-98, B849-02, G129-00

1.6 ENCLOSURES

General Requirements for Enclosures

  a. Portable fuel cell power systems shall have a provision for lifting in accordance with Section 2.8

  b. Portable fuel cell power systems shall have enclosures that shall enclose all live parts. Rack-mounted assemblies (e.g. component types) may have exposed parts where enclosed by the rack enclosure.

  c. 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.

1.6.1 Decorative Trim

Polymeric compounds that are used as decorative trim or features of the enclosure, and are specifically not part of the fire or electrical enclosure(s) of the product, may be classified as HB or less flammable. Small decorative parts, push buttons, etc, under 1g or 1cm³ shall not be required to have a flammability rating.
1.6.2 Openings in Enclosures

a. The minimum dimension of any cabinet opening(s) in the gas compartment necessary for the entrance of process or ventilation air shall not be less than 6.4 mm.

1.7 ELECTRICAL COMPONENTS

Electrical components shall be suitable for the environment in which they are installed as per 1.4.1 (a)

Unless otherwise specified in this document, electrical components shall comply with the applicable requirements of CSA Standard C22.2 No. 107.1

1.7.1 Gas detectors and sensors

Gas detectors or gas sensors, when used as protection means shall meet the applicable requirements of the Standard for Performance Requirements – Combustible Gas Detectors, ANSI/ISA RP 12.01.13 Part I, or if the gas mixture calibration setting is 25% of the lower flammability limit (LFL) or less, Underwriters Laboratories Bulletin for Gas and Vapor Detectors and Sensors, UL 2075.

1.8 INTERNAL WIRING

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 conductor(s).

1.9 GROUNDING AND BONDING

1.9.1 For portable standby and stand alone fuel cell power systems, each of the following shall apply:

a) For two wire systems, one conductor of the internal source ac output circuit shall be bonded to the equipment frame. For three wire systems, the internal source common point ac output circuit shall be bonded to the equipment frame.

b) For portable fuel cell power systems with an output supplied by either an internal ac power supply, or the electrical distribution system, a transfer switch shall make and break all current carrying conductors such that:

i) 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.

ii) When the unit is supplying power from its internal source, the neutral to the load shall be transferred to the neutral established for the internal source and disconnected from the distribution system neutral.

1.9.3 UPS systems shall comply with the grounding and bonding requirements described in CSA Standard C22.2 No. 107.1

1.9.4 The Receptacle Grounding Terminal shall be connected to the fuel cell equipment frame.

1.9.5 The markings specified in Section 1.17.4 shall appear next to the receptacle, as applicable.
1.10 HEATERS AND VESSELS

1.10.1 Electric heaters, when provided for protection of equipment at low ambient temperatures, shall comply with the applicable sections of CSA Standard C22.2 No. 88.

When for use in hazardous locations within the portable fuel cell power system, such heaters also shall comply with the applicable sections of the Standard for Electric Heaters for Use in Hazardous (Classified) Locations, ANSI/UL 823.

1.10.2 Gas heaters, when provided for protection of equipment at low ambient temperatures, shall comply with the applicable sections of ANSI Z83.8•CSA 2.6, Gas Unit Heaters, Gas Packaged Heaters, Gas Utility Heaters, and Gas-fired Duct Furnaces or other nationally recognized standard(s) covering such equipment. A Fuel Cell Power System using a gas heater shall be marked for outdoor use only per Section 1.17.3.

1.10.3 Pressurized vessels, such as heat exchangers, coolers, accumulators and similar containers, and associated pressure relief mechanisms, such as relief valves and similar devices, shall be constructed and marked in accordance with the applicable section(s) of the *Boiler, and Pressure Vessel, and Pressure Piping Code, CSA Standard B51*.

1.10.4 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 and might need the requirement of 2.6.

1.11 PIPING SYSTEMS

1.11.1 General

a. Steel pipe shall comply dimensionally with the Standard for Welded and Seamless Wrought Steel Pipe, ANSI/ASME B36.10M, for use at high or low temperatures and pressures.

b. Threaded portions of piping and associated component parts shall have threads conforming to the Standard for Pipe Threads, General Purpose, (Inch), ANSI/ASME B1.20.1.

c. Metallic pipe bends shall comply with the following:
   i) Bends shall be made only with bending equipment and procedures intended for that purpose.
   ii) All bends shall be smooth and free from buckling, cracks, or other evidence of mechanical damage. Pipes shall be annealed, if necessary to remove internal stresses.
   iii) The longitudinal weld of the pipe shall be near the neutral axis of the bend.
   iv) Pipe shall not be bent through an arc of more than 90 degrees.
   v) The inside radius of a bend shall be not less than 6 times the outside diameter of the pipe.

d. The internal surfaces of piping shall be thoroughly cleaned to remove loose particles, and the ends of piping shall be carefully reamed to remove obstructions and burrs.

1.11.2 Steam, Vapour, or Liquid Piping

When conveying steam or vapour at pressures exceeding 15 psi (103.4 kPa), or liquids at pressures exceeding 15 psi (103.4 kPa) or temperatures exceeding 150 °F (65 °C) or both, piping and associated component parts shall conform to all applicable specifications of the Standard for Boiler, Pressure Vessels, and Pressure Piping Code, CSA B51.
1.11.3 Gas Piping

a. Unless otherwise specified, all piping intended to convey natural gas and propane shall comply with the material, sizing, piping practices and connection requirements outlined in CSA B149.1.

b. All piping intended to convey gaseous hydrogen shall comply with the material compatibility requirements of 1.5.6.

c. A pilot line shall not be connected to the bottom of a horizontal fuel gas supply line, unless means are provided to prevent condensate from entering the pilot line.

When a pilot line is taken from a vertical fuel gas supply line, the connection shall be made above the main fuel gas supply line.

d. Compounds used on threaded joints of fuel piping shall be resistant to the action of liquefied petroleum gases or any other chemical constituent of the fuels conveyed through the piping.

e. Flexible connectors and associated fittings, when used for conveying gaseous fuel, shall comply with the Standard for Metal Connectors for Gas Appliances, ANSI Z21.24●CGA-6.10 or the Standard for Flexible Metallic Hose, ULC ORD C 536, as applicable. The Standard for Metal Connectors for Gas Appliances, ANSI Z21.24●CGA 6.10, is limited to pressures not exceeding $\frac{1}{2}$ psi (3.45 kPa).

