

**The Fuel Cells Testing & Standardisation
Network
FCTESTNET**

Fuel Cells Glossary



G. Tsoitridis, A. Podias (JRC-IE)

W. Winkler (HUAS-VDI), M. Scagliotti (CESI)

Editors

**DG JRC
Institute for Energy**

June 2006

Mission of the Institute for Energy

The Institute for Energy provides scientific and technical support for the conception, development, implementation and monitoring of community policies related to energy. Special emphasis is given to the security of energy supply and to sustainable and safe energy production.

European Commission

Directorate-General Joint Research Centre (DG JRC)

<http://www.jrc.ec.europa.eu>

Institute for Energy, Petten (the Netherlands)

<http://ie.jrc.ec.europa.eu>

Contact details:

G. Tsotridis

Tel. +31 224 565122

e-mail georgios.tsotridis@jrc.nl

A. Podias

Tel. +31 224 565254

e-mail andreas.podias@jrc.nl

Legal Notice

Neither the European Commission nor any person acting on behalf of the Commission is responsible for the use which might be made of this publication.

The use of trademarks in this publication does not constitute an endorsement by the European Commission.

The views expressed in this publication are the sole responsibility of the author and do not necessarily reflect the views of the European Commission.

Luxembourg: Office for Official Publications of the European Communities, 2006

ISBN 92-79-02747-6

ISSN 1018-5593

© European Communities, 2006

Reproduction is authorised provided the source is acknowledged.

Printed in the Netherlands



***The Fuel Cells Testing & Standardisation
Network
FCTESTNET***

Fuel Cells Glossary

Edited by

Georgios Tsotridis

European Commission, Directorate-General Joint Research Centre, Institute for Energy, Petten, The Netherlands

Andreas Podias

European Commission, Directorate-General Joint Research Centre, Institute for Energy, Petten, The Netherlands

Mauro Scagliotti

CESI, Italy

Wolfgang Winkler

Hamburg University of Applied Sciences, Fuel Cells Laboratory, Hamburg, Germany

**Petten
The Netherlands
June 2006**





FCTESTNET Fuel Cells Glossary (Version 2)

1. Preface

This report is the first of a series of reports resulting from the work that has been conducted in the Framework Program 5 (FP5) Thematic Network project “*Fuel Cells Testing & Standardisation NETWORK*” (FCTESTNET).

All network Work Packages (WP) contributed with specific terminology reports that were incorporated and harmonised in the FCTESTNET Glossary. Version 1 of the Glossary was distributed to the Network members and to International institutions. Comments and suggestions are included in the present Version 2 of the Glossary.

2. Terminology

The development of a commonly agreed terminology is an important step towards the harmonisation of testing procedures and methodologies related to a new fast growing technology. It is important for joint projects to have a common definition within the European Union. This is the main objective of this glossary. Nevertheless, it is seen as important by the contributors to do this work in close collaboration with the international standardisation activities and to integrate this document in a future international standardisation activity. This is an important reason to integrate already available definitions from overseas as far as possible, however some have been modified regarding European requirements.

The task is quite complex when highly inter-disciplinary technologies like fuel cells are concerned. Electrochemists, material scientists and engineers in some cases use different terms to indicate almost the same concept [1]. Moreover, as far as codes and standards are concerned, when a new technology develops documents that properly apply to related fields are often taken as starting points. Fuel cell power systems were therefore considered in the recent past as special cases of gas appliances, chemical plants or power generation plants.

Standardisation bodies (ANSI, ASME, IEC, etc.), fuel cell associations (US Fuel Cell Council, etc), editors (Fuel Cell Today, etc.) and research groups are currently compiling fuel cell glossaries, and some of them prepared with different purposes and scopes, are already available in the literature. They can be freely downloaded from the web, but in a few cases the access to the documents is limited.

Research into existing fuel cell glossaries was carried out. Some ten documents fully dedicated to fuel cell terminology or containing a relevant section of useful definitions were found. The following five glossaries were selected and examined in detail:

- The Fuel Cell Glossary (2nd edition, May 2000) of the US Fuel Cell Council (USFCC) (free download from the USFCC website www.usfcc.com);



- The Technical Specification TS 62282-1 (2005-03) Fuel Cell Technology – Part 1: Terminology of the Technical Committee 105 of the International Electrotechnical Commission (IEC);
- A contribution from the German Aerospace Centre (DLR) that was distributed to the FCTESTNET members before the FCTESTNET progress meeting of 24th-28th February, 2004, in Leysin (CH);
- The glossary of the Fuel Cell Today website (www.fuelcelltoday.com);
- The glossary prepared by Vicky Mc Connel, editor of Fuel Cell Industry Report, and co-workers (access free on the website www.sanewsletters.com).

Other glossaries found on the web, like those of the Smithsonian Institute and of Hydrogen Power Inc. (i.e. www.hydrogenpowerinc.com), contain a few useful definitions, but are far less complete. Terms and expression related to fuel cell testing can be found in standards like ASME PTC 50-2002 “FC power system performance” [2], and in the IEC standards under preparation (i.e. the draft 105/58/CDV).

3. FCTESTNET Glossary

Specific terminology and relevant definitions were established by each of the 8 Work Packages of FCTESTNET [3-8]. All these contributions were included and harmonised in the report FCTESTNET Glossary (Version 1).

Following the suggestions and contributions received by the Work Packages, CSIC-CIEMAT and LECA-CNRS and IEA by some basic choices were done; new definitions were included together with changes of definitions that in our opinion require harmonisation. In particular, the three Work Packages dedicated to the main fuel cell types (PEMFC, MCFC and SOFC), suggested several new terms and definitions related to the specific fuel cell components, while the other Work Packages focused on terms related to fuel cell performances and applications.

A few general comments on the five selected glossaries are considered in section 2 of WP6 Terminology Report quoted as [6]. This section is largely based on the contribution of Dr. M. Scagliotti at the WP6 (MCFC) Parallel Section of the Leysin FCTESTNET Progress Meeting (26th February 2004) and therefore particular attention is devoted to terms related to Molten Carbonate Fuel Cells technology.

The source of each term is always indicated in italics, unmarked terms have been added during collection or revision.



4. The EU funded Framework Program 5 (FP5) Thematic Network project FCTESTNET

The Fuel Cells Testing & Standardisation NETWORK (FCSTESTNET) was an FP5 thematic network funded by the European Commission, DG RTD. The overall objective was to define harmonised test procedures applicable to the component level (single cells, fuel cell stacks, Balance-of-Plant components), the sub-system level, and the entire fuel cell system level. This concerns all the main fuel cell types (PEMFC, SOFC, MCFC) in all current main application areas - **transport, stationary and mobile**.

The work therefore consisted of three levels:

- analysis of the main application areas and identification of application oriented test procedures applicable to fuel cell systems designed for these applications
- analysis of the Balance-of-Plant (BoP) of fuel cell systems in different applications and translation of the test requirements from the fuel cell system level to the level of BoP-components and fuel cell stacks
- analysis of the different fuel cell technologies and identification of test procedures applicable to fuel stacks and single cells

Its structure, mirrored in the construction of this project, is displayed in the figure below:

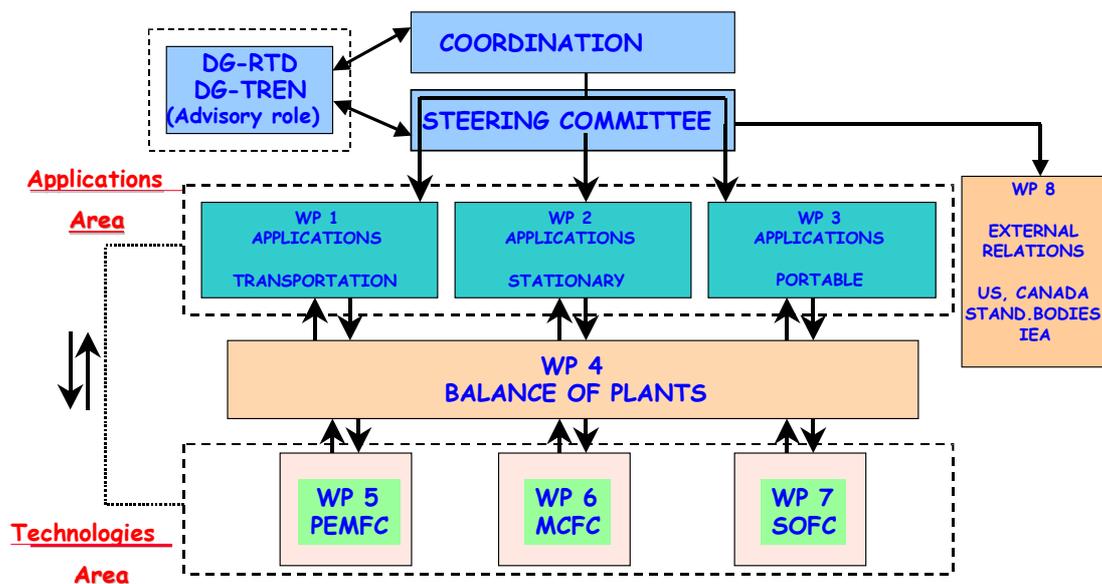


Figure 1 - FCTESTNET Work Package structure

4.1 Principles of the Thematic Networks

In a Thematic Network project it is not intended to generate new knowledge, technology or products. Instead the intention of a Thematic Network is to achieve certain goals by means of the exchange of existing knowledge and information available in the participating institutes. Within FCTESTNET this information exchange process was co-ordinated by the work package leaders, assisted by other work package members.



The FCTESTNET results were based on the willingness of the network members to share information and to make this information available in an appropriate form. As such, Thematic Networks in general are based on the **give-and-take** principle.

Another consequence of this working principle, and the associated level of EU-funding, is that gaps in the available knowledge and information within the network cannot be filled by means of additional research. FCTESTNET work packages worked only with available information.

Acknowledgements

This Fuel Cell Glossary was part of the efforts and support of many individuals and organisations from all participating members of the FCTESTNET, as well as from International institutions. Special recognition should be given to Dr. Mauro Scagliotti (CESI) for collecting the material to be included in this glossary, and to Prof. Dr-Techn. Wolfgang Winkler (VDI/HUAS) who has initiated its editing.

At this stage, the Joint Research Centre of the European Commission and its Institute for Energy acting as the Scientific Coordinator of the project would like to express its gratitude to the members that have greatly contributed to the accomplishment of the targets set within the duration of the project. FCTESTNET members that contributed to the glossary are all listed in the following page.

