



UL 2267

STANDARD FOR SAFETY

Fuel Cell Power Systems for Installation in Industrial Electric Trucks

UL Standard for Safety for Fuel Cell Power Systems for Installation in Industrial Electric Trucks, UL 2267

Third Edition, Dated March 26, 2020

Summary of Topics

This revision of UL 2267 dated February 12, 2025 includes the following changes in requirements:

– Revision to truck types for use with fuel cells; [1.1](#), [6.1](#), [6.2](#) (deleted), [6.3](#) (deleted)

Text that has been changed in any manner or impacted by ULSE's electronic publishing system is marked with a vertical line in the margin.

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated December 27, 2024.

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Fuel Cell Power Systems for Installation in Industrial Electric Trucks

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March 26, 2020

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The most recent designation of UL 2267 as an American National Standard (ANSI) occurred on February 12, 2025. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, and Title Page.

Comments or proposals for revisions on any part of the Standard may be submitted to ULSE at any time. Proposals should be submitted via a Proposal Request in the Collaborative Standards Development System (CSDS) at <https://csds.ul.com>.

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INTRODUCTION

1 Scope

1.1 These requirements cover fuel cell power systems intended to be installed in Type E, Type CGH, or Type E or CGH industrial trucks used in locations as defined in the Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operations, NFPA 505, the National Electrical Code, NFPA 70, and the Standard for Electric-Battery-Powered Industrial Trucks, UL 583.

1.2 The fuel cell power systems covered by this Standard are anticipated for use as described in the following standards as applicable to the intended truck:

- a) Safety Standard for Low Lift and High Lift Trucks, ITSDF B56.1;
- b) Safety Standard for Guided Industrial Vehicles and Automated Functions of Manned Industrial Vehicles, ITSDF B56.5;
- c) Safety Standard for Rough Terrain Forklift Trucks, ITSDF B56.6;
- d) Safety Standard for Industrial Crane Trucks, ITSDF B56.7;
- e) Safety Standard for Personnel and Burden Carriers, ITSDF B56.8;
- f) Safety Standard for Operator Controlled Industrial Tow Tractors, ITSDF B56.9; and the
- g) Safety Standard for Manually Propelled High Lift Industrial Trucks, ITSDF B56.10.

1.3 These requirements cover fuel cell power systems that incorporate a permanently mounted pressure vessel containing compressed hydrogen gas.

1.4 These requirements cover the use of designs that are fueled by hydrogen gas without the pressure vessel being removed from the industrial truck (onboard fueling).

1.5 These requirements cover only the fuel cell and fuel cell balance of plant components including the power and/or power conditioning electronics, regardless of packaging, as defined in [5.11](#) and [Figure 5.1](#), as well as any components in classified zones.

2 Components

2.1 A component of a product covered by this Standard shall:

- a) Comply with the requirements for that component;
- b) Be used in accordance with its rating established for the intended conditions of use;
- c) Be used within its established use limitations or conditions of acceptability; and
- d) Comply with the applicable requirements of this end product Standard.

2.2 A component of a product covered by this Standard is not required to comply with a specific component requirement that:

- a) Involves a feature or characteristic not required in the application of the component in the product;

- b) Is superseded by a requirement in this Standard; or
- c) Is separately investigated when forming part of another component, provided the component is used within its established ratings and limitations.

2.3 Specific components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions.

2.4 A component that is also intended to perform other functions such as overcurrent protection, ground-fault circuit-interruption, surge suppression, any other similar functions, or any combination thereof, shall additionally comply with the requirements of the applicable UL Standard that covers devices that provide those functions.

3 Units of Measurement

3.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

4 Referenced Publications

4.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.