1.11.4 Liquid Piping

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

b. All piping intended to convey diesel and kerosene shall comply with the requirements of CSA B139.

c. All piping intended to convey gasoline shall comply with the requirements of the applicable provincial territorial code.

d. Compounds used on threaded joints of fuel piping shall be resistant to the action of liquefied petroleum gases or any other chemical constituent of the fuels conveyed through the piping. All piping intended to convey liquid fuel shall comply with the material compatibility requirements of 1.5.5. Liquid hydrogen shall comply with the material compatibility requirements of 1.5.6.

e. Hose used for liquid fuels shall meet SAE J30, Fuel and Oil Hoses, as applicable. In addition to the tests and dimensional requirements of SAE J30, compatibility with the particular fuel (methanol, ethanol, gasoline, diesel, or other) must be determined in accordance with guidance found in SAE Report 2000-01-2013 A Rational Approach to Qualifying Materials for use in Fuel Systems. 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.

f. The hose shall not be exposed to maximum working pressures and temperatures exceeding those given in SAE J30 under normal, abnormal, emergency, and faulted operating and shutdown conditions of the portable fuel cell power system.
1.12 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.

1.12.1 Automatic Valves

Flammable gas supplied to the portable fuel cell power systems from a supply whose capacity exceeds an amount that would create a flammable gas and air mixture greater than 25% of LFL if fully released into a tight structure having a volume not exceeding 500 cu. ft. (14.1 cu. m), shall pass through at least two automatic valves, in series, each of which serves as an operating valve and a safety shutoff valve. If the portable fuel cell power system is intended and marked for outdoor use only or the flammable gas supply volume does not exceed the amount referenced above, then a single automatic valve may be used.

1. Electrically-operated safety shutoff valves shall be of a type that will close upon current failure.
2. The valve closing time of safety shutoff valves shall not exceed five seconds.
3. Safety shutoff valves may perform other control functions in addition to safety shutoff.
4. Automatic valves shall comply with the applicable sections of the Standard for Automatic Valves for Gas Appliances, ANSI Z21.21•CSA 6.5, the Standard for Electrically Operated Valves, CSA C22.2 No. 139 or the Approval Standard for Liquid and Gas Safety Shutoff Valves, FM 7400 or other nationally recognized standards.

The Standard for Automatic Valves for Gas Appliances, ANSI Z21.21•CSA 6.5 is limited to pressures not exceeding 60 psi (413.7 kPa).

1.12.2 Pressure regulators shall comply with the applicable sections of the Standard for Gas Appliance Pressure Regulators, ANSI Z21.18•CSA 6.3, the Standard for Compressed Gas Regulators, ANSI/UL 252 or the Standard for Pressure Regulating Valves for LP-Gas ANSI/UL 144.

The Standard for Gas Appliance Pressure Regulators, ANSI Z21.18•CSA 6.3 is limited to pressures not exceeding 5 psi (34.5 kPa). The Standard for Compressed Gas Regulators, ANSI/UL 252 is limited to pressures not exceeding 5,500 psi.

1.12.3 The gas pressure regulator specified in Section 1.12.2 shall be equipped with a vent limiter or other means to meet the requirements of Section 1.4.2.3.b.

1.13 AIR/FLUID-HANDLING EQUIPMENT

The provisions of this section do not apply to the equipment specified in Section 1.12.

a. Electrically-operated control (general purpose) and safety valves, when for use in ordinary (non-hazardous) locations, shall comply with the applicable sections of Electrically Operated Valves, CSA C22.2 No. 139.

When for use in hazardous locations, such valves, including motor-operated and magnetically-operated devices, also shall comply with the applicable sections of the Standard for Pressure Regulating Valves for LP-Gas ANSI/UL 144.

b. Manually-operated, pressure/temperature-operated and similar shutoff valves used for flammable fluids shall comply with the applicable sections of the Standard for Valves for Flammable Fluids, UL 842.
c. Back-pressure, excess-flow and similar check valves shall comply with the applicable sections of the Standard for Flow Control Valves for Anhydrous Ammonia and LP-Gas, UL 125 or the Standard for Double Check Valve Backflow Prevention Assembly, ANSI/AWWA C510 and Reduced Pressure Principle Backflow Prevention Assembly, AWWA C511, as applicable.

d. Pressure regulating valves shall comply with the applicable sections of the Standard for LP-Gas Regulators, ANSI/UL 144, or the Standard for Regulators, ANSI/UL 252, as applicable.

e. Process control equipment and monitoring devices, such as sensors, and indicators, shall comply with the applicable sections of UL 2075, Gas and Vapor Detectors and Sensors, the Standard for Limit Controls, ANSI/UL 353, the Standard for Temperature-Indicating and -Regulating Equipment, CSA 22.2 No. 24, the Standard for Gauges Indicating Pressure for Compressed Gas, UL 404, CSA Standard CAN/CSA-C22.2 No. 1010-1, or other nationally recognized standard as appropriate for the application.

f. Fluid filtering materials shall comply with the Standard for Granular Filter Material, ANSI/AWWA B100 and be reasonably accessible for inspection and replacement.

g. Air filters shall be of a type suitable for the application and shall be reasonably accessible for inspection and replacement.

The flammability of a filter shall be classified in accordance with the Standard for Test Performance of Air Filter Units, ANSI/UL 900. The air velocity through a filter shall not exceed the filter manufacturer's recommended air velocity.

h. Liquid Fuel Filters

Liquid fuel filters shall be suitable for the maximum working pressure of the adjacent fuel system and shall be reasonably accessible for inspection and replacement.

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

1.14 AIR/FLUID-MOVING EQUIPMENT

1.14.1 Electric motors shall be designed for continuous duty and shall be provided with overload protection in accordance with the applicable sections of Canadian Electrical Code Part I (also see applicable paragraphs of Section 11 of the Standard for Commercial-Industrial Gas Heating Equipment, UL 795).

Compliance with this provision may be established by any one of the following, as applicable:

a. Unless subjected to restricted ventilation, external heat source or similar conditions, an impedance-protected motor complying with the Standard for motors with Inherent Overheating Protection CSA C22.2 No. 77, meets the intent of this provision.

b. An integral-horsepower or polyphase motor not equipped with inherent overload protection shall be protected by a motor starter equipped with overload protection.
1.14.2 Electric motors, when for use in hazardous locations, shall comply with the applicable sections of CSA Standard C22.2 No. 145 the Standard for Motors and Generators for Use in Hazardous Location.