Georgios Tsotridis
European Commission
Directorate-General Joint Research Centre
Institute for Energy
Clean Energies Unit
Fuel Cells Performance Testing Sector
Petten, The Netherlands

Andreas Podias
European Commission
Directorate-General Joint Research Centre
Institute for Energy
Clean Energies Unit
Fuel Cells Performance Testing Sector
Petten, The Netherlands

Petten 19 June 2006

**Prepared for the EU funded Thematic Network FCTESTNET,
References: ENK5-CT-2002-20657**





FCTESTNET Fuel Cells Glossary (Version 2)

FCTESTNET members that contributed to the glossary:

Patrick Achard (EdM-CENERG)
Vincenzo Antonucci (ITAE-CNR)
Toste Azevedo (IST)
Francois Badin (INRETS)
Marc Bednarz (MTU)
Loreto Daza Bertrand (CSIC/CIEMAT)
Robert Boalch (Intelligent Energy)
Gianluca Bollito (CRF)
Nigel Brandon (Imperial College)
Michel Cassir (LECA-CNRS)
Antonio Martinez Chaparro (CIEMAT)
G rard Coquery (INRETS)
Thomas Crott (FEV)
Hendrik Dohle (FZJ)
Martin Dornheim (GKSS)
Darren Foster (TNO)
Hellmuth Frey (EnBW)
Edward Fort (LR)
Georg Frank (Dornier GmbH)
Rasmus Friberg (CG)
Alain Germain (ULG)
Ulf Groos (Fh-ISE)
Christopher Hebling (Fh-ISE)
Volke Heise (DELPHI)
Rudolf Hunik (KEMA)
Manuel Felipe Rosa Iglesias (INTA)
Ludwig J rissen (ZSW)
Michel Junker (ALPHEA)
Alexander Kabza (ZSW)
Jean-Marie Kauffmann (UTBM)
Thomas Klassen (GKSS)
Eleni Konstantinidou (VDI)
Anthony Kucernak (Imperial College)
Carina Lagergren (KTH)
Hagen Lorenz (HUAS)
Piero Lunghi (Univ. Perugia)
Augustin McEvoy (EPFL)
Erik Middelmann (Nedstack)
Jon Moore (Intelligent Energy)
Angelo Moreno (ENEA)
Suzzana Pereira-Nunes (GKSS)
Filippo Parodi (ANSALDO)
Andreas K.M. Podias (JRC-IE)
Armelle Ringuede (ENSCP)
Bert Rietveld (ECN)
Mauro Scagliotti (CESI)
Pierre Serre-Combe (CEA)
G nther G. Scherer (PSI)
Joachim Scherer (REINZ-DANA)
Matthias Schmidt (GL)
Joachim Scholta (ZSW)
Richard Smokers (TNO)
Raimund Stroebel (REINZ-DANA)
Nils Stelzer (ECHEM)
Herbert J. Thanner (AVL)
F. J. M. de Mota Torres (INEGI)
Peter Treffinger (DLR)
Efstathios Tselepis (CRES)
Georgios Tsotridis (JRC-IE)
Matti Valkiainen (VTT)
Gilbert van Bogaert (Vito)
Gemma van Druten (ECN)
Paul van den Oosterkamp (ECN)
Pieter H. van Dijkum (IS&P)
Alexander von Stryk (HUAS)
Alberto Vegas (INTA)
Izaak Vinke (FZJ)
Claus Voigt (DLR)
Andre Wakker (ECN)
Andr  Weber (UNIKARL)
Paul Welberg (KEMA)
Rob Winkel (TNO)
Wolfgang Winkler (VDI/HUAS)
Gerd Wursig (GL)
Laurent Zorzi (ULG)





FC TESTNET Fuel Cells Glossary (Version 2)

ACCEPTANCE TEST, SEE TEST

ACCESSIBLE

Readily. Having direct access without the need of moving or removing any panel, door or similar covering of the item described.

Reasonably. Having access to, but which first may require the removal of a panel, door or similar covering of the item described.

(USFCC Fuel Cell Glossary)

ACTIVATION

Chemical. Treatment of a substance by heat, radiation, or other activating reagent to produce a more complete or rapid chemical or physical change.

Electrochemical. The process of treating a cathode/anode to increase the rate of reduction/oxidation.

(from USFCC Fuel Cell Glossary, modified as suggested by FC TESTNET WP5 PEMFC)

ACTIVATION POLARISATION

Activation Polarisation is present when the rate of electrochemical reaction at an electrode surface is controlled by sluggish electrode kinetics. This is similar to chemical reactions where the reacting species must overcome an activation barrier. For fuel cells, this region is characterized by a drop from the theoretical EMF or ideal voltage prior to electron or ion flow.

(USFCC Fuel Cell Glossary)

ACTIVE LAYER, see CATALYST LAYER

AIR

The mixture of oxygen, nitrogen and other gases which, with varying amounts of water vapour, forms the atmosphere of the earth. Also referring to any or all air for combustion, heating, cooling, ventilation and other uses as follows:

Ambient. Air that surrounds the equipment.

Atmospheric. Air under the prevailing atmospheric conditions.

Combustion. Air required for safe and proper combustion of fuel gas.

Dilution. Air which enters a draft regulator or similar device and mixes with the flue gases.

Excess. Air which passes through the fuel cell cathode compartment and any flues in excess of that which is theoretically required for complete combustion.

Exhaust. Air removed from a space and not reused.

Outdoor. Air taken from the outdoors and, therefore, not previously circulated through the system.

Recirculated. Air removed from a space and intended for reuse as supply air.

Return. Air removed from a space and recirculated or exhausted.

Standard. Air at standard temperature and pressure.

Supply. That air delivered to each or any space in the system or the total delivered to all spaces in the system.

Ventilation. That portion of supply air which comes from the outside (outdoors) plus any



recirculated air that has been treated to maintain the desired quality of air within a designated space.

(from USFCC Fuel Cell Glossary, definitions of "excess" and "standard air" are modified as suggested by FCTESTNET WP5 PEFC)

AIR BLEED

In the context of fuel cells, air bleed refers to the introduction of small levels of air (around 5 %) into the fuel stream, upstream of the fuel inlet to the cell or stack or within the anode compartment. Its purpose is to mitigate poisoning by species such as CO by catalytic oxidation of the poison within the anode compartment of the fuel cell.

(FCTESTNET WP5 PEFC Terminology Report)

AIR INLET, PRIMARY

The opening(s) through which primary air is admitted into the reformer, fuel cell, burner or other sub-system. *(FCTESTNET WP5 PEFC Terminology Report)*

ALKALINE FUEL CELL (AFC)

Fuel cell that employs aqueous solution of alkali as the electrolyte.

NOTE - Generally, aqueous solution of potassium hydroxide is used as the electrolyte.

(IEC-TC105 TS 62282-1)

AMBIENT STATUS

Thermodynamic status (Temperature, pressure) of the medium surrounding a device, equipment or installation which may affect the performance of the device, equipment or installation

See STANDARD CONDITION

(from IEC-TC105, modified)

ANODE

The anode is the electrode in a cell where oxidation occurs.

(Fuel Cell Today glossary, as suggested by CSIC-CIEMAT terminology contribution)

APPLIANCE, COGENERATION

A self-contained, fuelled appliance providing electrical energy and thermal energy to be used remote from or adjacent to its location.

(USFCC Fuel Cell Glossary)

AREA (CATALYST)

Gas phase active catalyst surface area (Pt) (as determined by gas phase H₂ or CO adsorption) - Specific surface area of the catalytically active component, i.e. noble metal, of the catalyst powder. Unit cm² g⁻¹.

Gas phase total catalyst surface area (Pt + C) (as measured by N₂ adsorption at 77 k) - Specific surface area of the catalyst powder, including active, i.e. noble metal area, and support surface area. Unit cm² g⁻¹.

(FCTESTNET WP5 PEFC Terminology Report)



AREA (ELECTRODE)

Electrochemical catalyst surface area (measured by CV) - Microscopic area of the electrochemically accessible electrocatalyst surface, using a liquid electrolyte pervading the catalyst layer. Unit $\text{cm}^2 \text{g}^{-1}$.

(Geometric) Active area - Geometric area of the active or catalyst layer. Unit cm^2 .

In situ electrochemical catalyst surface area (measured by CV) - Microscopic area of the electrochemically accessible electrocatalyst surface, determined *in situ* using a polymer electrolyte. Unit $\text{cm}^2 \text{g}^{-1}$.

(FCTESTNET WP5 PEFC Terminology Report)

AREA (GDL)

Geometric area of the gas diffusion layer. Unit cm^2 .

(FCTESTNET WP5 PEFC Terminology Report)

AREA (MEA)

Geometric area of the entire MEA perpendicular to the direction of net current flow, including active area, uncatalysed areas of the membrane and sealing components, if present. Unit cm^2 .

(FCTESTNET WP5 PEFC Terminology Report)

AREA (CELL)

Geometric area of the bipolar or separator plate perpendicular to the direction of current flow. Unit cm^2 . (see also **CELL ACTIVE AREA**)

(FCTESTNET WP5 PEFC Terminology Report)

AUXILIARY POWER UNIT (APU)

A type of power generator (for example, a fuel cell) which provides electricity which is supplemental to the main power source for a device (such as car's internal combustion engine)

(Fuel Cell Today glossary, as suggested by CSIC-CIEMAT terminology contribution)

AVAILABILITY FACTOR

The ratio of the time a generating unit or piece of equipment is ready for, or in service to, the total time interval under consideration.

(USFCC Fuel Cell Glossary)

BACKGROUND NOISE LEVEL

Sound pressure level, expressed in decibels (dB(A)), generated by the surroundings of a plant and measured at a specified measurement point when the plant is in the shutdown state.

(IEC-TC105 TS 62282-1)

BACK PRESSURE

Pressure against which a fluid or gas is flowing, resulting from friction in lines, restrictions in pipes, valves, pressure in vessel to which fluid is flowing, hydrostatic head, or other impediment that causes resistance to fluid flow.

(USFCC Fuel Cell Glossary)

BAFFLE

An object placed in an appliance to change the direction of or retard the flow of gas, air, gas air mixtures, or flue (exhaust) gases.

(USFCC Fuel Cell Glossary)

BALANCE-OF-PLANT (BOP)

Supporting/auxiliary components based on the power source or site-specific requirements and



integrated into a comprehensive power system package centred around the power source. In general, all components besides the fuel cell stack and the fuel processor are called Balance of Plant Components.

(from USFCC Fuel Cell Glossary, modified as suggested by IEA)

BARRIER LAYER

Functional layer in the MEA impeding or preventing the passage of chemical species (atoms, molecules, ions) or electrons from one side to the other.

(FCTESTNET WP5 PEFC Terminology Report)

BASE LOAD

The constant electrical demand by a system to a power supply.

(USFCC Fuel Cell Glossary)

BIOLOGICAL INPUTS (BIOLOGICAL CONDITIONS)

Biological inputs are defined as the test inputs associated with biological variables such as fungus, moulds, rodents, etc.

(FCTESTNET WP3 Applications-Portable, sixth version of the testing model)

BIOMASS

Biomass is organic material which has stored sunlight in the form of chemical energy. Biomass fuels include wood, wood waste, straw, manure, sugar cane, and many other by-products from a variety of agricultural processes.

(FCTESTNET WP7 SOFC Terminology Report)

BIPOLAR PLATE

Conductive plate separating individual cells in a stack, acting as current collector and providing mechanical support for the electrodes. It usually incorporates flow field on either side for the distribution of reactants (fuel and oxidant) and removal of products, and may also contain conduits for heat transfer. The bipolar plate provides a physical barrier to avoid mixing of oxidant, fuel and coolant fluids

(from definitions suggested by FCTESTNET WP5 PEFC and WP6 MCFC)

BLACK START

A power source's ability to power up from a cold state to fully operational status through a dedicated auxiliary power source that is totally independent of external systems.

See also: **COLD START**

(USFCC Fuel Cell Glossary)

BLOWDOWN

The difference between the opening and closing pressures of a relief/safety valve.

(USFCC Fuel Cell Glossary)

BLOWER

A fan used to force air and/or gas under pressure.

(USFCC Fuel Cell Glossary)

BOOST REGULATOR

Voltage conversion device used to raise the voltage in a DC system. *(USFCC Fuel Cell Glossary)*



BURNER

A device for the final conveyance of the gas, or a mixture of gas and air, to the combustion zone

Forced-Draft. A burner for which air for combustion is supplied by a fan ahead of the gas utilisation equipment.

Induced-Draft. A burner which depends on the draft induced by a fan beyond the gas utilisation equipment for its proper operation.

Injection “Bunsen, Type. A burner employing the energy of a jet of gas to inject air for combustion into the burner and mix it with the gas.

Injection Type, Atmospheric. A burner in which the air at atmospheric pressure is injected into the burner by a jet of gas.

Luminous or Yellow-Flame. A burner in which secondary air only is depended on for combustion of the gas.

Power. A burner in which either gas or air, or both, are supplied at pressures exceeding the line pressure for gas and atmospheric pressure for air, this added pressure being applied at the burner.

Premixing. A power burner in which all or nearly all of the air for combustion is mixed with the gas as primary air.

Pressure. A burner which is supplied with a gas-air mixture under pressure, usually from 13 to 356 mm water column (1/8 to 3.5kPa) and occasionally higher.

(modified USFCC Fuel Cell Glossary)

CAPACITY FACTOR

The ratio of the average power load of an electric power source to its rated capacity over a selected period of time. (Also known as “plant factor”).

(USFCC Fuel Cell Glossary)

CATALYST

Substance that increases the rate of a reaction without being consumed itself. The catalyst lowers the activation energy of the reaction, allowing for an increase in the reaction rate, or to proceed at a lower temperature. A catalyst that promotes an electrochemical reaction is termed an ‘electrocatalyst’.