4.2 The following publications are referenced in this Standard:

ANSI:

ANSI HGV 2, *Compressed Hydrogen Gas Powered Vehicle Fuel Containers*

ANSI/IAS NGV 4.2, *Hoses for Natural Gas Vehicles and Dispensing Systems*

ANSI Z21.24/CSA/CGA 6.10, *Connectors for Gas Appliances*

ANSI Z535.1, *American National Standard for Safety Colors*

ANSI Z535.3, *American National Standard for Criteria for Safety Symbols*

ANSI Z535.4, *American National Standard for Product Safety Signs and Labels*

ASME:

ASME B31, *Code for Pressure Piping*

ASME B31.3, *Process Piping*

ASTM:

ASTM D3580, *Standard Test Methods for Vibration (Vertical Linear Motion) Test of Products*

ASTM D5112, *Standard Test Method for Vibration (Horizontal Linear Motion) Test of Products*

ASTM E230/E230M, *Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples*

ASTM F1459, *Standard Test Method for Determination of the Susceptibility of Metallic Materials to Hydrogen Gas Embrittlement (HGE)*

ASTM G142, *Standard Test Method for Determination of Susceptibility of Metals to Embrittlement in Hydrogen Containing Environments at High Pressure, High Temperature, or Both*

CFR:

CFR 1910.145, (OSHA) Specifications for Accident Prevention Signs and Tags

CGA:

CGA G-5.5, *Hydrogen Vent Systems*

CSA:

CSA HGV 3.1, *Fuel System Components for Compressed Hydrogen Gas Powered Vehicles*

CSA HPIT 1, *Compressed Hydrogen Powered Industrial Truck On-Board Fuel Storage and Handling Components*

CSA HPIT 2, *Dispensing Systems and Components for Fueling Hydrogen Powered Industrial Trucks*

CSA HPRD1, *Thermally Activated Pressure Relief Devices for Compressed Hydrogen Vehicle Fuel Containers*

IEC:

IEC 60079-10-1, *Explosive Atmospheres – Part 10-1: Classification of Areas – Explosive Gas Atmospheres*

IEC 60529, *Degrees of Protection Provided by Enclosures (IP Code)*

IEC 60812, *Analysis Techniques for System Reliability – Procedure for Failure Mode and Effects Analysis (FMEA)*

IEC 61025, *Fault Tree Analysis (FTA)*

IEC 61508 (all parts), *Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems*

IEC/ISO:

IEC/ISO 31010, *Risk Management - Risk Assessment Techniques*

ISO:

ISO 4080, *Rubber and Plastics Hoses and Hose Assemblies – Determination of Permeability to Gas*

ISO 12100, *Safety of Machinery – General Principles for Design – Risk Assessment and Risk Reduction*

ISO 13849-1, *Safety of machinery – Safety-Related Parts of Control Systems – Part 1: General Principles for Design*

ISO 13849-2, *Safety of Machinery – Safety-Related Parts of Control Systems – Part 2: Validation*

ISO 15916, *Basic Considerations for the Safety of Hydrogen Systems*

ISO 19881, *Gaseous Hydrogen – Land Vehicle Fuel Containers*

ISO 26262, *Road Vehicles – Functional Safety* (all parts)

MIL (DoD):

MIL-STD-882E, *System Safety*

NFPA:

NFPA 54, *National Fuel Gas Code*

NFPA 70, *National Electrical Code*

NFPA 70E, *Standard for Electrical Safety in the Workplace*

NFPA 79, *Electrical Standard for Industrial Machinery*

NFPA 497, *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*

NFPA 505, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operations*

SAE:

SAE J517, *Hydraulic Hose*

SAE J1127, *Low Voltage Battery Cable*

SAE J1128, *Low Voltage Primary Cable*

SAE J1654, *Unshielded High Voltage Primary Cable*

SAE J1678, *Low Voltage Ultra Thin Wall Primary Cable*

SAE J1739, *Potential Failure Mode and Effects Analysis in Design (Design FMEA), Potential Failure Mode and Effects Analysis in Manufacturing and Assembly Processes (Process FMEA)*