1.14.3 Electric pumps shall comply with the applicable sections of CSA Standard C22.2 No. 108.

1.14.4 When provided, commutator motors and power ventilators shall comply with the applicable sections of CSA Standard C22.2 No. 100 and C22.2 No. 113 respectively.

1.14.5 Except for motors employed on cooling units, motors using belt drives shall be supplied with adjustable pulleys.

1.14.6 On belt-driven fans or blowers, means for adjusting the belt tension shall be provided. Belts shall be reasonably accessible for inspection and replacement.

1.14.7 Bearings of equipment covered in 1.14.1 to 1.14.6 shall be of a type suitable for the temperatures to which subjected in normal operation and, where requiring lubrication, shall be either permanently lubricated or provided with reasonably accessible means for lubrication.

1.14.8 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 container or routed to a safe place.

b. An automatic shutdown 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.

1.15 SAFETY ANALYSIS

1.15.1 The application of this section will identify safety control issues for a portable fuel cell power system design and the mitigation technique necessary to demonstrate that foreseeable risks have been reduced to an acceptable level. These safety control issues are then evaluated as necessary to confirm that the identified mitigation technique is valid.

A Failure Modes and Effects Analysis (FMEA) or equivalent reliability analysis intended to identify failures which have significant consequences affecting the system safety, shall be submitted to the testing agency for evaluation. 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.
1.15.2 The provisions of this section apply only to electrical protective equipment that comprises a safety-control circuit function of the portable fuel cell power system. A device involving electronic safety control circuits shall be investigated under the conditions of actual service to determine if it complies with all applicable requirements and it is otherwise suitable for its intended application.

1.15.3 An electronic or solid-state circuit used in a system, limiting, or safety control, including controls that require a calibration test, shall successfully complete a reliability evaluation of electronic components, in addition to complying with the specific requirements of the control. These circuits and systems shall comply with the applicable test and evaluation methods described in CSA Standard C22.2 No. 0.8.

1.15.4 Controls employing safety-related software shall be evaluated using the applicable requirements of Annex H of CSA E60730.

1.16 INSTRUCTIONS

1.16.1 Printed instructions to be referred to as the maintenance manual shall be provided with the portable fuel cell power system. 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 located, 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 under 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 under water.

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 to determine that:

   i. Any intake or exhaust openings are clear and free of obstructions.
   ii. There are no obvious signs of physical deterioration of the portable fuel cell power system
       or its support (i.e., base, frame, cabinet, etc.).

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

   The manual shall indicate the necessity and minimum frequency for these examinations and also shall
   specify the periodic inspection of the portable fuel cell power system by qualified service personnel.

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

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

m. The following statement for fuel cell power systems intended only for indoor use:

   **WARNING: FOR INDOOR USE ONLY**

n. The following statement for fuel cell power systems intended only for outdoor use:

   **WARNING: FOR OUTDOOR USE ONLY**

o. Provisions for adequate process and ventilation air, including the statement, “This portable fuel cell
   power system uses oxygen from the area in which it is being used. It should not be used in a confined
   space or unusually tight construction unless provisions are provided for adequate process and
   ventilation air.”

### 1.16.2 User's Information Manual

A user’s information manual shall be provided for a portable fuel cell power system. When appropriate,
the applicable requirements of Section 1.17.1 and 1.17.2 may be incorporated into one manual.

The user's information manuals shall be typed or typeset and formatted to provide easy-to-follow
procedures. 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:

a. 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 0.120 inch (3.05 mm). The minimum vertical spacing between lines of type shall be 0.046 inch (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.

b. 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 at least the following shall be included in the safety section with references to specific section or page of the manual.

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

2. 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.

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

4. 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."
5. 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.

6. Recommended methods for periodic cleaning of necessary parts.

7. Instructions for examining the portable fuel cell power system to determine that:
   (a) Any intake or exhaust openings are clear and free of obstructions.
   (b) There are no obvious signs of deterioration of the fuel cell.

8. Provisions for adequate process and ventilation air. This information shall include the statement, “This portable fuel cell power system uses oxygen from the area in which it is being used. It should not be used in a confined space or unusually tight construction unless provisions are provided for adequate process and ventilation air.”

9. The controlled environmental conditions for use, if the portable fuel cell power generator is for use in a controlled environment only.

c. 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.

1.17 MARKING

1.17.1 All marking materials shall be identified by class number (see below) and, when specified, shall be suitable for application to surfaces upon which applied. The designation of any class of marking shall not preclude use of marking of a lower number class.

INTEGRAL MARKING.
Class I. Marking shall be embossed, cast, stamped or otherwise formed in the part. This includes markings baked into an enameled surface.

PERMANENT PLATE.
Class IIA-1. Marking shall be made of rustproof metal having a minimum thickness of 0.012 inch (0.305 mm) and shall be securely attached by mechanical means.

Class IIA-2. Marking shall be made of rustproof metal having a thickness of 0.006 to 0.012 inch (0.152 to 0.305 mm) and shall be attached by mechanical means at all corners with a maximum spacing of 6 inches (15.2 cm) between mechanical fasteners.

Class IIA-3. Marking shall be made of rustproof metal having a thickness less than 0.006 inch (0.152 mm) and shall be attached by means of non-water-soluble adhesive.

Class IIA-4. Marking shall be made of pressure-sensitive metal foil requiring no solvent or activator.
PERMANENT LABEL.
Class IIIA-1 and IIIA-2. Marking shall be made of material not adversely affected by water and shall be attached by means of non-water-soluble adhesive.

WATERPROOF MARKING.
Class IIIB. Marking shall be printed directly on the part not adversely affected by water.

WATERPROOF LABEL.
Class IIIC. Marking shall be made of material not soluble in water, and may use water-soluble adhesive for attachment means.

NON-WATERPROOF LABEL.
Class IV. Marking shall be made of material that may be soluble in water, and may use water-soluble adhesive for attachment means.

PRINTED MARKING.
Class V. Marking shall be clear and prominent and may be applied directly by any printing means.

ATTACHED TAGS.
Class VI. Marking.