In a fuel cell, electrocatalysts are used in the active or catalyst layer. Gas phase catalysts are used in fuel processing (reforming) or exhaust gas treatment.

(adopted and modified from fuelcellstoday.com as suggested by FCTESTNET WP5 PEFC)

CATALYST COATED MEMBRANE (CCM)

Term used to describe a membrane (in a PEM fuel cell) whose surfaces are coated with a catalyst layer to form the reaction zone of the electrode. (See also Membrane Electrode Assembly [MEA].)

CATALYST COATED MEMBRANE, see 3-LAYER MEA

CATALYST LAYER

Layer adjacent to the membrane on either side comprising the electrocatalyst and ionomer with co-existing ionic and electronic conductivity. This layer comprises the spatial region where the electrochemical reactions may take place, including a triple phase boundary.

(FCTESTNET WP5 PEFC Terminology Report)



CATALYST LOADING

The amount of catalyst incorporated in the fuel cell per unit area, specified either per anode or cathode separately, or combined anode and cathode loading per unit active area. Typical units mg cm^{-2} .

(from USFCC Fuel Cell Glossary, modified as suggested by FCTESTNET WP5 PEFC)

CATHODE

The electrode at which reduction occurs.

(USFCC Fuel Cell Glossary)

CELL

Active Area. The surface area of an individual cell that is available for chemical reaction. The active area is typically less than the total area of a cell to accommodate cooling, distribution and sealing mechanisms.

Components. The substructures within a cell that support the reaction, provide physical structure, receive and distribute reactants, remove products, dissipate heat, and perform other functions necessary for operation.

Coolant. A liquid or gaseous substance provided to or around the cell to remove heat produced by the cell's operation and to maintain the optimum operating temperature of the cell.

Degradation Rate. The rate at which a cell's performance deteriorates over time. The degradation rate can be used to measure both recoverable and permanent losses in cell performance. The typical unit of measure is volts(dc) per unit time.

Internal Resistance Loss. The loss in cell performance due to ohmic resistance losses caused by internal structures that create resistance to electron or ion flow. The most noticeable impact is seen in the cell's operating region that occurs after activation, but before concentration polarisation occurs. (See Activation, Ohmic and Concentration Polarisation)

Life. The length of time that a cell can be used to produce useful amounts of power.

Power Density. The amount of power produced per unit measure. For a single cell, this is typically measured as W/cm^2 .

Pressure Differential. The difference in pressure across the electrolyte as measured from one electrode to the other.

(USFCC Fuel Cell Glossary, modified as suggested by FCTESTNET WP5 PEFC)

CERAMIC

Material consisting of complex compounds or solutions containing both metallic and nonmetallic elements joined by covalent or ionic bonds. These materials are characterised by good strength and high melting temperatures, but poor ductility and electrical conductivity.

Source: Askeland, The Science and Engineering of Materials (2nd Edition)

(Proposal TNO)

CERMET

Typically used as the anode material. It is a composite made of a mixture of a ceramic material (ionic conductor) and a metallic material (electronic conductor).

(FCTESTNET WP7 SOFC Terminology Report)

CHANNEL (RELATED TO FLOW FIELD)

Recessed structure in the flow field providing pathways for convective fluid flow over the active area. *(FCTESTNET WP5 PEFC Terminology Report)*



CHEMICAL CONDITIONS

Chemical inputs are defined as the test inputs associated with chemical variables such as sulfur dioxide, ozone, chlorine, etc.

(FCTESTNET WP3 Applications-Portable, sixth version of the testing model)

CLIMATIC CONDITIONS

Climatic inputs are defined as the test inputs associated with natural climatic variables such as temperature, humidity, etc.

(FCTESTNET WP3 Applications-Portable, sixth version of the testing model)

COAL GAS

A fuel gas obtained through the carbonization (distillation by heat in the absence of air) of coal under addition of steam. Typical coal gas mixtures include high concentrations of hydrogen and carbon monoxide.

(derived from USFCC Fuel Cell Glossary)

CO-FIRING

Simultaneous heat processing of multiple ceramics.

(FCTESTNET WP7 SOFC Terminology Report)

COFLOW

A fluid flow in same parallel directions in adjacent parts of an apparatus, as in a heat exchanger or in a fuel cell. This flow configuration can be adopted for example in internally manifolded fuel cell stack for the oxidant and the fuel gas streams. See also 'Counter Flow' and 'Cross Flow'.

(from the definitions suggested by FCTESTNET WP5 PEFC and WP6 MCFC)

COGENERATION

The simultaneous on-site production of electric energy and process steam or heat from the same power source.

(USFCC Fuel Cell Glossary)

COLD START

Start-up after a shut-down while the temperature of the fuel cell equipment is at ambient temperature.

See also: **BLACK START**

(Proposal TNO)

COLD STATE

Condition of a fuel cell power system at ambient temperature with no power input or output.

(IEC TC105 62282-3-2, 3.1.10).

COMBINED FUEL CELL CYCLE see HYBRID FUEL CELL/GAS TURBINE PLANTS

COMBINED HEAT AND POWER GENERATION (CHP) see COGENERATION

COMBUSTION

The direct chemical reaction of a fuel with oxygen accompanied by the production of heat, or heat and light.

(from USFCC Fuel Cell Glossary, modified as suggested by FCTESTNET WP5 PEFC)



COMBUSTION CHAMBER

The portion of an appliance within which combustion occurs.

(USFCC Fuel Cell Glossary)

COMBUSTION PRODUCTS

Constituents resulting from the combustion of a fuel with oxygen. For combustion processes that obtain oxygen from air, the products include the inert components contained in air but excludes excess air used in the combustion.

(USFCC Fuel Cell Glossary)

COMPRESSION

The exertion of pressure to a substance or onto a component by means of spatially distributed system of forces.

(FC TESTNET WP5 PEFC Terminology Report)

COMPRESSOR

A device used for increasing the pressure and density of gas. Also see TURBOCHARGER.

(USFCC Fuel Cell Glossary)

CONDENSATE (CONDENSATION)

The liquid that separates from a gas (including flue gases) due to a reduction in temperature.

(USFCC Fuel Cell Glossary)

CONDITIONING FACILITY

A plant specifically dedicated to fuel cell stack conditioning (first heat-up).

(FC TESTNET WP6 MCFC Terminology Report)

CONTACT RESISTANCE, see RESISTANCE

CONTROLS

Devices designed to regulate the fuel, air, water or electrical supplies to the controlled equipment. These may be manual, semi-automatic or automatic.

Operating. A control, other than a safety control or interlock, to start or regulate equipment operation according to load demand and to stop or regulate equipment operation on satisfaction of demand or upon reaching normal temperature or pressure in the equipment being operated. An operating control also may actuate auxiliary equipment.

Safety. Automatic controls and interlocks (including relays, switches, and other auxiliary equipment used in conjunction therewith to form a safety-control system) which are intended to prevent unsafe operation of the controlled equipment.

Safety, Primary. A control responsive directly to flame properties; sensing the presence of flame and causing fuel to be shut off in the event of ignition or flame failure requiring manual reset.

(USFCC Fuel Cell Glossary, partially modified)

CONVECTION

The motion that occurs in a fluid owing to the variation of its density and the action of a force. Generally fluid flow occurs because of natural convection (convection caused by density gradients), and forced convection (convection enhanced by mechanical means), and may be characterized by stagnant regions, laminar flow and turbulent flow.

/from USFCC Fuel Cell Glossary, modified by FC TESTNET WP5 PEFC)



COOLANT

A fluid used to affect heat transfer between various media and components.

(from USFCC Fuel Cell Glossary, modified by FCTESTNET WP5 PEFC)

COOLANT HEAT

Heat dissipated to the atmosphere through the cooling circuit of the system, typically by an air-to-liquid heat exchanger

(Proposal TNO)

COUNTER FLOW

A fluid flow in opposite directions in adjacent parts of an apparatus, as in a heat exchanger or in a fuel cell. This flow configuration can be adopted for example in an internally manifolded stack. See also 'Coflow' and 'Cross Flow'

(derived from USFCC Fuel Cell Glossary and modified as suggested by FCTESTNET WP5 and WP6)

CROSS FLOW

A flow going across another flow at an angle essentially perpendicular to one another in adjacent parts of an apparatus, as in a heat exchanger or a fuel cell. This is the flow configuration of choice for externally manifolded fuel cell stack See also 'Coflow' and 'Counter Flow'

(derived from USFCC Fuel Cell Glossary and modified by FCTESTNET WP5 and WP6)

CROSSOVER (see GAS CROSSOVER)

CURRENT COLLECTOR

Term used to describe the conductive material in a fuel cell that collects electrons from the anode side or conducts electrons to the cathode side. The current collectors lie in between the catalyst/electrolyte surfaces and the bipolar plates in the case of planar cells.

(from USFCC Fuel Cell Glossary, modified as suggested by FCTESTNET WP5 PEFC and WP6 MCFC)

CURRENT DENSITY

A vector-point function describing the magnitude and direction of charge flow per unit area, generally expressed in amperes per square meter.

(USFCC Fuel Cell Glossary)

DEAD END Cell or stack configuration lacking fuel and/or oxidant outlet ports in a single cell or a stack. In dead end operation, 100 % of the reactant fed to the cell or stack is consumed.

(FCTESTNET WP5 PEFC Terminology Report)

DELAMINATION

Partial or total separation of individual functional layers of the membrane electrode assembly or other layered fuel cell components.

(FCTESTNET WP5 PEFC Terminology Report)



DESULFURIZER

A component for removing sulfur from a fuel mixture.
(USFCC Fuel Cell Glossary)

DEW POINT (of a gas)

The temperature at which the water vapour in a given volume of gas becomes saturated, i.e. relative humidity is 100 %. At a temperature below the dew point, water condensation occurs.
(FC TESTNET WP5 PEFC Terminology Report)

DIFFUSION

Movement of a species under the influence of a gradient of chemical potential (i.e. a concentration gradient).
(USFCC Fuel Cell Glossary)

DIRECT INTERNAL REFORMING

Production of a desired product (*hydrogen/reformate*) within a fuel cell from a hydrocarbon based fuel (*methanol, gasoline, etc.*) fed to the fuel cell or stack.
(derived from USFCC Fuel Cell Glossary)

DIRECT FUEL CELL

A type of fuel cell directly using a raw fuel. (*Attn. Direct Fuel Cell is the trade mark of a molten carbonate fuel cell system developed by Fuel Cell Energy Inc.*)
(DLR proposal, from SAE glossary).

DIRECT METHANOL FUEL CELL (DMFC)

A type of fuel cell in which the fuel is methanol (CH_3OH), in gaseous or liquid form. The methanol is oxidised directly at the anode with no reformation to hydrogen. The electrolyte is typically a proton exchange membrane.
(from USFCC Fuel Cell Glossary, modified as suggested by FC TESTNET WP5 PEFC)

DISCHARGE WATER

Water discharged from the fuel cell power system including waste water and condensate.
(IEC TC105 TS 62282-1)

DISCRETIONARY DOWNTIME

A period during which equipment is not operating because of the operator's choice, rather than equipment failure.
(USFCC Fuel Cell Glossary)

DISTRIBUTED GENERATION

Any small-scale power generation technology that provides electric power at or closer to the customer's site than centrally sited generation stations.
(USFCC Fuel Cell Glossary)

DRAIN

A passageway or conduit for conveying liquid products to the outside atmosphere.
(FC TESTNET WP5 PEFC Terminology Report)



DURABILITY INPUTS

Durability inputs are defined as the test variables associated with how the test object is influenced by time.

(FC TESTNET WP3 Applications-Portable, sixth version of the testing model)

EFFICIENCY

The ratio of useful energy produced by a system (such as a fuel cell) compared to the energy supplied (usually chemical energy).

(Fuel Cell Today Glossary, as suggested by CSIC-CIEMAT terminology contribution)

EFFICIENCY, ELECTRICAL

Ratio of the useable electrical energy output to the energy input of the fuel cell power system. NOTE- Where electric power is supplied from an external source for a parasitic load, this energy is deducted from the electrical energy output of the generator.

(IEC-TC105 TS 62282-1)

EFFICIENCY, HEAT RECOVERY

Ratio of the thermal power recovered at a given instant from a fuel cell power system to the total power of the fuel and oxidant entering the fuel cell power system at the same instant.