SAE J2601, *Fueling Protocols for Light Duty Gaseous Hydrogen Surface Vehicles*

SAE J2601-3, *Fueling Protocol for Gaseous Hydrogen Powered Industrial Trucks*

SAE J2579, *Standard for Fuel Systems in Fuel Cell and Other Hydrogen Vehicles*

SAE J2600, *Compressed Hydrogen Surface Vehicle Refueling Connection Devices*

SAE J2719, *Hydrogen Fuel Quality for Fuel Cell Vehicles*

UL:

UL 50E, *Enclosures for Electrical Equipment, Environmental Considerations*

UL 79, *Power-Operated Pumps for Petroleum Dispensing Products*

UL 157, *Gaskets and Seals*

UL 429, *Electrically Operated Valves*

UL 458, *Power Converters/Inverters and Power Converter/Inverter Systems for Land Vehicles and Marine Crafts*

UL 507, *Electric Fans*

UL 536, *Flexible Metallic Hose*

UL 583, *Electric-Battery-Powered Industrial Trucks*

UL 705, *Power Ventilators*

UL 746A, *Polymeric Materials – Short Term Property Evaluations*

UL 746C, *Polymeric Materials – Use in Electrical Equipment Evaluations*

UL 778, *Motor-Operated Water Pumps*

UL 810A, *Electrochemical Capacitors*

UL 840, *Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment*

UL 842, *Valves for Flammable Fluids*

UL 969, *Markings and Labeling Systems*

UL 991, *Tests for Safety-Related Controls Employing Solid-State Devices*

UL 1004-1, *Rotating Electrical Machines – General Requirements*

UL 1004-2, *Impedance Protected Motors*

UL 1004-3, *Thermally Protected Motors*

UL 1012, *Power Units Other Than Class 2*

UL 1310, *Class 2 Power Units*

UL 1450, *Motor-Operated Air Compressors, Vacuum Pumps, and Painting Equipment*

UL 1581, *Reference Standard for Electrical Wires, Cables, and Flexible Cords*

UL 1642, *Lithium Batteries*

UL 1741, *Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources*

UL 1836, *Electric Motors and Generators for Use in Class I, Division 2, Class I, Zone 2, Class II, Division 2 and Zone 22 Hazardous (Classified) Locations*

UL 1989, *Standby Batteries*

UL 1998, *Software in Programmable Components*

UL 2075, *Gas and Vapor Detectors and Sensors*

UL 2580, *Batteries for Use In Electric Vehicles*

UL 2271, *Batteries for Use in Light Electric Vehicle Applications*

UL 5085-1, *Low Voltage Transformers – Part 1: General Requirements*

UL 5085-3, *Low Voltage Transformers – Part 3: Class 2 and Class 3 Transformers*

UL 60730-1, *Automatic Electrical Controls for Household and Similar Use, Part 1: General Requirements*

UL 60950-1, *Information Technology Equipment – Safety – Part 1: General Requirements*

5 Glossary

5.1 For the purpose of this Standard, the following definitions apply.

5.2 **BONDING** – The permanent joining of metallic parts to form a positive electrically conductive path that provides electrical continuity between non-current carrying metal parts and is capable of conducting any fault current that may occur. This applies to bonding within the fuel cell system and between the fuel cell system and truck and does not refer to the means to ground the truck itself, such as with a grounding strap or with tires.

5.3 **CHECK-VALVE** – Fluid control device that allows fluids to flow in only one direction.

5.4 **DILUTION BOUNDARY** – The extent of a flammable area or zone created by a limited release of flammable gas or vapor, internal to the fuel cell power system or truck in which it is mounted, and controlled by mechanical ventilation or other effective means as outlined by Explosive Atmospheres – Part 10-1: Classification of Areas – Explosive Gas Atmospheres, IEC 60079-10-1.

5.5 **ELECTROSTATIC DISCHARGE (ESD)** – Discharge created by static electricity.