Class IIA- (3,4) and IIIA-1. Marking materials shall not be located on surfaces having temperatures exceeding 300°F (149°C), and Class IIIA-2 and IIIB marking materials shall not be located on surfaces having temperatures exceeding 175°F (79.4°C), as determined during the conduct of Section 2.4.

Class IIA- (3,4) and IIIA-(1,2). Marking materials shall demonstrate good adhesive quality, and all Class IIA and III (A,B) marking materials shall demonstrate suitable legibility, as specified in Section 2.12.

1.17.2 The equipment shall be plainly marked on Class IIIA marking material, in a place where the details will be readily visible after installation, with the following, as applicable:

a) Type of fuel;
   i) Gas supply pressures (minimum and maximum) to the portable fuel cell power system, or for units with integral fuel supply, the specific fuel container;
   ii) Fuel consumption at rated power (including the neutral current of a 3-phase, 4-wire portable fuel cell power system if larger than the phase current).

1.17.3 A fuel cell power system intended for indoor use only shall bear a label on Class IIIA marking material that is clearly visible stating:

   WARNING: FOR INDOOR USE ONLY

A fuel cell power system intended for outdoor use only shall bear a label on Class IIIA marking material that is clearly visible stating:

   WARNING: FOR OUTDOOR USE ONLY

1.17.4 Portable fuel cell power systems with ac output receptacles, shall have the status of the neutral conductor marked for each mode of operation.
Portable stand-alone fuel cell power systems, with dc output receptacles, shall be marked by one of the following, as appropriate:

- POSITIVE CONDUCTOR BONDED TO FRAME
- NEGATIVE CONDUCTOR BONDED TO FRAME
- POSITIVE AND NEGATIVE CONDUCTORS ISOLATED FROM FRAME

1.17.5 When requiring air for combustion or ventilation, the fuel cell power system shall bear a label type Class III-A or III-B or on the marking plate the following:

Do not block or obstruct air openings. The required clearances for intake and discharge air are specified in B149.1, B139 or the applicable provincial Fire Code depending on the system fuel.

1.17.6 A label of Class IIIC marking material shall, when practical, be affixed by the manufacturer to the fuel cell power system in a conspicuous location when the fuel supply capacity may exceed an amount that would create a flammable gas and air mixture greater than 25% of LFL if fully released into a tight structure having a volume not exceeding 500 cu. Ft.:

WARNING: Improper adjustment, alteration, service, or maintenance can cause property damage, personnel injury, or loss of life. Refer to the Maintenance and User Information Manual.

1.17.7 Indoor fuel cell power systems shall bear a marking, independent of any other marking, on Class IIA-1 marking material in a conspicuous location when the fuel supply capacity may exceed an amount that would create a flammable gas and air mixture greater than 25% of LFL if fully released into a tight structure having a volume not exceeding 500 cu. Ft.:

Before locating and initiating the fuel cell power system, make sure that provisions for process and ventilation air are made. Refer to the Maintenance and User Information Manual.
PART II
TESTING

Unless otherwise specified below, the fuels used in performing the following tests shall comply with the specifications provided by the manufacturer for use with the portable fuel cell power system. Natural Gas and Propane test gases shall comply with the applicable characteristics as shown in Table II:

a. A portable fuel cell power system for use with natural gas shall be tested with test gas A.

b. A portable fuel cell power system for use with liquefied petroleum gases shall be tested with test gas E. In addition, in systems having reformers, the test outlined in 2.19 (Burner Operating Characteristics), shall be conducted with test gas D after rating and adjustment with this fuel gas.

2.1 ULTIMATE STRENGTH

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 100% their maximum allowable working pressure.

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

Any listed or similarly-recognized part(s), when pressure-rated at or greater 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 if they operate at the same pressure.

2.1.1 Method of Test

Prior to conduct of this test, it shall be established which liquid-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.

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.

2.1.2 All parts, including joints and connections, that convey a flammable gas 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 $1/2$ psi, an internal static pressure of 5 times (except three times for the fuel cell stack)
their maximum allowable working pressure.

b. For portable fuel cell power systems, or components thereof, subject to a maximum working pressure over 1/2 psi, but not exceeding 125 psi, the test pressure to be used shall be no less than 100% maximum allowable working pressure.

c. For portable fuel cell power systems, or components thereof, subject to a maximum working pressure exceeding 125 psi, the maximum allowable working pressure shall not exceed a value that produces a hoop stress in the piping or component greater than 50 percent of the specified minimum yield strength of the pipe or component.

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 assembly 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.

2.2 LEAKAGE TEST FOR LIQUID FUEL SYSTEMS

Any part(s) judged suitable under Section 1.4.1-c and any part(s) constructed of elastomeric, polymeric or similar material, shall comply with the applicable provision of this section following exposure to a continuous operating period of not less than 720 hours, or submittal by the manufacturer of evidence indicating such exposure.

2.2.1 Liquid fueled systems may be tested for preliminary leak tightness with water if the manufacturer so permits.

Liquid fueled systems must be tested with their proper fuel for final leak testing. Methanol fueled systems shall be tested with the manufacturer’s specified concentration of methanol. Ethanol fueled systems shall be tested with the manufacturer’s specified concentration of ethanol. Diesel or gasoline or kerosene or naphtha fueled systems shall be tested with fuel meeting the specifications of the manufacturer for use with the power system, with the provision that solid particulate shall be filtered out prior to filling the system with particulate filters meeting the requirements of the manufacturer.

All parts that convey liquid fuel shall not show any evidence of liquid leakage when pressurized at 1.5 times their maximum operating pressure. The pressure shall be set and monitored continuously for a minimum of one hour while checking continuously for leakage. All external surfaces of the parts that convey liquids shall be made visible to check for leakage, or provisions shall be made to capture and route leakage down-slope to a suitable telltale. 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.

Method of Test

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. Standard 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 by a calibration lab using appropriate metrology procedures and calibration standards traceable to the National Bureau of Standards or other nationally recognized standards.

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 that 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. Any evidence of leakage is cause for failing the test.

2.3 FLAMMABLE GAS CONCENTRATION TEST

This test shall determine the maximum flammable gas concentration within the system enclosure under normal operation.

The Portable Fuel Cell System shall be operated within the nominal temperature range until steady state conditions are achieved. The testing shall be carried in an area free from appreciable draughts.

Four 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. If there are air intakes or openings along the ventilation air path, measurements shall be made upstream of these points as well.

The test shall be continued until four consecutive measurements have shown that the increase in the flammable concentration does not exceed by more than 5% the mean of the four measurements. The time interval between measurements shall be not less than 30 min.

The test shall be carried out at least twice.

The test is satisfactory if the concentration of flammable gas is less than 25% of the lower flammability limit.
2.4 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) specified below:

MAXIMUM SURFACE TEMPERATURES, °F (°C)*

<table>
<thead>
<tr>
<th>Material</th>
<th>Temperature, °F (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bare or painted metal</td>
<td>152 (67)</td>
</tr>
<tr>
<td>Porcelain Enamel</td>
<td>160 (72)</td>
</tr>
<tr>
<td>Glass</td>
<td>172 (79)</td>
</tr>
<tr>
<td>Plastic**</td>
<td>182 (84)</td>
</tr>
</tbody>
</table>

* Temperatures are based on a 77°F (25°C) room temperature. When the room temperature is other than 77°F (25°C), the allowable temperatures are to be increased or decreased 1 degree for each degree of room temperature greater or less than 77°F (25°C).

** Includes plastic with a metal plating not more than 0.005 inch (0.127 mm) thick and metal with a plastic or vinyl covering not less than 0.005 inch (0.127 mm) thick.

Method of Test

Surfaces to be measured shall be clean or, when necessary, shall be cleaned to remove foreign particles. Surface temperatures shall be measured using the probe shown in Figure 2 (Temperature-Measuring Probe). For each measurement, the probe is to be at the ambient temperature, and then is to be heated for 15 seconds to approximately the temperature of the surface under consideration. The probe then is to be applied to the surface with a 5 pound (22 N) force for 10 seconds.

The probe is to be moved from the preheat position to the surface as quickly as possible, and is to be applied so the tip will fully contact the surface. The tip is considered to be the disc and the flat surface of the cork surrounding the disc.

The portable fuel cell power system shall be operated at the normal test pressures specified by the manufacturer, at the rated voltage and frequency, and within 5 percent of the rated fuel consumption and 2 percent of the rated power output specified by the manufacturer. When equilibrium conditions are attained, temperatures shall be determined for any surface(s) that can be fully contacted by the flat tip of the test probe specified above.
2.5 WIND AND RAIN TEST (OUTDOOR USE ONLY)

2.5.1 Wind Test

The procedures of this section apply only to 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 31 miles per hour (50 km/h).

Method of Test

A wind, produced by a fan/blower of sufficient capacity to develop a draft having a velocity up to and including 31 miles per hour (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 18 inches (45.7 cm) from the windward surface of the portable fuel cell power system.

If applicable, fuel cell power systems with reformers or gas heaters when subjected to a wind having a nominal velocity of 10 miles per hour (16 Km/h), the pilot, when provided, shall be capable of being ignited.

With the power plant subjected to a wind having a nominal velocity of 31 miles per hour (50 Km/hr), the burner gas shall ignite from the ignition device without excessive delay and the burner and pilot flames shall not extinguish. The pilot, when provided, shall be operated alone, as well as simultaneously with the burner.

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

2.5.2 Rain Test

Outdoor fuel cell power systems shall start and operate normally, without damage or malfunctioning of any part and without creating the risk of electric shock, when subjected to a simulated rainstorm.

Method of Test

The spray heads of the rain test apparatus described in Figures 3 and 4 shall be placed in position, with respect to the power plant or portion(s) thereof, deemed most critical by the testing agency.

The rain test apparatus then shall be placed in operation and each spray head adjusted by means of the control valve to operate at 5 psi (34.5 kPa). The spray head unit shall be adjusted to varying elevations and horizontal distances from the power plant to determine the most critical location. The exposure at the position deemed most critical by the testing agency shall be maintained throughout the test.

After adjustment of the spray head unit, the rain test apparatus shall be operated for 15 minutes, at which time the power plant shall be placed in operation as specified in Section 2.15.3. The equipment shall continue in operation until it is determined that the power plant functions normally during exposure to the simulated rainstorm.
Upon completion of exposure to the simulated rainstorm, there shall be no evidence of damage or malfunctioning of any part of the power plant, nor detrimental accumulation of water in any part of the power plant. The test is not to result in the entrance of water into an electrical enclosure above the lowest live part or in wetting live parts, except motor windings may be judged by the electric withstand test provided the motor(s) is constructed, located or shielded so the windings are not directly exposed to water.

The above test procedure shall be repeated with the spray heads located in any other position(s), with respect to the power plant, deemed necessary by the testing agency.

At the conclusion of this test, a power plant also shall comply with the leakage current test and with the dielectric strength test.

2.6 CONTAINER PRESSURE TEST

All containers shall withstand a hydrostatic pressure test of 150 percent of the maximum storage pressure, unless they are pressure vessels, in which case they shall comply with hydrostatic strength requirements Boiler, and Pressure Vessel, and Pressure Piping Code, CSA B51 or containers for the transport of dangerous goods, in which case they shall comply with the hydrostatic strength requirements from CSA B339.

2.7 STABILITY

2.7.1 Under conditions of normal use, portable fuel cell power systems shall not become physically unstable.

Under conditions of normal use, a stabilizing means, if needed, shall be automatic in operation when drawers, doors, etc., are opened.

During operations the stabilizing means, if needed, shall either be automatic in operation, or a marking shall be provided to instruct the user to deploy the stabilizing means.

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 that 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 10° 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.
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 12.5 cm by 20 cm. 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.

2.8 LIFTING MEANS

2.8.1 If means such as a handle, eyelet or lug are provided for the purpose of lifting a portable fuel cell generator, these shall be capable of withstanding the mechanical stress of a static pull with a force calculated from the mass of the portable fuel cell generator as follows:

For portable fuel cell generators of less than 150 kg a force calculated from 10 times the mass shall be used.

For portable fuel cell generator of 150 kg or more a force calculated from four times the mass or at least 15 kN shall be used.

2.8.2 If only a single lifting means is provided, it shall be designed so that a torque applied during lifting cannot cause it to be loosened.

2.8.3 The portable fuel cell generator shall be fitted with all the associated attachments that are likely to be installed. The portable fuel cell generator shall be anchored rigidly at its base and a chain or cable shall be attached to it’s lifting means, as recommended by the manufacturer, and an upward force shall then be exerted continuously for 10 s.

2.8.4 If two or more lifting means are provided, the chains or cables shall be arranged so that the force is equally shared between them and is applied at an angle not greater that 15 deg. to the vertical.

2.8.5 The results of the tests specified in Section 2.8.3 shall be considered acceptable if:

a) an uninsulated live part is or a moving part that may involve a risk of injury to persons cannot be contacted by the probe (see Figure 1);

b) the sample complies with the dielectric strength test specified in the CSA Standard C22.2 No. 107.1, with the test potential applied between live parts and accessible non-current carrying metal parts.

2.9 ADHESION AND LEGIBILITY OF MARKING MATERIALS

The adhesive quality of Class IIA-(3,4) and IIIA-(1,2) marking materials and the legibility of all Class IIA and III(A,B) marking materials shall not be adversely affected when the marking materials are exposed to heat, cold and moisture as specified below.

Class IIA-(3,4) and IIIA-(1,2) marking materials complying with the applicable sections of the Standard for Adhesive Labels, CSA C22.2 No. 0.15, shall be considered as complying with this section. The marking materials also shall be temperature-rated at or below the minimum ambient temperature specified by the manufacturer.
Method of Test

Adhesive type marking materials shall be applied to surfaces having the particular type of finish used on the portable fuel cell power system in production. A suitable test panel of this finish shall be cleaned with a solvent and dried. Half of the panel shall be wiped with a clean cloth lightly oiled with SAE-30 medium machine oil. Two samples of the marking material shall be applied to the panel, one on the dry area and one on the oiled area. Each sample shall be applied with firm pressure, unless otherwise specified by the manufacturer's application instructions.

Both samples of the marking material then shall be allowed to set for 24 hours. Following this period, each sample shall exhibit:

a. Good adhesion (1) with no curling at its edges and (2) when a dull metal blade (such as the back of a pocketknife blade) is held at 90 degrees (1.57 rad.) to the applied marking material and scraped across its edges, and
b. Suitable legibility with no illegible or defaced printing when rubbed (back and forth ten times) with thumb or finger pressure.

Non-adhesive type marking materials also shall comply with the procedure specified in "b". Two samples of the marking material shall be used.

The above samples then shall be placed in a suitable chamber for two weeks with the chamber temperature maintained at 350°F (177°C) for Class IIA-(1,2), IIA(3,4) and IIIA-1 marking materials or 250°F (121°C) for Class IIIA-2 and IIIB marking materials. This procedure shall be repeated for all marking materials, but with the chamber temperature maintained at the minimum ambient temperature specified by the manufacturer. Following exposure to these temperatures, adhesion (when applicable) and legibility of the samples shall be checked again as specified above.

The same samples then shall be immersed in water for 24 hours. Following this period, adhesion (when applicable) and legibility of the samples shall be rechecked as specified above.

Good adhesion (when applicable) and legibility qualities shall be obtained for all samples under the test conditions specified above. Final acceptance of marking materials shall be the marking material to the portable fuel cell power system.

2.10 FLAMMABLE GAS ACCUMULATION

Reliable means (see Section 1.4.2.3 (b)) 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 500 cu. ft. (14.1 cu. m), and 50% or the lower flammability limit at the system outlet boundary 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.

2.10.1 This test procedure shall verify the functionality of the reliable means provided to prevent accumulation of fuel gas.
2.10.2 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; or

b. Have interior length, width, and height measurement each between 7.5 and 8.5 feet, with a total interior volume not exceeding 500 cubic feet.

2.10.3 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.

2.10.4 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.

2.10.5 Using ASTM E779, the flow rate pressurizing the room shall be adjusted using the equation $Q = c(\bar{N}P)^n$ to achieve the desired air change per hour (ACH).

2.10.6 Abnormal Operation

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 litre per minute shall be introduced, and the leakage 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 litre per minute shall be introduced, and the leakage 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.

2.11 OXYGEN DEPLETION

The following requirements apply to portable fuel cell power systems where the fuel supply capacity may exceed an amount that may exceed an amount that is capable of depleting the oxygen content below 18 percent of a tight structure having a volume not exceeding 500 cu. ft. (14.1 cu. m).

Reliable means (see Section 1.4.2.3 (b)) shall be provided to prevent depletion of oxygen from reaching 18 percent of the atmosphere operating within a tight structure having a volume of 500 cu. ft. (14.1 cu. m).

2.11.1 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 500 cu. ft. (14.1 cu. m).

2.11.2 The tight structure shall comply with the provisions of 2.10.2.
2.11.3 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.

2.11.4 Normal Operation

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.

The room air temperature shall be maintained at 80°C ± 5°C. Room air temperature shall be measured with at least 5 thermocouples at different levels and plan locations. The thermocouples shall be shielded from direct radiation from the appliance under test. Room atmosphere shall be sampled at the same locations. The average of 5 separate room atmosphere measurement, or a single measurement through the use of a manifold which mixes samples shall be used. Air circulation within the room shall be provided to evenly mix the atmosphere and not interfere with the operation of the appliance under test. The air will be considered evenly mixed when the temperature readings, as indicated by the 5 thermocouples in the room, do not differ by more than 3°C during the test.

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.

2.12 TIP TEST

2.12.1 For this test the portable fuel cell generator shall be equipped with all associated attachments that are likely to be installed.

2.12.2 The portable fuel cell generator shall be tipped over onto its side in the direction most likely to produce adverse results.

2.12.3 All fuel and/or liquid containing parts shall be full.

2.12.4 The results of the tests specified in Section 2.12.2 shall be considered acceptable if:

a) an uninsulated live part or a moving part that may involve a risk of injury to persons cannot be contacted by the probe (see Figure 1);
b) the sample complies with the dielectric strength test specified in CSA Standard C22.2 No. 107.1, with the test potential applied between live parts and accessible non-current-carrying metal parts.
c) There is no leakage of fuel or other liquid.

2.13 DROP TEST

2.13.1 A portable fuel cell generator shall be capable of withstanding a drop test. For this test the portable fuel cell generator shall be equipped with all associated attachments that are likely to be installed.

The heights for the drop test shall be as follows:

a) A portable fuel cell generator having a mass of 15 kg and less shall be dropped three times on a concrete surface from a height of 0.9 m to strike a surface in the positions most likely to produce adverse results.
b) A portable fuel cell generator having a mass of more than 15 kg shall be dropped three times on a concrete surface from a height of 100 mm to strike a surface in the positions most likely to produce
adverse results.

2.13.2 The results of the tests specified in Section 2.13.1 shall be considered acceptable if:

   a) an uninsulated live part or a moving part that may involve a risk of injury to persons cannot be contacted by the probe (see Figure 1);
   b) the sample complies with the dielectric strength test specified in Section the CSA Standard C22.2 No. 107.1, with the test potential applied between live parts and accessible non-current-carrying metal parts.

2.14 DISCHARGE TEMPERATURE

Indoor fuel cell power systems shall not discharge any effluents (ventilation air, or effluents from the reformer) at a temperature above ambient by more than 155.5°C (280°F).

2.15 TEST PRESSURES FOR OUTDOOR PORTABLE POWER SYSTEMS CONNECTED TO A FUEL UTILITY DISTRIBUTION SYSTEM

2.15.1 Natural Gas and Propane Test Pressures

Fuel cell power systems with reformers shall be tested for Open Room Emissions (2.18), Burner Operating Characteristics (section 2.19), and Automatic Ignition Systems (section 2.20). The tests under sections 2.18, 2.19, and 2.20 shall be conducted at normal inlet test pressure, at reduced inlet test pressure and at increased inlet test pressure, in accordance with (a) below, as shown in Table III. Tests to be conducted according to 'b' below, shall be conducted at inlet test pressures at the discretion of the testing agency.

   a) For portable power systems operating at normal atmospheric inlet gas pressure, the test pressure shall be as shown in Table III.
   b) For portable power systems operating at pressures higher than shown in Table III, the power plant shall be tested over the range of gas inlet pressures shown on the label required in 1.17.2 a(i).

The inlet test pressures shall be the pressures immediately ahead (upstream) of all fuel gas controls at the connection to the power plant. The manifold pressure, when applicable, shall approximate that recommended by the manufacturer.

2.15.2 Test Gas Pressures When Fuel Fired Boilers or Heating Equipment Is Used

The tests conducted under 2.18 (emission of effluents, open room) and 2.19 (burner operating characteristics) shall be performed: 1) with any fuel-fired boiler or heating equipment in place and operating at normal test pressure; 2) at the minimum and maximum test pressures specified by the manufacturer unless provisions are made to prevent operation at those pressures.

2.15.3 Operation

Unless otherwise stated the power system shall be operated at the normal test pressures specified by the manufacturer, operated at the rated voltage and frequency, and operated within 5 percent of the rated fuel consumption and 2 percent of the rated power output specified by the manufacturer.

2.16 TEST PRESSURES FOR PORTABLE POWER SYSTEMS NOT CONNECTED TO A FUEL UTILITY DISTRIBUTION SYSTEM
2.16.1 Test Pressures

Portable power systems with reformers shall be tested for Emissions (sections 2.17, and 2.18), Burner Operating Characteristics (section 2.19), and Automatic Ignition Systems (section 2.20). These shall consist of a series of three tests: one at normal test pressure, one at reduced test pressure, and one at increased test pressure, as shown in TABLE IV.

2.16.2 Operation

Unless otherwise stated the power system shall be operated at the normal test pressures specified by the manufacturer, operated at the rated voltage and frequency, and operated within 5 percent of the rated fuel consumption and 2 percent of the rated power output specified by the manufacturer.

2.17 EMISSION OF EF_FLUENTS – OPEN ROOM

A portable fuel cell power system capable of producing carbon monoxide shall not produce a concentration of carbon monoxide in excess of 0.02 percent 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 between 85 percent and 110 percent of the rated output voltage 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.

2.18 BURNER OPERATING CHARACTERISTICS

The procedures of this section are associated with the start burner of a reformer section and shall be performed with the burner both hot and cold.

2.18.1 The automatic ignition system shall effect ignition of burner fuel gas immediately after the gas reaches the burner port(s).

2.18.2 During any tests specified in this standard:

a. The burner fuel shall ignite effectively without delayed ignition, flashback, undue noise or damage to the reformer section,
b. The burner flames shall extinguish without flashback and undue noise,
c. The burner flames shall not flash outside the combustion chamber,
d. The burner shall not deposit carbon, and
e. There shall be no back pressure at the burner mixer face.
f. Burner flames shall carry to all ports and burn in all ports.
2.19 AUTOMATIC IGNITION SYSTEMS

The procedures of this section are associated with the start burner of a reformer section.

2.19.1 Under the conditions of voltage variation specified below, an automatic ignition system either shall (1) ignite burner fuel within 4 seconds after the fuel reaches the burner port(s) or (2) lock out within the lockout time at voltages to the igniter of less than 85 percent of the rated voltage.

For purposes of this test, the control manufacturer's specified maximum lockout time shall be used.

Method of Test

These tests shall be conducted under the following voltage conditions:

a. Undervoltage.
   The voltage to the control system shall be adjusted to 85 percent of the rated voltage.

b. Overvoltage.
   The voltage to the control system shall be adjusted to 110 percent of the rated voltage.

   Under the conditions specified above, ignition cycles shall be repeated 10 times.

   In each case, the automatic ignition system shall ignite burner fuel gas within 4 seconds after the fuel reaches the burner port(s).

2.19.2 The time from initiation of fuel flow to proof of the ignition source or burner flame, as applicable, shall not exceed the appropriate flame-establishing period.

For purposes of this test, the control manufacturer's specified maximum flame-establishing period shall be used.

2.19.3 The primary safety control shall de-energize all fuel safety shutoff valves within the flame failure response time in the event of burner flame outage during an operational cycle.

With a recycling system, pilot fuel need not be shut off until the primary safety control is required to assume a lockout position.

For purposes of this test, the control manufacturer's specified maximum flame failure response time shall be used.

Method of Test

The reformer section shall be operated until equilibrium conditions are attained. The fuel supply then shall be shut off manually; the flame failure response timing shall begin when all flames are extinguished and shall end when the safety shutoff valve closes. The flame failure response time shall not exceed the specified maximum timing.

For test purposes only, the manual valve used for attaining the flame outage condition may be located either upstream or downstream from all other fuel supply components to simulate flame outage without loss of pressure, as deemed appropriate by the testing agency for the control system under test.
2.19.4 A pilot, when provided, shall effect safe ignition of fuel at the burner when the pilot fuel supply is reduced to an amount just sufficient to keep the safety shutoff valve open or just above the point of flame extinction, whichever represents the higher pilot fuel rate.