(IEC TC105 TS 62282-1)

EFFICIENCY, THERMAL

Efficiency with which a power source transforms the potential heat of its fuel into work or output, expressed as the ratio of the useful work done by the power source in a given time interval to the total heat energy contained in the fuel burned during the same time interval, both work and heat being expressed in the same units.

(USFCC Fuel Cell Glossary)

EFFLUENT

The products of reaction plus the excess reactants discharged from an appliance.

(from USFCC Fuel Cell Glossary, modified as suggested by FC TESTNET WP5 PEFC)

EJECTOR

Component to introduce fluid under pressure into an appliance.

(FC TESTNET WP5 PEFC Terminology Report)

ELECTRO FARMING

Concept that comprises the conversion of energy crops (biomass) via steam reforming and fuel cells into electricity.

(hydrogen.org website glossary, as suggested by DLR and WP6)

ELECTRODE

An electronic conductor (or semi-conductor) through which an electric current enters or leaves a medium, whether it be an electrolytic solution, solid, molten mass, gas, or vacuum.



Oxidation or reduction processes occur and electrons are either accepted or released.

(from USFCC Fuel Cell glossary, modified as suggested by FCTESTNET WP6 MCFC and WP7 SOFC)

ELECTROSMOTIC DRAG

The flux of a polar species (H_2O , CH_3OH) due to its attraction to a charged specie (such as a proton H^+) that migrates through the electrolyte of an electrochemical cell driven by the electric field between the anode and the cathode.

(from USFCC Fuel Cell Glossary, modified as suggested by FCTESTNET WP5 PEFC)

ELECTROLYTE

A non-metallic electrical conductor (e. g. solution, solid, molten salt, gas or vacuum) in which current is carried by the movement of ions. The respective transference number characterises the fraction of the current carried either by anions or cations. The electrolyte is the medium for charge transfer between the electrodes in an electrochemical cell. It is the main distinctive feature of the different fuel cell technologies and determines the useful operating temperature range.

(from USFCC Fuel Cell Glossary, modified as suggested by FCTESTNET WP5 and WP6).

ELECTROLYTE LEAKAGE

An undesired escape of liquid electrolyte from a fuel cell stack or module.

(FCTESTNET WP6 MCFC Terminology Report)

ELECTROLYTE LOSS

Any decrease with respect to the initial electrolyte inventory of a fuel cell. The electrolyte losses may originate by different processes such as evaporation, leakage, migration and consumption in metallic component corrosion.

(FCTESTNET WP6 MCFC Terminology Report)

ELECTROLYTE MATRIX

Insulating gastight cell component with a properly tailored pore structure that retains the liquid electrolyte. The pore structure has to be adjusted with respect to those of the adjacent electrodes to assure a complete filling.

(FCTESTNET WP6 MCFC Terminology Report)

ELECTROLYTE MIGRATION

Potential driven effect experienced by external manifolded MCFC stacks. The electrolyte tends to migrate from the positive end of the stack to the negative end. The migration occurs through the gaskets placed between the external manifolds and the stack edges.

(FCTESTNET WP6 MCFC Terminology Report)

ELECTROLYTE RESERVOIR

A component of liquid electrolyte fuel cells (e.g. PAFC and MCFC). A proper amount of liquid electrolyte is stored therein with the purpose to replenish electrolyte losses over the cell life.

(FCTESTNET WP6 MCFC Terminology Report)

END PLATE

Component located on either end of the fuel cell stack in the direction of current flow, serving to transmit the required compression to the stacked cells. The end plate may comprise ports, ducts or manifolds for the supply of fluids (reactants, coolant) to the stack.



(FC TESTNET WP5 PEFC Terminology Report)

ENERGY (NET, GROSS, ELECTRICAL, THERMAL, TOTAL)

Electrical. Energy delivered by the fuel cell in the form of electricity.

Gross. Total electrical energy, including peripherals consumption (fans, valves, meters...) delivered by the fuel cell.

Net. Useful electrical energy delivered by the fuel cell.

Thermal. Energy delivered by the fuel cell in the form of heat.

Total. Electrical and thermal energy delivered by a fuel cell.

(FC TESTNET WP5 PEFC Terminology Report)

ENERGY MANAGEMENT SYSTEM (EMS)

For a complex energy generating system, composed of single components (such as fuel cells, batteries, electrolyser, reformer, etc.) the energy management system controls the coordinated function of the different components.

(FC TESTNET WP5 PEFC Terminology Report)

ENVIRONMENTAL CONDITIONS

Environmental inputs are the collective term for all test conditions that originate from natural and anthropogenic influences on the test object during operation. The environmental conditions can be broken down into climatic conditions, chemical conditions, biological conditions and mechanical conditions.

(FC TESTNET WP3 Applications-Portable, sixth version of the testing model)

EQUIVALENCE RATIO

Equivalence ratio (ER) is defined as the stoichiometric air/fuel ratio divided by the actual air/fuel ratio. The equivalence ratio describes if the air/fuel ratio is fuel rich, fuel lean or stoichiometric as follows:

ER > 1 Rich

ER = 1 Stoichiometric

ER < 1 Lean

See **EXCESS AIR**

(Proposal TNO)

EXCESS AIR

The ratio of the total airflow supplied to the fuel cell and the stoichiometric necessary airflow to oxidise the fuel completely.

EXHAUST AIR see AIR (EXHAUST)

EXHAUST GAS

All gas leaving the fuel cell module and not being reused within the fuel cell system.

(Winkler, as suggested by DLR Terminology contribution)

EXHAUST GAS COOLER

A heat exchanger for cooling the exhaust gas from a fuel cell system.

(as suggested by DLR Terminology contribution)

EXHAUST GAS TURBINE GENERATOR

A gas turbine generator driven by exhaust air from fuel cell, exhaust gas from reformer, etc.



(as suggested by DLR Terminology contribution)

EXHAUST GAS SYSTEM

System to transport and to cool or to reheat the exhaust gas.
(Winkler, as suggested by DLR Terminology contribution)

EXHAUST HEAT

Sum of thermal and chemical energy associated with the reaction products emitted to the atmosphere
(Proposal TNO)

EXHAUST STEAM

All steam leaving the fuel cell system and not to be utilized.
(Winkler, as suggested by DLR Terminology contribution)

EXHAUST STEAM SYSTEM

System to transport and to cool or to reheat the exhaust steam.
(Winkler, as suggested by DLR Terminology contribution)

EXTERNAL MANIFOLDING

The *external manifolding* design refers to a stacking of cells where the gas mixtures are supplied from a central source to large fuel and oxidant inlets covering adjacent sides of the stack and sealed with properly designed gaskets. The exhaust gases area collected on the opposite sides with similar systems. The gas flow configuration in externally manifolded stacks is necessarily crossflow.
(derived from FCTESTNET WP6 MCFC Terminology Report)

EXTERNAL REFORMING

The production of hydrogen or syngas (see: “REFORMATE GAS”) from a hydrocarbon fuel (*methanol, gasoline, natural gas, propane, etc.*) prior to entry to the fuel cell or stack.
(derived from USFCC Fuel Cell Glossary)

FAILURE MODES AND EFFECTS ANALYSIS (FMEA)

A structured process of analysis to identify and classify concerns, features and reasoning, and to recommend corrective actions for as many potential failures as is reasonably possible.
(USFCC Fuel Cell Glossary)

FAN

A device consisting of a rotor and housing for moving air or gas at relatively low pressure differentials.
(USFCC Fuel Cell Glossary)

FILLING (LEVEL)

The fraction of the total pore volume of a fuel cell porous component (e.g. electrode or electrolyte matrix) that is occupied by a liquid electrolyte.
(derived from FCTESTNET WP6 MCFC Terminology Report)

FILTER

A device intended to remove solid material from a medium, such as air or fluid.
(USFCC Fuel Cell Glossary)



FLAT PLATE CELLS

Fuel cells that are structurally planar.

(USFCC Fuel Cell Glossary)

FLOW FIELD

Structure in the bipolar plate / separator plate, generally consisting of an array of channels allowing convective fluid flow and hence distribution of reactant gases and removal of reaction products. Following flow field types are most common:

Parallel: an array of parallel channels with distribution channel ('header') on either end.

(N-fold) serpentine: gas channels are not straight, but contain bends. 'N-fold serpentine' means that there are N parallel channels ('transit') that follow a serpentine pattern as a whole.

Interdigitated: a comb-like arrangement of discontinuous (dead-ended) channels, with staggered channels respectively connected to the gas inlet and outlet. In this type of flow field, the gas is forced to flow laterally through the gas diffusion layer.

(adopted from W. Vielstich, A. Lamm, H.A. Gasteiger (Eds), Handbook of Fuel Cells, Vol. 3, John Wiley & Sons, 2003. as suggested by FC TESTNET WP5 PEFC)

FLOW RESISTANCE

Friction loss due to viscous flow of a fluid in a manifold, duct, flow field or other spatially confined region, resulting in a pressure drop in the fluid.

(FC TESTNET WP5 PEFC Terminology Report)

FLOW THROUGH

Cell or stack configuration, whereby excess reactant leaves through fuel and/or oxidant outlet ports.

(FC TESTNET WP5 PEFC Terminology Report)

FORCED DERATING HOURS

Time that is measured in hours that a generating unit is required to operate at less than full power because of a maintenance or operating problem. This reduction in power level is not voluntary and cannot be delayed.

(USFCC Fuel Cell Glossary)

FORCED OUTAGE

A power outage that results from the failure of a system component requiring that the power system be taken out of service immediately, either automatically or manually. Also an outage caused by improper operation or human error.

(USFCC Fuel Cell Glossary)

FORCED OUTAGE RATE

The mean number of failures of a component per unit exposure time. Usually exposure time is expressed in years.

(USFCC Fuel Cell Glossary)

FUEL

A substance used to create heat and/or power through chemical or electrochemical conversion in processes such as combustion or electrochemical conversion.

(from USFCC Fuel Cell Glossary, modified as suggested by FC TESTNET WP5 PEFC)

FUEL CELL

An electrochemical device that continuously converts the chemical energy of a fuel and an



oxidant to electrical energy (DC power), heat and other reaction products. The fuel and oxidant are typically stored outside of the cell and transferred into the cell as the reactants are consumed. See also Reversible Fuel Cell, PEFC, SOFC, MCFC, PAFC, DMFC.
(USFCC Fuel Cell Glossary definition modified by FCTESTNET WP6).

FUEL CELL ELECTRIC VEHICLE (FCEV)

A vehicle that is propelled by a fuel cell system by means of electric energy. The path along which energy flows from the fuel cell system to the wheels is irreversible.
(Proposal TNO)

FUEL CELL HYBRID ELECTRIC VEHICLE (FCHEV)

A vehicle that is propelled by two sources of power, a fuel cell system and an electrical energy storage system, usually a battery or super capacitors. The fuel cell system can charge the storage system, drive the wheels, or both. The path along which energy flows from the storage system to the wheels is reversible, while the path from the fuel cell system to the wheels is irreversible.
(Proposal TNO)

FUEL CELL MODULE

Assembly including a fuel cell stack(s) which electrochemically converts chemical energy to electric energy and thermal energy intended to be integrated into a vehicle or power generation system.

NOTE - A fuel cell module is comprised of the following main components: one or more fuel cell stack(s), piping system for conveying fuels, oxidants and exhausts, electrical connections for the power delivered by the stack(s) and means for monitoring and/or control. Additionally, a fuel cell module(s) may comprise: means for conveying additional fluids (e.g. cooling media, inert gas), means for detecting normal and/or abnormal operating conditions, enclosures or pressure vessels and ventilation systems.
(IEC-TC105 TS 62282-1).

FUEL CELL SYSTEM

A fuel cell system comprises of a FC-stack plus balance of plant equipment (BOP-equipment).
(derived from FCTESTNET WP3 Applications-Portable, sixth version of the testing model)

FUEL PROCESSING SYSTEM

Chemical processing equipment including any associated heat exchangers and controls required to convert input fuel to a composition suitable for the fuel cell stacks.

(IEC TC 105 TS 62282-1)

FUEL UTILIZATION

In fuel cells, the ratio of the fuel that gets electrochemically converted to generate the cell current to the total amount of the fuel entering the cell.
(FCTESTNET WP5 PEFC Terminology Report)

FULL LOAD CURRENT

Maximum continuous load current as specified by the manufacturer, at which the fuel cell module has been designed to operate. (IEC TC 105 TS 62282-1)



FUNCTIONAL INPUTS

Functional inputs are defined as the test inputs associated with the required inputs to operate the actual function of the test object. Examples are fuel, air, etc.

(FC TESTNET WP3 Applications-Portable, sixth version of the testing model)

GAS CLEANUP

Removal of a contaminant from gaseous feed streams by a mechanical or chemical process.

(USFCC Fuel Cell Glossary)

GAS CROSSOVER (FUEL)

Leakage between the fuel side and the oxidant side in either direction, generally through the electrolyte.

(from IEC TC105 TS 62282-1, modified as suggested by IEA)

GAS DIFFUSION ELECTRODE

Component on the anode or cathode side comprising all electronic conductive elements of the membrane electrode assembly (MEA), i.e. gas diffusion layer and catalyst layer, optionally including a microporous layer and other functional layers.

(FC TESTNET WP5 PEFC Terminology Report)

GAS DIFFUSION LAYER (GDL), GAS DIFFUSION MEDIUM (GDM)

Porous component placed between the catalyst layer and the separator plate, to serve as electric contact and allow access of reactants to the reaction zone and the removal of reaction products.

(FC TESTNET WP5 PEFC Terminology Report)

GASKET

Component that prevents exchange of fluids between two or more compartments of a device, or leakage of fluids from a device to the outside.

(FC TESTNET WP5 PEFC Terminology Report)

GAS LEAKAGE

The sum of all gases leaving the fuel cell module except the intended exhaust gases.

(IEC TC105 TS 62282-1)

GAS SEAL

An airtight mechanism which prevents the reaction gas from leaking out of a prescribed flow path. The gas seal may be dry or wet, depending on the fuel cell type

(from IEC TC105, modified as suggested by WP6 MCFC)

see **GASKET**

see **WET SEAL**

GAS-TIGHTNESS

System characteristic, that ensures that no exchange of fluids between two or more

compartments of a device occurs, i. e. between anode and cathode.

(suggested by WP8, following "GASKET"-definition)



GAS TURBINE

A turbine rotated by expanding gases.
(USFCC Fuel Cell Glossary)

GRID CONNECTED

A power delivery method that utilizes an independent power source which normally operates in parallel with a utility power system.
(USFCC Fuel Cell Glossary)

GRID INDEPENDENT see GRID ISOLATED

GRID ISOLATED

A power delivery scheme consisting of an independent power source that serves a dedicated load and is not interconnected with the utility power system.
(USFCC Fuel Cell Glossary)

GRID PARALLEL see GRID CONNECTED

GROSS POWER

The fundamental power output of an energy source prior to any conditioning and losses associated with the production of power suitable for the connected load.
(USFCC Fuel Cell Glossary)

HAZARDOUS LOCATION see LOCATION, HAZARDOUS

HAZARDS

Potential source of physical injury or damage to the health of people, or damage to property or the environment.

(IEC TC105 TS 62282-1)

HEAT EXCHANGER

A vessel in which heat is transferred from one medium to another.
(USFCC Fuel Cell Glossary)

HEATING VALUE (TOTAL)

The value of the heat of combustion of a fuel defined by the heat supplied to a thermal system by the entire reaction enthalpy of the exothermal combustion reaction at standard conditions (25°C, 1 bar).

NOTE - The heating value is thus the negative reaction enthalpy of the combustion reaction.

Lower (LHV). The value of the heat of combustion of a fuel as measured by allowing all products of combustion to remain in the gaseous state. This method of measure does not take into account the heat energy put into the vaporisation of water (heat of vaporisation).

Higher Heating Value (HHV). The value of the heat of combustion of a fuel as measured by reducing all of the products of combustion back to their original temperature and condensing all water vapour formed by combustion. This value takes into account the heat of vaporisation of water.

(derived from USFCC Fuel Cell Glossary)



HOT START

Start-up after a shut-down while the temperature of the fuel cell equipment is still within the fuel cell equipment's normal operating temperature range.

(as suggested by DLR Terminology contribution)

HOT TIME

The cumulative period of time that the fuel cell spends in the normal operating temperature range, independently from the actual power output.

(FC TESTNET WP6 MCFC Terminology Report)

HUMIDIFICATION

Process of introducing water into the fuel cell with the fuel and/or oxidant reactant gas stream.

(FC TESTNET WP5 PEFC Terminology Report)

HUMIDIFIER

Equipment for adding moisture to reaction gas.

(SAE Information Report J2574 Draft, Fuel Cell Vehicle Terminology, 2001, as suggested by DLR Terminology contribution)

HYBRID FUEL CELL/BATTERY SYSTEM

A fuel cell system combined with a battery, for delivering useful electrical energy. The fuel cell system can charge the energy storage system, deliver useful electrical energy, or both. The system can deliver and accept electrical energy.

(Proposal TNO)

HYBRID FUEL CELL/GAS TURBINE PLANTS (HYBRID PLANT)

A power plant based on the integration of a high temperature fuel cell (MCFC or SOFC) and a gas turbine. The system operates by using the fuel cell's thermal energy and residual fuel to drive a gas turbine.

(FC TESTNET WP6 MCFC Terminology Report)

IDLE POWER

The system rate of doing work when only the minimum work rate is employed by the system.

(USFCC Fuel Cell Glossary)

IDLE TIME

The time when a system is capable of but not producing power.

(USFCC Fuel Cell Glossary)

IMPURITIES

Foreign material(s) in a pure substance or mixture.

(from USFCC Fuel Cell Glossary, modified as suggested by IEA)

INDIRECT INTERNAL REFORMING

The reformer section is separated, but adjacent to, the fuel cell anode. This structure takes advantage of the close coupled thermal benefit from the exothermic reaction of the fuel cell to support the endothermic reforming reaction.

(USFCC Fuel Cell Glossary)

INTERCONNECT

To link power systems in a manner that enables them to draw on one another's reserves in time



of need.

(USFCC Fuel Cell Glossary)

INTERCOOLER

A heat exchanger for cooling gas between stages of a multistage compressor with a consequent savings in power.

(USFCC Fuel Cell Glossary)

INTERFACE POINT

Measurement point at the boundary of a fuel cell power system at which material and/or energy either enters or leaves.

NOTE - This boundary is intentionally selected to accurately measure the performance of the system. If necessary, the boundary or the interface points of the fuel cell power system to be assessed should be determined by agreement of the parties.

(IEC TC105 TS 62282-1)

INTERLOCK

A control to prove the physical state of a required condition and to furnish that proof to the safety shutoff device circuit.

(USFCC Fuel Cell Glossary)

INTERNAL MANIFOLDING

The *internal manifolding* refers to a system of ducts inside the stack and penetrating the separator plates, that distributes the gas flows among the cells.

(derived from FC TESTNET WP6 MCFC Terminology Report)

INTERNAL REFORMING see DIRECT INTERNAL REFORMING

IR LOSS (OHMIC POLARISATION)

Losses created by the resistance to the flow of ions in the electrolyte and resistance to flow of electrons through the electrode and bipolar plate materials. Because both the electrolyte and fuel cell electrodes obey Ohm's law, the ohmic losses can be expressed by the equation $Ohm = iR$

(USFCC Fuel Cell Glossary)

I²R LOSS

Power loss due to the current (I) flow through the resistance (R) of a conductor.

(USFCC Fuel Cell Glossary)

ISLANDING

A condition in which a portion of the utility system that contains both load and distributed resources remains energized while isolated from the remainder of the utility system.

(IEEE Standard Dictionary of Electrical and Electronics Terms and IEEE P1547 Draft)

ISOLATED OPERATION

A mode of operation in which the fuel cell power plant is separated, electrically and mechanically, from all other sources of electrical energy.

See also GRID ISOLATED

(USFCC Fuel Cell Glossary)

JOINTS

Points of connection: between heat transfer surfaces; between positive and negative pressure



zones within components of the power plant; and between power plant components.
(*USFCC Fuel Cell Glossary*)

LAND (RELATED TO FLOW FIELD)

Protruding structure in the flow field that is in contact with the gas diffusion layer and thereby providing electronic contact and, consequently, pathways for electron flow.
(*FCTESTNET WP5 PEFC Terminology Report*)

LEAKAGE CURRENT

Electric current in an unwanted conductive path other than a short-circuit (IEV 151-15-49).

(*IEC TC105 TS 62282-1*)

LEVELIZED COST

The cost of power, taking into account the capital cost of the generating unit, the fuel and other O&M costs, any transmission and distribution costs applicable to the particular situation, all amortised equally over the life of the unit.
(*from USFCC Fuel Cell Glossary, modified without reference to nominal or actualised devise, as suggested by CSIC-CIEMAT*)

LOAD DURATION CURVE

A curve of loads, plotted in descending order of magnitude, against time intervals for a specified period.
(*USFCC Fuel Cell Glossary*)

LOAD-FOLLOWING

A mode of operation where a power plant is generating variable power depending on the load demand.
(*USFCC Fuel Cell Glossary*)

LOCATION, HAZARDOUS (CLASSIFIED)

Any area or space where combustible dust, ignitable fibres, or flammable, volatile liquids, gases, vapours or mixtures are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures.
(*USFCC Fuel Cell Glossary and IEC-TC105*)

LOW EMISSION VEHICLE (LEV)

LEV are light duty passenger vehicles which meet strict specific emissions regulations in California. Vehicles meeting tighter standards yet are described as ultra-low emissions vehicles (ULEV), super-ultra-low emissions vehicles (SULEV), partial zero emissions vehicles (PZEV) or zero emission vehicles (ZEV). These terms are subject to stringent definitions by the Californian Air Resources Board.
(*from Fuel Cell Today glossary, modified as suggested by IEA*)

LOWER FLAMMABILITY LIMIT (LFL)

Minimum concentration of a flammable gas/vapour in air in which flame is propagated.
(*IEC TC105 TS 62282-1*)



MANIFOLD

Conduit which supplies gas to or collects it from the fuel cell or the fuel cell stack. For the coolant, either gaseous or liquid, manifolds are used as well.

(from IEC-TC105 TS 62282-1, modified as suggested by IEA)

MASS ACTIVITY

Current density at a given electrode potential or cell voltage per unit of mass of active catalyst. Unit mA mg⁻¹.

(FC TESTNET WP5 PEFC Terminology Report)

MASS TRANSPORT (OR CONCENTRATION) LOSS

Losses created by the inability to diffuse enough reactants to the reaction sites and/or to diffuse reaction products from the fuel cell. They occur at high current densities and result in a sharp decrease in the cell voltage.

(FC TESTNET WP6 MCFC Terminology Report)

MAXIMUM OPERATING PRESSURE see OPERATING PRESSURE, MAXIMUM

MEANTIME BETWEEN FAILURES (MTBF)

The mean exposure time between consecutive failures of a component. It can be estimated by dividing exposure time by the number of failures in that period, provided that sufficient number of failures has occurred in that period.

(USFCC Fuel Cell Glossary)

MEAN TIME BETWEEN FORCED OUTAGE (MTBFO)

A measure of the reliability of a power source, equal to its average operating time between forced outages, as calculated on a statistical basis from the known failure rates of various components of the power source.

(derived from USFCC Fuel Cell Glossary)

MEAN TIME TO REPAIR (MTR)

The time interval (hours) that may be expected to return failed equipment to proper operation.

(USFCC Fuel Cell Glossary)

MECHANICAL INPUTS

Mechanical inputs are defined as the test inputs associated with mechanical variables such as vibration, free fall, shock, etc.

(FC TESTNET WP3 Applications-Portable, sixth version of the testing model)

MEMBRANE (to detail for PEFC)

The separating layer in a fuel cell that acts as electrolyte (an ion-exchanger) as well as a barrier film separating the gases and electronic conducting material in the anode and cathode compartments of the fuel cell. The membrane may provide additional functionalities outside the active area, e.g. as sealing material.

see **ELECTROLYTE**

(FC TESTNET WP5 PEFC Terminology Report)

MEMBRANE ELECTRODE ASSEMBLY (MEA)

Component consisting of a proton exchange membrane with catalyst/carbon/binder layers on either face and sandwiched by two porous conductive layers (which function as the gas diffusion layers and current collectors).