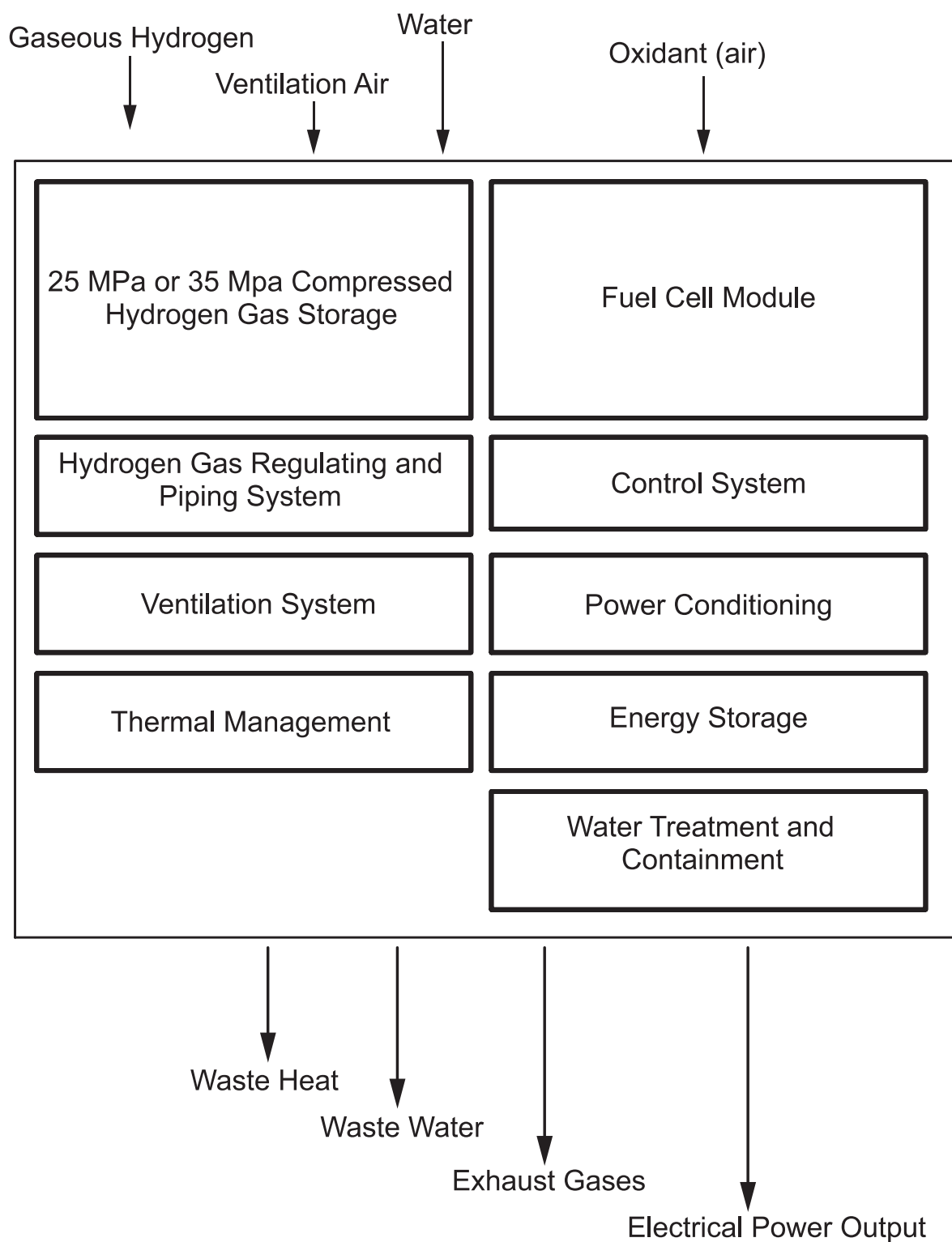
5.6 **EQUIPOTENTIAL BONDING** – For the purpose of controlling static electric hazards, the process of connecting two or more conductive objects together by means of a conductor so that they are at the same electrical potential, but not necessarily at the same potential as the earth.