For purposes of this test, the control manufacturer's specified maximum flame failure response time shall be used.
### TABLE I

**MINIMUM CORROSION PROTECTION OF FERROUS MATERIALS USED IN THE CONSTRUCTION OF FUEL CELL POWER SYSTEMS FOR OUTDOOR INSTALLATION**

<table>
<thead>
<tr>
<th>POWER SYSTEM PART</th>
<th>METAL THICKNESS</th>
<th>COMPLIANCE WITH NOTE(S):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside Casing</td>
<td>Not less than 0.0508 inch (1.29 mm)</td>
<td>1, 2 or 3</td>
</tr>
<tr>
<td>Outside Casing</td>
<td>Less than 0.0508 inch (1.29 mm)</td>
<td>4, 5, 6, 7 or 8</td>
</tr>
<tr>
<td>Outside cabinet which is the sole enclosure of current carrying parts</td>
<td>Of any thickness</td>
<td>4, 5, 6, 7 or 8</td>
</tr>
</tbody>
</table>

### NOTES APPLICABLE TO TABLE I

1. Hot-dipped mill galvanized sheet steel conforming with the coating designation G60 or A60 specified in Table I of Specification for General Requirements, for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, ASTM A525, with not less than 40 percent of the zinc on either side. The weight of zinc coating may be determined by any suitable method. However, in case of question, the weight of coating shall be established in accordance with Methods of Test for Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles, ASTM A90/A90M. A hot-dipped mill galvanized A60 (alloyed) coating or an annealed zinc coating which is bent or similarly formed after annealing shall be additionally painted in the bent or formed area if the bending or forming process damages the zinc coating, except on the inside surfaces of a cabinet or enclosure not exposed to water when tested in accordance with 2.33.5. (This shall also apply to annealed coatings complying with Notes 2 and 5);

2. A zinc coating, provided by a method other than that specified in Note 1, uniformly applied to an average thickness of not less than 0.00041 inch (0.0104 mm) on each surface with a minimum thickness of 0.00034 inch (0.0086 mm). The thickness of the coating shall be established in accordance with Method for Measurement of Metal and Oxide Coating Thicknesses by Microscopical Examination of a Cross Section, ASTM B487, Method for Measurement of Coating Thicknesses by the Magnetic Method: Nonmagnetic Coatings on Magnetic Basis Metals, ASTM B499 or Method for Measurement of Thickness of Metallic Coatings by the Coulometric Method, ASTM B504; or

3. Two coats of an organic finish of the epoxy or alkyd-resin type or other outdoor paint on both surfaces. The suitability of the paint may be determined by consideration of its composition or by corrosion tests if these are considered necessary.

4. Hot-dipped mill galvanized sheet steel conforming with the coating designation G90 specified in Table I of ASTM A525, with not less than 40 percent of the zinc on either side. The weight of zinc coating may be determined by any suitable method. However, in case of question, the weight of coating shall be established in accordance with ASTM A90;

5. A zinc coating, provided by a method other than that specified in Note 4, uniformly applied to an average thickness of not less than 0.00061 inch (0.0155 mm) on each surface, with a minimum thickness of 0.00054 inch (0.0137 mm). The thickness of the coating shall be established in accordance with ASTM B487, B499 or B504;

6. A cadmium coating not less than 0.001 inch (0.0254 mm) thick on both surfaces. The thickness of coating shall be established in accordance with ASTM B487, B499 or B504;

7. A zinc coating conforming with Note 1 or 2 with one coat of outdoor paint of the type specified in Note 3 applied to the outside surface; or

8. A cadmium coating not less than 0.00075 inch (0.0191 mm) thick on both surfaces with one coat of outdoor paint on both surfaces, or not less than 0.0005 inch (0.0127 mm) thick on both surfaces with two coats of outdoor paint on both surfaces. The thickness of the cadmium coating shall be established in accordance with ASTM B487, B499, or B504, and the paint shall be as specified in Note 3.
### TABLE II

**CHARACTERISTICS OF TEST GASES**

<table>
<thead>
<tr>
<th>Heating Value</th>
<th>(Btu/ft²)</th>
<th>(MJ/m²)</th>
<th>Sp Gr(Air = 1.0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas A (Natural)</td>
<td>1075</td>
<td>(40.1)</td>
<td>0.65</td>
</tr>
<tr>
<td>Gas D (n-Butane)</td>
<td>3200</td>
<td>(119.2)</td>
<td>2.00</td>
</tr>
<tr>
<td>Gas E (Propane HD-5)</td>
<td>2500</td>
<td>(93.1)</td>
<td>1.55</td>
</tr>
</tbody>
</table>

### TABLE III

**INLET TEST PRESSURES**

<table>
<thead>
<tr>
<th>Test Gas</th>
<th>Normal</th>
<th>Reduced</th>
<th>Increased</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>7.0 (1.74)</td>
<td>3.5 (0.87)</td>
<td>10.5 (2.61)</td>
</tr>
<tr>
<td>D</td>
<td>11.0 (2.74)</td>
<td>8.0 (1.99)</td>
<td>13.0 (3.23)</td>
</tr>
<tr>
<td>E</td>
<td>11.0 (2.74)</td>
<td>8.0 (1.99)</td>
<td>13.0 (3.23)</td>
</tr>
</tbody>
</table>

### TABLE IV

**Test Pressure, Percent of Manufacturer's Specified**

<table>
<thead>
<tr>
<th>Test Conditions</th>
<th>Regulator Outlet Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced</td>
<td>73</td>
</tr>
<tr>
<td>Normal</td>
<td>100</td>
</tr>
<tr>
<td>Increased</td>
<td>118</td>
</tr>
</tbody>
</table>
Note: All dimensions are in millimeters

Figure 1. Articulated Probe
Figure 2. Temperature-Measuring Probe

* Dimensions shown above are based on use of the following purchased parts:
  Marlin 1060 Iron-Constantan Plug
  Marlin 1050 Tube Adapter
  #C420-045-1000 Spring
  (Associated Spring Corp.)

** This dimension will vary so that 5 lbs. (22.2 N) calibration will align with reference mark on probe shaft.
Figure 3. Arrangement of Spray Heads and Associated Piping for Simulated Rainstorm Test
Figure 4 Spray Head Assembly and Details of Construction