3-layer MEA \equiv *catalyst coated membrane*. Assembly consisting of an electrolyte membrane coated on both sides with a catalyst layer.

5-layer MEA. Laminated assembly consisting of a membrane, catalyst layers and gas diffusion layers. A microporous layer may be included between catalyst layer and gas diffusion layer

7-layer MEA. 5-layer MEA with added sealing component.

9-layer MEA. 7-layer MEA with added flow field component.

(primary definition from USFCC Fuel Cell Glossary, modified and with additional definitions as suggested by FC TESTNET WP5 PEFC)

MICROPOROUS LAYER

Carbon containing and electronically conducting layer between the catalyst layer and the gas diffusion layer. This layer improves the electronic contact between the adjacent layers and water management properties of the MEA.

(suggested by WP5)

MIXED CONDUCTOR

A material which is both an electronic and ionic conductor.

(FC TESTNET WP7 SOFC Terminology Report)

MODE

Disconnect. A condition of disconnection of the power plant from a utility grid following a clearing of the interrupt mode.

Interrupt. A condition of momentary interruption of the current flow from the power plant to a utility grid.

(USFCC Fuel Cell Glossary)

MODULE (see FUEL CELL MODULE)

MOLTEN CARBONATE FUEL CELL (MCFC)

Fuel cell that employs molten carbonate as the electrolyte.

NOTE - Usually, either molten lithium potassium or lithium sodium carbonate salts are used as the electrolyte.

(IEC TC 105 TS 62282-1)

NERNST POTENTIAL

An electrode potential corresponding to the reversible equilibrium between fuel gas at a certain pressure, temperature and the corresponding level of the fuel gas ion activity.

(from USFCC Fuel Cell Glossary, modified as suggested by IEA)

or

NERNST POTENTIAL

Concentration potential established between two phases, at which the reduced and oxidised species are present at different concentrations.

(FC TESTNET WP5 PEFC Terminology Report)

NET POWER

The generated gross power of a power source minus the parasitic loads of the power source system necessary to operate the total power source system



NOISE LEVEL (POWER SYSTEM)

Sound pressure level, expressed as decibels (dB(A)), generated by the fuel cell power system at the steady state operating condition where it generates maximum noise, and measured at a specified point.

(IEC-TC105 TS 62282-1)

NOMINAL CAPACITY

A capacity used for general rating/specification purposes. The actual capacity of a specific unit will be approximately the same as the nominal capacity but need not be exactly the same.

(USFCC Fuel Cell Glossary)

NON-REPEAT COMPONENTS

All the components of a fuel cell stack that are not part of the repeated cell unit (e. g. the stack endplates).

See REPEAT COMPONENTS

(FC TESTNET WP6 MCFC Terminology Report)

OPEN CIRCUIT VOLTAGE

The voltage of an electrochemical device in the absence of external current flow. Also known as NO LOAD VOLTAGE.

(from USFCC Fuel Cell Glossary modified as suggested by FC TESTNET WP5 PEFC)

OPERATION

Grid-Connected. Operation of the power plant while electrically connected to a utility grid.

Grid-Independent. Operation of the power plant while electrically isolated from a utility grid.

(USFCC Fuel Cell Glossary)

OPERATING PRESSURE

The variable pressure at which a system operates in response to changes in various operating conditions.

(USFCC Fuel Cell Glossary)

OPERATING PRESSURE, MAXIMUM (MOP)

The steady-state or transient gauge pressure at which a part or system 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.

(USFCC Fuel Cell Glossary)

OPERATIONAL CONDITIONS

Operational conditions is a collective term for the conditions set on the test inputs, that is functional conditions, environmental conditions, and durability conditions. The operational conditions are prescribed values on the test inputs to be used in the test methods.

(FC TESTNET WP3 Applications-Portable, sixth version of the testing model)

OPERATIONAL REQUIREMENTS

“Operational requirements” is the collective term for functional requirements, environmental requirements, safety and durability requirements. The operational requirements are compared with the test outputs in the verification step.

(FC TESTNET WP3 Applications-Portable, sixth version of the testing model)



OPPORTUNITY FUELS

Those created in enterprises not directly tied to fuel cell applications but capable of being utilised in fuel cell operation, such as digester gas, landfill gas, industrial off gases, coal gas, and coal-mine methane gas.

(Fuel Cell Industry glossary, as suggested by WP6)

OUTPUT VOLTAGE

The fundamental rms. (root mean square) voltage between the output terminals.

(USFCC Fuel Cell Glossary)

OVERPOTENTIAL

For a single redox process taking place at an electrode it is the difference between the measured electrode potential and the equilibrium potential for that redox couple. In the fuel cell context, 'overpotential' is sometimes used analogous to 'polarisation'. Unit V.

(FCTESTNET WP5 PEFC Terminology Report)

OXIDANT PROCESSING SYSTEM

System that meters, conditions, processes, and may pressurize the incoming oxidant supply for use within the fuel cell power system.

(IEC-TC105 TS 62282-1)

OXIDANT UTILIZATION

The ratio of oxidant consumed to the oxidant supplied for consumption $[(O_{2in}-O_{2out})/O_{2in}]$

See also EXCESS AIR

(USFCC Fuel Cell Glossary)

OXYGEN-TO-CARBON RATIO

The ratio of the number of oxygen atoms to the number of carbon atoms in the fuel (e.g., methanol would have a ratio of 1, ethanol would have 0.5). In reforming, oxygen to carbon ratio, mostly used as O_2/C , is used as a process condition to manage the conversion and heat management in the reformer.

(from USFCC Fuel Cell Glossary, modified as suggested by IEA)

PARASITIC LOAD

Power for auxiliary machines and equipment such as balance of plant (BOP) necessary to operate a fuel cell power system.

NOTE - Examples are blowers, pumps, heaters, sensors, etc. The parasitic load can strongly depend on the system power output.

(from IEC-TC105, modified as suggested by IEA)

PARTIAL OXIDATION

Exothermic fuel reaction where the fuel is partially oxidized to carbon monoxide and hydrogen rather than fully oxidized to carbon dioxide and water. This is accomplished by injecting air with the fuel stream prior to the reformer.

(derived from USFCC Fuel Cell Glossary)

PARTIAL OXIDATION BURNER

Heat source for the partial oxidation reactor.

(USFCC Fuel Cell Glossary)

PASSIVE STATE. See STORAGE STATE



**PEM (PROTON EXCHANGE MEMBRANE) or PEMFC see
POLYMER ELECTROLYT FUEL CELL (PEFC)**

PHOSPHORIC ACID FUEL CELL (PAFC)

Fuel cell that employs aqueous solution of phosphoric acid as the electrolyte.
(IEC-TC105 TS 62282-1)

PILOT

A small fuel flame used to ignite the fuel at the main burner.
(USFCC Fuel Cell Glossary, only this primary definition should be maintained)

PITCH

Dimension of the repetitive unit in a fuel cell stack perpendicular to the current flow. Unit cm.
(FCTESTNET WP5 PEFC Terminology Report)

PLANAR CELLS see FLAT PLATE CELLS

PLANT FOOTPRINT

An x-y illustration indicating the ground area needed for a plant (power generator) and all associated peripherals.
(USFCC Fuel Cell Glossary)

PLANT HEAT RATE

Ratio of the energy input to the electrical energy output of the fuel cell power system.
See also ELECTRICAL EFFICIENCY

POISONING

Irreversible degradation of the electrolyte properties and/or of the catalytic properties of electrodes and reformer caused by contaminants that may be present into the inlet gas streams. The poisoning sensitivity is specific to the fuel cell technology and is usually lower in high temperature fuel cells.
(from MCFC WP6 FCTESTNET Terminology Report, modified as suggested by IEA)

POLARISATION

Departure of the cell voltage from the thermodynamic value (1.23 V for a H₂/O₂ cell at standard conditions) as a consequence of irreversible processes occurring within the cell components. Polarisation is analogous to efficiency loss. It increases as a function of faradaic current passing through the cell. Unit V.

Polarisation is caused by a number of phenomena:

Activation polarisation: Caused by finite electrode kinetics. Its extent is directly related to the rate of the electrochemical reaction taking place. The processes contributing to activation polarisation are the adsorption of reactant species, transfer of electrons across the double layer, and desorption of product species.

Ohmic polarisation: Loss created by the resistance to the flow of ions in the electrolyte and electrons in the electrode and bipolar plate materials. The term Ohmic refers to the fact that the correlation between voltage drop and current obeys Ohm's law, i.e. they are proportional with the Ohmic resistance as proportionality constant.

Concentration polarisation: Mass transport limitation as a consequence of reactant being consumed at the electrode by the electrochemical reaction and limited supply of reactant to the electrode surface, resulting in a concentration gradient of the reactant.

(suggested by WP5 and modified by IEA)



POLARISATION CURVE

Typically a plot of cell voltage as a function of current density (V vs. A/cm² or similar units)
(derived from USFCC Fuel Cell Glossary)

POLYMER ELECTROLYTE FUEL CELL (PEFC or PEMFC)

Fuel cell that employs an ion exchange polymer as the electrolyte. The ion could be of positive or negative charge. Presently, most of the PEFCs systems developed employ cation exchange membranes as the polymer electrolyte. In this type of fuel cell, a type of acid based fuel cell, the transport of protons (H⁺) from the anode to the cathode is achieved in a solid cation exchange polymer film, referred to as a 'proton exchange membrane' (PEM). This type of fuel cell typically operates at low temperatures (<100 °C) and pressures (< 5 atm). PEMFC for operation above 100 °C are in development as well.

(from FC TESTNET WP5 PEFC Terminology Report, modified as suggested by IEA)

POROSITY

The ratio of the volume of pores to the total volume of an electrode material or of an electrolyte matrix in the case of fuel cells. The porosity features, like overall open porosity, pore shape, size and size distribution, are key properties of fuel cell active components and significantly influence the performances.

(from FC TESTNET WP6 MCFC Terminology Report)

POWER

Real. (ACTIVE USEFUL) For sinusoidal quantities in a two-wire circuit; the product of the voltage, the current, and the cosine of the phase angle between them. In a polyphase circuit; the sum of the active powers of the individual phases.

Reactive. For sinusoidal quantities in a two-wire circuit; the product of the voltage, the current, and the sine of the phase angle between them. In a polyphase circuit; the sum of the reactive powers of the phases.

Apparent. The square root of the sum of the squares of the active and the reactive powers.

(USFCC Fuel Cell Glossary)

POWER CONDITIONING (SYSTEM)

Equipment which is used to change the magnitude or waveform of the voltage, or otherwise alter or regulate the output of a power source.

(IEC TC 105 TS 62282-1)

POWER DENSITY

In the context of a single cell, the power density is often measured in terms of power/unit area of active cell, e.g., kW/sq.m; in the context of a complete cell stack, the power density could also be defined in terms of power/unit stack volume, e.g., kW/m³, (kW/liter). Compare SPECIFIC POWER. (kW/kg)

(USFCC Fuel Cell Glossary)

POWER FACTOR

The ratio of the total active power in Watts to the total apparent power in Volt-Amperes (the product of root-mean-square (rms.) voltage and rms. current).

Leading. A designation of the relative instantaneous direction of the currents to the voltages (angle is 0 to -90°).

Lagging. A designation of the relative instantaneous direction of the currents to the voltages (angle is 0 to +90°) (USFCC Fuel Cell Glossary)



POWER PLANT

A packaged, self-contained, automatically operated assembly of integrated systems for generating useful electrical energy and recoverable thermal energy.

(USFCC Fuel Cell Glossary)

PREFERENTIAL OXIDATION (PROX)

Preferential oxidation is a catalytic process used in the reforming of a fuel to oxidise carbon monoxide in the presence of a large excess of hydrogen in a reformat gas stream.

(from Fuel Cell Today, modified as suggested by FC TESTNET WP5 PEFC and IEA)

PRESSURE (PRESSURIZED) VESSEL see VESSEL, PRESSURE

PRESSURE GRADIENT MONITOR

An instrument that continuously measures the pressure difference between two compartments in a technical device and handles alarm and exception events.

(FC TESTNET WP5 PEFC Terminology Report)

PROGRAMMABLE CONTROLLER

A digitally operating electronic system designed for use in an environment, which uses a programmable memory for the internal storage of user-oriented instructions for implementing specific functions such as logic, sequencing, timing, counting and arithmetic to control, through digital or analogue inputs and outputs, various types of processes or machines.

(USFCC Fuel Cell Glossary)

PROTON EXCHANGE MEMBRANE (PEM)

Proton ion exchange resin membrane employed in a PEM fuel cell as the electrolyte. The same membrane can be used for other applications, in which other cations than protons can be employed.

(from IEC-TC105 modified as suggested by IEA)

PROTON EXCHANGE MEMBRANE FUEL CELL (PEMFC) see POLYMER ELECTROLYT FUEL CELL (PEFC)

PURGE

To free a gas conduit of air, gas or a mixture of air and gas usually by supplying an inert gas like nitrogen, noble gases or similar.

(USFCC Fuel Cell Glossary)

RATED POWER

The value stated on the generator nameplate. It is the power available at the output terminals of a component or piece of equipment that is operated in compliance with the manufacturer's performance specifications.

(USFCC Fuel Cell Glossary)



REACTION RATE

A measure of the speed of a chemical reaction. The reaction rate depends on the rate constant, the number of reactants involved in the reaction, their concentration, temperature, the reactor volume, the active area and any other parameter affecting kinetics. For reactions that are otherwise slow, a catalyst is employed to increase the reaction rate.

(from USFCC Fuel Cell Glossary, modified as suggested by FC TESTNET WP5 PEFC and IEA)

RECIRCULATION

The capture of excess reactant and its re-introduction into the reactant flow streams conducted to the system.

(suggested by WP5)

RECOVERED HEAT

Thermal energy actually recovered from the fuel cell power system.

NOTE - The recovered heat is measured by determining the temperatures and flow rates of fluid media (water, steam, air, oil, etc.) entering and leaving the thermal energy recovery subsystem at the interface point of the fuel cell power system.

(IEC-TC105 TS 62282-1)

REDOX COUPLE

Two chemical species (Ox and Red) related by an electronic exchange reaction of the type: $Ox + ne \rightarrow Red$, where n is the number of electrons (e) exchanged. See also redox potential.

(FC TESTNET WP5 PEFC Terminology Report)

REDOX POTENTIAL

The thermodynamic potential assigned to a redox couple. It is calculated by applying the Nernst equation to an electrochemical cell where the cathodic reaction is the that of the redox couple ($Ox + ne \rightarrow Red$), and the anodic reaction is the oxidation of hydrogen at 1 atm partial pressure and pH=0 (hydrogen reference electrode).

(FC TESTNET WP5 PEFC Terminology Report)

REFERENCE CONDITIONS

Arbitrarily chosen conditions for measured volumes of gases when recalculated to a reference temperature and an absolute pressure.

(IEC-TC105 TS 62282-1)

REFORMER

A vessel within which fuel and other gaseous recycle stream(s) (if present) are reacted with water vapour and/or air and heat, usually in the presence of a catalyst, to produce hydrogen rich gas for use within the fuel cell power plant.

(from USFCC Fuel Cell Glossary, modified as suggested by IEA)



REFORMATE GAS

The fluid which exits the fuel reformer and acts as feed to the fuel cell stack.

(USFCC Fuel Cell Glossary)

REFORMING

Reforming is the process of producing a hydrogen-rich gas stream for eventual use in a fuel cell from a feedstock.

(Fuel Cell Today Glossary)

REGENERATIVE FUEL CELL see **REVERSIBLE FUEL CELL**

RELATIVE HUMIDITY

Ratio of the actual water vapour pressure to the saturation pressure at a given temperature.

(FC TESTNET WP5 PEFC Terminology Report)

RELIABILITY

The ability of an item to perform a required function under stated conditions for a stated period of time.

(USFCC Fuel Cell Glossary)

RELIABILITY, ASSESSED

The probability that a device will function without failure over a specified time period or amount of usage.

(USFCC Fuel Cell Glossary)

REPEAT COMPONENTS

This expression refers to all the components of the cell unit that is repeated in a fuel cell stack, e.g. the cell active components (anode, electrolyte, cathode), the separator plates, the gas distributors and the current collectors.

(FC TESTNET WP6 MCFC Terminology Report)

RESIDENTIAL POWER PLANT

A residential power plant (for example, a fuel cell) is used to power a home or a small number of homes. In terms of design it could be identical to a system used to power an office. The power generated of a single system doesn't exceed some kW. Usually the released heat is used for residential heating purposes.

see **COGENERATION**

(derived from Fuel Cell Today Glossary)

RESISTANCE (ELECTRICAL)

A material's opposition to the flow of electric current, resulting in the loss of cell voltage due to irreversible charge carrier (electrons, ions) transport processes occurring in the components of the cell or stack.

Ohmic resistance: see 'ohmic polarisation'

Contact resistance: voltage loss across the interface between two electron or ion conducting materials, e.g. between the gas diffusion medium and the bipolar plate.

(FC TESTNET WP5 PEFC Terminology Report)



RESPONSE TIME

Time required for a fuel cell power system to transfer from one defined state to another.
(IEC-TC105 TS 62282-1)

REVERSIBLE FUEL CELL

An electrochemical cell able to produce electrical energy from a fuel and an oxidant, and to produce the fuel and oxidant in an electrolysis process from electrical energy.
(as suggested by WP5 PEFC)

RIPPLE CURRENT

The undesirable AC (ripple) component of a pulsating DC current produced by a rectifier or similar power conditioning device.
(USFCC Fuel Cell Glossary)

ROUGHNESS FACTOR

Electrochemically measured surface area, referenced to the geometric area of the electrode.
Units $\text{cm}^2 \text{cm}^{-2}$.
(FC TESTNET WP5 PEFC Terminology Report)

RUPTURE MEMBER

A device that will automatically rupture at a predetermined pressure.
(USFCC Fuel Cell Glossary)

SAFEGUARDING

Procedure for actions of the controlling system based on monitoring of the technical process in order to avoid process conditions which would be hazardous to personnel, plant, product or environment.
(IEC-TC105 TS 62282-1)

SAFETY-CONTROL CIRCUIT see CIRCUIT, SAFETY-CONTROL

SCHEDULED OUTAGE

An outage that results when a power plant is deliberately taken out of service at a selected time, usually for the purposes of construction, maintenance or repair.
(USFCC Fuel Cell Glossary)

SCHEDULE OUTAGE DURATION

The period from the initiation of a scheduled outage until construction, preventive maintenance, or repair work is completed and the affected component is made available to perform its intended function.
(USFCC Fuel Cell Glossary)

SEAL, see GASKET

SELECTIVE OXIDATION see PREFERENTIAL OXIDATION

SEPARATOR PLATE, see BIPOLAR PLATE

SERIES CONNECTION

The connection of electrical cells in a positive to negative pattern such that individual cell voltages are additive. (USFCC Fuel Cell Glossary)



SERVICE FACTOR

A multiplier that, when applied to the rated power, indicates a permissible power loading that may be carried under the conditions specified for service factor.

(USFCC Fuel Cell Glossary)

SHIELD, RADIATION

A separate panel or panels interposed between surfaces and jackets to reduce heat losses through radiation.

(USFCC Fuel Cell Glossary)

SHORT STACK

Fuel cell stack with number of cells significantly smaller than the designed stack with rated power, but with number of cells high enough to represent the scaled characteristics of the full stack.

(FC TESTNET WP5 PEFC Terminology Report)

SHUTDOWN

The complex of operations, specified by the manufacturer, that occur between the instant when the electric load is removed at rated power and the instant when the fuel cell plant reaches the “cold” state. Different procedures may characterise scheduled shutdowns and emergency shutdowns.

(FC TESTNET WP6 MCFC Terminology Report)

SHUTDOWN TIME

Duration between the instant when the load is removed at rated power and the instant when the shutdown is completed as specified by the manufacturer.

(IEC TC 105 TS 62282-1)

SINGLE CELL TEST

A test of the fuel cell performance based on one unit cell. The test is typically a laboratory scale test in which several variables can be adjusted in order to obtain data over a wide range of conditions, such as temperature, current density, fuel and oxidant flow rates, etc. The outcome of a single cell test may be a polarisation curve, a voltage stability plot, or other data related to fuel cell performance.

(USFCC Fuel Cell Glossary)

SINTERING

Densification by heating without complete melting.

(FC TESTNET WP7 SOFC Terminology Report)

SOLID ELECTROLYTE / SOLID OXIDE

A hard oxide ion conductive ceramic compound in which current is carried by the migration of oxide ions.

(FC TESTNET WP7 SOFC Terminology Report)



SOLID OXIDE FUEL CELL (SOFC)

Fuel cell that employs an ion-conducting oxide as the electrolyte.

(IEC-TC105 TS 62282-1)

SOUND LEVEL

The sound pressure level (in decibels) at a point in a sound field, averaged over the audible frequency range and over a time interval, with a frequency weighting and time interval specified by ISO.

(modified USFCC Fuel Cell Glossary)

SPECIFIC ACTIVITY

Current density at a given electrode potential or cell voltage divided by the roughness factor. Unit mA cm⁻².

(suggested by WP5)

SPECIFIC POWER

A measure of the energy generating or storage potential of a system per unit of weight, usually in (kW/kg)

(derived from USFCC Fuel Cell Glossary)

SPFC (SOLID POLYMER FUEL CELL) see POLYMER ELECTROLYT FUEL CELL (PEFC)

(FUEL CELL) STACK.

A fuel cell stack is an arrangement of individual fuel cells, usually in series.

(Fuel Cell Today Glossary)

STACKING

The process of placing individual fuel cells adjacent to one another to form a fuel cell stack. Normally, the stack is connected in a series.

(USFCC Fuel Cell Glossary)

STACK (CELL) CONDITIONING

The first heat up after the MCFC assembling. This phase is realised following procedures specified by the manufacturer and is aimed mainly to transform the assembled pieces (e.g. green tape casted foils, porous metal cathode sheets and so on) into components with the properties required to operate the cell (e.g. porous lithiated nickel oxide cathodes, etc.). It can be considered as the final phase of the MCFC stack fabrication process.

(FCTESTNET WP6 MCFC Terminology Report)

STACK END FRAME

A frame used to compress the individual cells together to maintain electrical conductivity. Also may be known as an end plate or compression end plate.

(USFCC Fuel Cell Glossary)

STACK LIFE

The cumulative period of time that a fuel cell stack may operate before its output deteriorates below a useful minimum value.

(USFCC Fuel Cell Glossary)



STACK TEST

Experiment where an electrical load is applied to a stack of fuel cells to determine its ability to perform.

(USFCC Fuel Cell Glossary)

STACKING

The process of placing individual fuel cells adjacent to one another to form a fuel cell stack. Normally, the stack is connected in a series.

(USFCC Fuel Cell Glossary)

STANDARD CONDITIONS

The test or operating conditions that have been predetermined to be the basis of the test in order to have reproducible, comparable sets of test data. Typical conditions that are standardised are fuel and oxidant flow rates and ratios, temperature, pressure, electrode area, catalyst loading, etc.

See also REFERENCE CONDITIONS

(USFCC Fuel Cell Glossary)

STANDBY STATE

Operational state of a fuel cell power system being at sufficient operating temperature and in such an operational mode, with zero electrical output power, that the fuel cell power system is capable of being promptly switched to an operational state with substantial electrical active output power.

(IEC-TC105 TS 62282-1)

START-UP ENERGY

Sum of electrical, thermal and/or chemical (fuel) energy required during the start-up time.

(IEC-TC105 TS 62282-1)

START-UP TIME

Duration required for transitioning from cold state to net electrical power output for

systems that do not require external power to maintain a storage state (for system that

require external power to maintain a storage state- duration required for transitioning

from storage state to net electrical power output).

(IEC-TC105 TS 62282-1)

STATIONARY FUEL CELL POWER PLANTS

Fuel cell power system that is connected and fixed in place.

(IEC-TC105 TS 62282-1)

STEAM BOTTOMING CYCLE

A heat recovery system that uses waste heat from a power system to evaporate water and to superheat steam that would typically be used to run a steam turbine to generate additional



power from the heat that would otherwise be wasted. This increases the efficiency of the basic device.

(derived from USFCC Fuel Cell Glossary)

STEAM REFORMING

The process for reacting a hydrocarbon fuel, such as natural gas, in the presence of steam to form hydrogen as a product. This is the commonly preferred method of bulk hydrogen generation.

(USFCC Fuel Cell Glossary)

STEAM-TO-CARBON RATIO

The number of moles of water per mole of carbon in either the reformat or the fuel streams. This term is used when steam is injected into the reformat stream for the water-gas shift reaction or into the fuel for steam reforming.

(USFCC Fuel Cell Glossary)

STOICHIOMETRIC RATIO

The perfect oxidiser to fuel ratio (O/F) in a reaction such that all of the oxidiser exactly reacts with all of the fuel.

See also EXCESS AIR

(USFCC Fuel Cell Glossary)

STOICHIOMETRY (fuel cell context)

Ratio of the rate of reactant (H₂, O₂, methanol) supplied to the cell to the rate consumed in the electrochemical reaction of the cell (given by the cell current).

(FCTESTNET WP5 PEFC Terminology Report)

STORAGE STATE

State of a fuel cell power system being non-operational and possibly requiring, under

conditions specified by the manufacturer, the input of thermal and/or electric energy in

order to prevent deterioration of the components.

(IEC-TC105 TS 62282-1)

SUBSTACK

Typically a group of stacked fuel cells that makes up the base repetitive unit number of cells per full stack. Sub stacks may form an intermediate step in manufacturing and may be used to test new stack concepts prior to scale-up to full size stacks.

(USFCC Fuel Cell Glossary)

SYNCHRONIZATION

Operation at which a power plant is electrically connected and controlled to operate at the same frequency & voltages, and where the phase-angle displacements between voltages in them are constants or vary about steady and stable average values.

(USFCC Fuel Cell Glossary)

TEMPERATURE

A measure of heat intensity. *(USFCC Fuel Cell Glossary, primary definition)*



TEST

Acceptance Test. Contractual test to prove to the customer that the item meets certain conditions of its specifications (*from IEC-TC 105 as suggested by CSIC-CIEMAT terminology contribution*)

Routine Test: A routine test is a test where each individual device during or after the manufacturing process is checked that it complies with certain operational requirements.

Test Inputs (Test Conditions, Operational Conditions). The test inputs are defined as the test conditions that the test object is exposed to during a test. The test inputs can also be referred to as operational conditions. Test inputs are divided into functional inputs, climatic inputs, chemical inputs, mechanical inputs, biological and durability inputs.

Test Object. The test object is defined as the system which is regarded as the “black box” during a test.

Test Outputs. The test output is defined as the response by the test object that is exposed to a certain number of test inputs. Test outputs are divided into functional outputs, environmental outputs, safety outputs and durability outputs.

Type Test. A type test is a test of one or more devices of a certain design to show that the design meets certain specifications (operational requirements). They shall be performed on representative number of test objects, each one considered as a “black box”. The purpose is to verify the compliance of the design with a certain number of selected operational requirements.

(FCTESTNET WP3 Applications-Portable, sixth version of the testing model)

TEST FOR POWER OUTPUT CHANGE

Test to verify the characteristic representing the response of the electric output power system to the change of load for the fuel cell power system.

(IEC-TC105 TS 62282-1)

THERMAL MANAGEMENT SYSTEM

Subsystem intended to provide cooling and heat rejection in order to maintain thermal equilibrium within the fuel cell power system, and, if necessary, to affect the recovery of excess heat and to assist in heating the power train during start-up.

(IEC-TC105 TS 62282-1)

THERMAL STABILITY

Stable temperature conditions, pseudo steady-state, arbitrarily indicated by temperature changes of no more than 3 K or 1% of the absolute operating temperature, whichever is higher between two readings 15 minutes apart.

(IEC-TC105 TS 62282-1)

THERMOSTAT

An automatic control device actuated by temperature and designed to be responsive to temperature.

(USFCC Fuel Cell Glossary)

TIME TO FULL POWER

Time taken to change from the standby state to reach 100% of rated power specified by the manufacturer (see IEC 62282-3-2).



(IEC-TC105 TS 62282-1)

TRIGENERATION

Whereas cogeneration refers to the simultaneous exploitation of heat and electric power from a system utilising the same fuel, trigeneration additionally provides cooling energy. (CHCP = combined heat, cooling and power production)
(FCTESTNET WP5 PEFC Terminology Report)

TRIPLE PHASE BOUNDARY

Microstructural spatial region with coexisting ionic and electronic conductivity and access to reactants, within which the half cell reactions of the fuel cell may take place. Technologically, the catalyst layer forms the triple phase boundary. See also ‘Catalyst Layer, Active Layer’.
(FCTESTNET WP5 PEFC Terminology Report)

TUBULAR CELLS

Fuel Cells that are formed in cylindrical fashion and allow fuel and oxidant to flow on the inner or outer surfaces of the pipe
(USFCC Fuel Cell Glossary)

TURBOCHARGER

A device used for increasing the pressure and density of a fluid entering a fuel cell power plant using a compressor driven by a turbine that extracts energy from the exhaust gas.
(USFCC Fuel Cell Glossary)

TURBOCOMPRESSOR

Machine for compressing air or other fluid (*reactant if supplied to a fuel cell system*) in order to increase the reactant pressure and concentration
(USFCC Fuel Cell Glossary)

TURBOEXPANDER

Machine for expanding air or other fluid (*reactant if supplied to a fuel cell system*) in order to decrease the fluid pressure and concentration. The unit is normally used in conjunction with a compressor to recover unused energy from hot, pressurised gases, thereby reducing the net amount of energy required to power the compressor.
(USFCC Fuel Cell Glossary)

VALVE

A device used in piping to control the fuel supply to any section of a system of piping or to fuel utilisation equipment.
(USFCC Fuel Cell Glossary, only the primary definition should be maintained)

VALVE, CONTROL

A valve used to control the flow of any medium.
(USFCC Fuel Cell Glossary)

VALVE, RELIEF

A safety valve designed to forestall the development of a dangerous condition by relieving either pressure, temperature or vacuum in a fluid based system
(USFCC Fuel Cell Glossary, primary definition only as suggested by CSIC-CIEMAT)



VENT

A passageway or conduit for conveying gaseous products to the outside atmosphere.
(from USFCC Fuel Cell Glossary, modified as suggested by FC TESTNET WP5 PEFC)

VENTILATION

The natural or mechanical process of supplying conditioned or unconditioned air to, or removing such air from any space.
(USFCC Fuel Cell Glossary)

VENTILATION SYSTEM

Subsystem of the fuel cell power system that provides, by mechanical means, air to its cabinet.

(IEC-TC105 TS 62282-1)

VESSEL, PRESSURE

Containers for the containment of pressure either internal or external. This pressure may be obtained from an external source, or by the application of heat from a direct or indirect source, or by any combination thereof. Exceptions: vessels having an internal or external operating pressure not exceeding 103.4 kPa with no limitation on size; vessels having an inside diameter, width, height or cross section diagonal not exceeding 152 mm with no limitation on length of vessel or pressure.
(derived from USFCC Fuel Cell Glossary, primary definition)

VESSEL, UNPRESSURIZED

A vessel for containment of fluids not subject to the definition of PRESSURE VESSEL
(USFCC Fuel Cell Glossary)

VIBRATION LEVEL

Maximum measurement value of mechanical oscillations produced by the fuel cell power system during all modes of operation.

NOTE - The vibration level is expressed in decibels (dB).

(IEC-TC105 TS 62282-1)

VOLTAGE, HARMONIC

A voltage whose frequency is a multiple of the fundamental frequency.
(USFCC Fuel Cell Glossary)

WARM START: See HOT START

WASTE HEAT

Thermal energy released and not recovered.
(IEC-TC105 TS 62282-1)

WASTE WATER

Excess water that is removed from the fuel cell power system, and which does not constitute part of the thermal recovery system. *(IEC-TC105 TS 62282-1)*



WATER GAS SHIFT CONVERSION

The reaction of CO with water to generate carbon dioxide and hydrogen. This process is performed immediately after the reformer and, if present, before the preferential oxidiser to reduce CO from approximately 10% down to 0.5% to 0.1% usually through a water gas shift reaction. The water gas shift reaction is often performed in two different stages, the high temperature shift and the low temperature shift, due to the combination of slow kinetics and unfavourable thermodynamics at high temperature.

(from USFCC Fuel Cell Glossary, modified as suggested by IEA)

WATER TREATMENT SYSTEM

Subsystem intended to provide treatment and purification of recovered or added water for use within the fuel cell power system.

(IEC-TC105 TS 62282-1)

WET SEAL

In MCFC the wet seal consists of a thin continuous layer of molten carbonate formed between the outer edges of the separator plate and the electrolyte matrix. It assures gas tightness between different atmospheres. This is a critical area for corrosion attack and the edges of the metallic separator plate must be covered with a protective layer.

(FC TESTNET WP6 MCFC Terminology Report)

WORKING PRESSURE, ALLOWABLE

The maximum gauge pressure at which a part or system may be operated in accordance with the provisions of the relevant design standard. It is the pressure used in determining the setting of pressure limiting/relieving devices installed to protect the part or system from accidental overpressuring.

(derived USFCC Fuel Cell Glossary)

WORKING TEMPERATURE

Temperature at which the fuel cell operates

(derived from FC TESTNET WP7 SOFC Terminology Report)

ZERO EMISSION VEHICLE (ZEV)

Zero Emission Vehicle, a vehicle that produces no air emissions from its fuelling or operation. See also **LOW EMISSION VEHICLES (LEV)**. These terms are subject to stringent definitions by the Californian Air Resources Board.

(from USFCC Fuel Cell Glossary, modified as suggested by IEA)



4. *BIBLIOGRAPHY*

- [1] J. Larminie and A. Dicks, "Fuel Cell Systems Explained", John Wiley & Sons LTD, New York 2000, section 3.2 Terminology.
- [2] "Fuel Cell Power Systems Performance", ASME PTC 50-2002, The American Society of Mechanical Engineers, November 2002.
- [3] FCTESTNET-WP1, Applications-Transportation, Terminology Report (TNO)
- [4] FCTESTNET-WP3, Applications-Portable, Testing Model Report (Catella Generics)
- [5] FCTESTNET-WP5, PEFC, Terminology Report (CEA)
- [6] FCTESTNET-WP6, MCFC, Terminology Report (CESI Report n. A4/009147)
- [7] FCTESTNET-WP7, SOFC, Terminology Report (LECA-CNRS)
- [8] CSIC-CIEMAT, Terminology Contribution



European Commission

EUR22295EN – DG JRC – Institute for Energy – THE FUEL CELLS TESTING AND STANDARDISATION NETWORK - FCTESTNET: FUEL CELLS GLOSSARY

Luxembourg: Office for Official Publications of the European Communities
2006 – 50 pp. – 21 x 29.7 cm
Scientific and Technical Research Series ISSN 1018-5593
ISBN 92-79-02747-6

Editors:

G. Tsotridis (JRC-IE)
A. Podias (JRC-IE)
M. Scagliotti (CESI)
W. Winkler (VDI/Hamburg University of Applied Sciences)

Abstract

This report is the first one of a series of reports produced by the EC-funded FP5 Thematic Network project FCTESTNET. All network Work Packages contributed with specific terminology reports that were incorporated and harmonised in the FCTESTNET Fuel Cells Glossary. The Version 1 of the Glossary was distributed to the Network members and to International institutions. Comments and suggestions are included in the present Version 2 of the Glossary.

The development of a commonly agreed terminology is an important step towards the harmonisation of testing procedures and methodologies related to a new fast growing technology. It is important for joint projects to have a common definition within the European Union. This is the main objective of this glossary. Nevertheless, it is seen as important by the contributors to do this work in close collaboration with the international standardisation activities and to integrate this document in a future international standardisation activity. This is an important reason to integrate already available definitions from overseas as far as possible, however some have been modified regarding European requirements.

The mission of the Joint Research Centre is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies. As a service of the European Commission, the JRC functions as a reference centre of science and technology for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national.