5.7 FUEL CELL POWER SYSTEM - An assembly of components and parts that together electrochemically converts fuel and oxidant to electrical current. See [Figure 5.1](#) for a block diagram of a fuel cell power system. A fuel cell power system may contain all or some of the components shown in [Figure 5.1](#). The fuel cell power system for use with industrial trucks will be in one of the following forms:

- a) **SELF-CONTAINED SYSTEM** – A complete system incorporated into its own housing that is intended to replace or combine with a battery system to power an industrial truck. Additional counterweighting may be located outside of the system's housing. Display and control functions may be located outside the system's housing in proximity to the operator's compartment.
- b) **INTEGRATED SYSTEM** – A complete system of fuel cell components and parts that are incorporated into the industrial truck with the various parts of the system potentially distributed throughout the truck.
- c) **TYPE CGH-E FUEL CELL POWER SYSTEM** – A fuel cell power system intended for use in Type E industrial trucks only.
- d) **TYPE CGH-EE FUEL CELL POWER SYSTEM** – A fuel cell power system intended for use in Type EE industrial trucks that, in addition to meeting all requirements for a Type CGH-E and Type CGH-ES units, has its electric motors and all other electric equipment completely enclosed.
- e) **TYPE CGH-ES FUEL CELL POWER SYSTEM** – A fuel cell power system intended for use in Type ES industrial trucks that, in addition to meeting all requirements for Type CGH-E units, is provided with additional safeguards to the electric system to prevent the emission of hazardous sparks and to limit surface temperatures.
- f) **TYPE CGH-EX FUEL CELL POWER SYSTEM** – A fuel cell power system intended for use in Type EX industrial trucks that, in addition to meeting all requirements for Type CGH-E units, has electric fittings and equipment so designed, constructed, and assembled that the unit can be used in atmospheres containing specifically named flammable vapors, dusts, and, under certain conditions, fibers.

NOTE: Dilution by ventilation is a not viable protection measure against flammable gas leaks in fuel cell power systems used in hazardous (classified) areas.

Figure 5.1
Fuel Cell Power System



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Note: A fuel cell power system may contain all or some of the above components

5.8 HAZARDOUS (CLASSIFIED) AREAS – Any work area or space where combustible dust, ignitable fibers, or flammable, volatile liquids gases, vapors or mixtures are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures as defined by the National Electrical Code, NFPA 70, or by Explosive Atmospheres – Part 10-1: Classification of Areas – Explosive Gas Atmospheres, IEC 60079-10-1.

5.9 HAZARDOUS VOLTAGE CIRCUIT - A circuit involving a potential greater than 42.4 V peak (30 Vrms) or 60 Vdc.

5.10 HPIT – Hydrogen Powered Industrial Truck

5.11 INTEGRAL – For the purposes of this standard, something that is either contained within the fuel cell power system or is external, but is a part of the fuel cell power system.

5.12 LIMITED POWER CIRCUIT – A circuit supplied from a source whose open circuit voltage is less than or equal to 60 Vdc and whose maximum current and power after 60 seconds of operation comply with the values in [Table 30.1](#) and [Table 30.2](#). Limited power circuits are considered equivalent to NEC Class 2 circuits as outlined in the National Electrical Code, NFPA 70 and to low-voltage limited energy circuits as defined in Section 16 of the Standard for Electric-Battery-Powered Industrial Trucks, UL 583.

5.13 LOW-VOLTAGE CIRCUIT – A circuit involving a peak open-circuit potential of not more than 42.4 V (30 Vrms) or 60 Vdc under both normal and single fault conditions.

5.14 LOWER FLAMMABILITY LIMIT (LFL) – The lowest volume percentage of a gas in air that will ignite.

NOTE: The LFL for hydrogen is 4% by volume.

5.15 MAXIMUM ALLOWABLE WORKING PRESSURE – The maximum gauge pressure of the contained fluid for which each portion of the system is rated with consideration of an abnormal condition that initiates the operating of the safety pressure relief devices. See Annex [A](#) for a comparison table of pressure terms. (MAWP)

5.16 MAXIMUM CONTINUOUS LOAD RATING – Maximum continuous power that can be sustained by the fuel cell system independent of any electrical energy storage device or storage component at 25°C (77°F) and 1 atm.

5.17 MAXIMUM CONTINUOUS VA – The maximum Volt-Amps (VA) that can be delivered for at least 3 hours under the conditions of maximum continuous load rating (see [5.16](#)).

5.18 MAXIMUM OPERATING PRESSURE (MOP) – The highest gauge pressure of a component or the system that is expected during normal operation. See Annex [A](#) for a comparison table of pressure terms.

NOTE: It is typically no more than 1.25 times the service pressure and a 10%-margin below the pressure relief device setting.

5.19 NORMAL RELEASE – Limited internal localized volumes of flammable vapor concentrations released during normal operation that may include fuel cell purge.

5.20 NORMAL OPERATION – All operating and non-operating modes encountered during product use that are not the result of a failure.

5.21 PRESSURE RELIEF DEVICE (PRD) – A pressure and/or temperature activated device used to prevent the pressure from rising above a predetermined maximum and thereby prevent failure of a pressurized part or system.

5.22 RISK ANALYSIS – Systemic use of available information to identify hazards and to estimate the risk.

5.23 RISK ASSESSMENT – Overall process comprising a risk analysis and a risk evaluation.

5.24 RISK EVALUATION – Procedure based on the risk analysis to determine whether a tolerable risk has been achieved.

5.25 SAFETY CONTROL – Automatic controls and interlocks including relays, switches, sensors and other auxiliary equipment used in conjunction therewith to form a safety control system, which is intended to prevent unsafe operation of the controlled equipment.

5.26 SAFETY CRITICAL COMPONENT – A component, device, circuit, software, or similar part whose failure would affect the safety of the fuel cell power system as determined by the requirements of Section [7](#), Risk Assessment and Risk Reduction.

5.27 SERVICE PRESSURE – This term only relates to the hydrogen pressure vessel, and is the pressure, as specified by the manufacturer, at a uniform gas temperature of 15°C (59°F) and full gas content. Service pressure is equivalent to the term "nominal working pressure". See Annex [A](#) for a comparison table of pressure terms.

5.28 STACK PURGE – A controlled hydrogen release from the stack fuel circuit.

5.29 TOUCH CURRENT – Electric current through a human body or an animal body when it touches one or more accessible parts.

5.30 TYPE CGH INDUSTRIAL TRUCK – An electrically operated industrial truck that utilizes a compressed hydrogen powered unit utilizing a fuel cell for conversion of the hydrogen fuel gas to electricity that has minimum acceptable safeguards against inherent fire hazards.

5.31 TYPE CGH-EE INDUSTRIAL TRUCK – A type EE industrial truck that utilizes a Type CGH-EE fuel cell power system.

5.32 TYPE CGH-ES INDUSTRIAL TRUCK – A type ES industrial truck that utilizes a Type CGH-ES fuel cell power system.

5.33 TYPE CGH-EX INDUSTRIAL TRUCK – A type EX industrial truck that utilizes a Type CGH-EX fuel cell power system.

5.34 TYPE E INDUSTRIAL TRUCK – An electrically powered truck that has minimum acceptable safeguards against inherent fire and electrical shock hazards. Type E Industrial Trucks can be operated in locations as outlined in the Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operations, NFPA 505.

5.35 ZONE SYSTEM OF CLASSIFICATION – The means for classifying areas within the fuel cell power system in accordance with Article 505 of the National Electrical Code, NFPA 70, and the methods outlined in Explosive Atmospheres – Part 10-1: Classification of Areas – Explosive Gas Atmospheres, IEC 60079-10-1. The potential zones of this system are:

a) Class I, Zone 0 – A location in which ignitable concentrations of flammable gases or vapors are present for long periods of time (e.g. inside the fuel cell stack or other hydrogen carrying components).

b) Class I, Zone 1 – A location: