

INTERNATIONAL STANDARD

NORME INTERNATIONALE



Fuel cell technologies –

Part 3-400: Stationary fuel cell power systems – Small stationary fuel cell power system with combined heat and power output

Technologies des piles à combustible –

Partie 3-400: Systèmes à piles à combustible stationnaires – Petits systèmes à piles à combustible stationnaires avec chaleur et puissance en sortie combinées



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

FUEL CELL TECHNOLOGIES –

**Part 3-400: Stationary fuel cell power systems –
Small stationary fuel cell power system
with combined heat and power output**

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International Standard IEC 62282-3-400 has been prepared by IEC technical committee 105: Fuel cell technologies.

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

FDIS	Report on voting
105/620/FDIS	105/624/RVD

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

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

A list of all parts in the IEC 62282 series, published under the general title *Fuel cell technologies*, can be found on the IEC website.

The reader's attention is drawn to the fact that Annex B, Annex C and Annex D list all of the “in-some-countries” clauses on differing practices of a less permanent nature relating to the subject of this standard.

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FUEL CELL TECHNOLOGIES –

Part 3-400: Stationary fuel cell power systems – Small stationary fuel cell power system with combined heat and power output

1 Scope

This part of IEC 62282 applies to small stationary fuel cell power systems serving as a heating appliance providing both electric power and useful heat with or without a supplementary heat generator providing peak load function.

This standard applies to fuel cell power systems that are intended to be permanently connected to the electrical system of the customer (end user). Direct connection to the mains (parallel operation) is also within the scope of this standard.

NOTE 1 Parallel operation is subject to the permission of the local electric power supply utility.

This standard is limited to gas and liquid fuelled fuel cell CHP appliances that have a heat input based on lower heating value of less than or equal to 70 kW. For some regional applications, the output electric power is limited. Specific limitations are given in Clause C.1 for Japan.

This standard applies to systems as shown in Figure 1.

One is a system where both stationary fuel cell power system and supplementary heat generator are installed in one enclosure without any partition.

This standard does not have to apply to the supplementary heat generator of systems where the stationary fuel cell power system and the supplementary heat generator are not built in one enclosure, and whose ducts are not common (that is, each appliance has its own dedicated duct system).

This standard applies to systems intended for operation on the following supplied input fuels:

- natural gas and other methane rich gases;
- fuels derived from oil refining (liquefied petroleum gases, propane, and butane);
- hydrogen as supply gas for the CHP generator.

NOTE 2 It is possible that other fuels such as alcohols (methanol, ethanol), kerosene, or hydrogen for the supplementary heat generator will be added in future amendments or revisions.

This part of IEC 62282 applies to systems where:

- the heat transfer fluid (heat output) is water or a mixture of water and additives to prevent corrosion and to prevent freezing;
- the heat transfer fluid circuit (heat output) can be designed for open or sealed operation;
- the maximum temperature of the heat transfer fluid (heat output) does not exceed 100 °C, or the value given in Clause B.1 for Europe or in Clause D.1 for the USA;
- the maximum pressure of the heat transfer fluid (heat output) circuit does not exceed 0,3 MPa, or the limits given in Clause B.1 for Europe, or C.4.3 for Japan or Clause D.1 for the USA;
- the maximum pressure of the domestic hot water circuit, if installed, does not exceed 0,1 MPa, or the limits as given in Clause D.1 for the USA.

This standard applies to systems with either condensing or non-condensing conditions in the exhaust gas.

This standard applies to appliances

- with ducts included as part of the appliance (Type B, Type C) and
- without ducts (Type A)

Duct systems are shown in Annex F. The chimney in the figures is part of the building and is not within the scope of this standard.

Different combustion air/flue duct circuit configurations are accommodated, see Annex F.

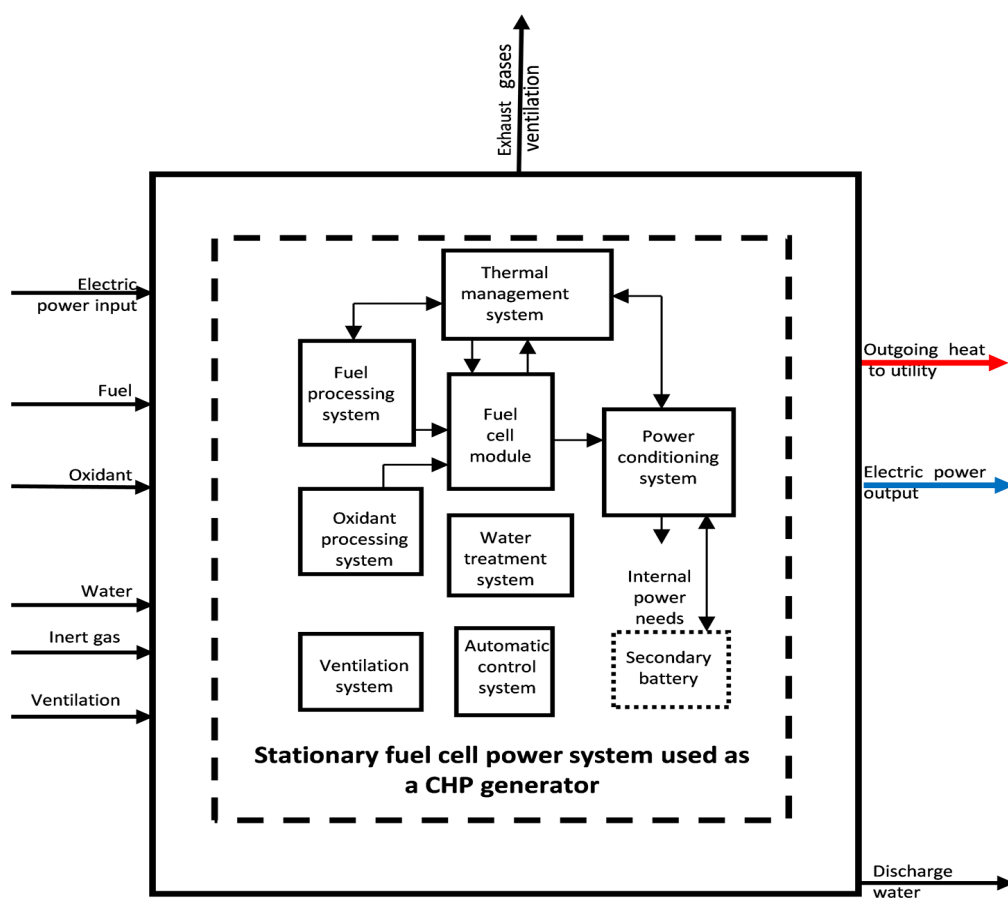
This standard applies to both indoor and outdoor installations.

This standard applies to type testing only.

This standard specifies the requirements for construction, safety, installation, fitness for purpose, rational use of energy, marking, and performance measurement of these appliances.

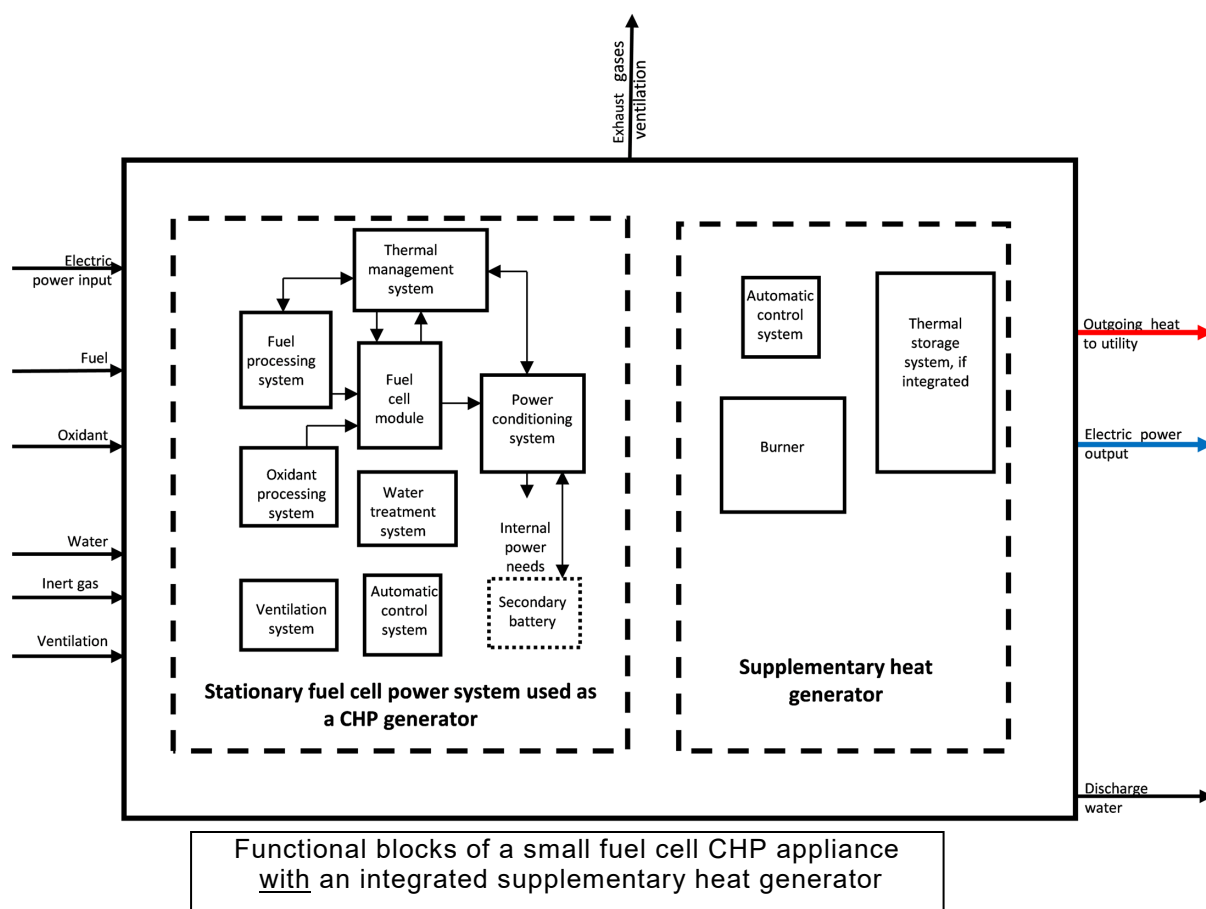
This standard also provides regional and country specific requirements to facilitate the worldwide application of this IEC standard. These essential regional and country specific requirements are given in Annex B for Europe, in Annex C for Japan and in Annex D for the USA.

If the user or manufacturer chooses a regional specific annex to apply this standard, then that annex applies to the appliance in its entirety without mixing requirements between annexes. The chosen regional or country specific annex becomes normative.



Functional blocks of a small fuel cell CHP appliance without an integrated supplementary heat generator

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Figure 1 – Configuration with and without integrated supplementary heat generator

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE Regional specific standards are given in Clause B.2 for Europe, in Clause C.2 for Japan and in Clause D.2 for the USA.

IEC 60079 (all parts), *Explosive atmospheres*

IEC 60079-0, *Explosive atmospheres – Part 0: Equipment – General requirements*

IEC 60079-2, *Explosive atmospheres – Part 2: Equipment protection by pressurized enclosure "p"*

IEC 60079-10-1, *Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres*

IEC 60079-20-1, *Explosive atmospheres – Part 20-1: Material characteristics for gas and vapour classification – Test methods and data*

IEC 60079-30-1, *Explosive atmospheres – Part 30-1: Electrical resistance trace heating – General and testing requirements*

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

IEC 60335-2-102:2004, *Household and similar electrical appliances – Safety – Part 2-102: Particular requirements for gas, oil and solid-fuel burning appliances having electrical connections*

IEC 60335-2-102:2004/AMD1:2008

IEC 60335-2-102:2004/AMD2:2012

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

IEC 60721-3-1, *Classification of environmental conditions – Part 3 Classification of groups of environmental parameters and their severities – Section 1: Storage*

IEC 60721-3-2, *Classification of environmental conditions – Part 3 Classification of groups of environmental parameters and their severities – Section 2: Transportation*

IEC 60721-3-3, *Classification of environmental conditions – Part 3-3: Classification of groups of environmental parameters and their severities – Stationary use at weatherprotected locations*

IEC 60730-1, *Automatic electrical controls – Part 1: General requirements*

IEC 60730-2-5, *Automatic electrical controls – Part 2-5: Particular requirements for automatic electrical burner control systems*

IEC 60730-2-9, *Automatic electrical controls – Part 2-9: Particular requirements for temperature sensing control*

IEC 61000-3-2, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic currents emissions (equipment input current ≤ 16 A per phase)*

IEC 61000-3-3, *Electromagnetic compatibility (EMC) – Part 3-3: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection*

IEC TS 61000-3-4, *Electromagnetic compatibility (EMC) – Part 3-4: Limits – Limitation of emission of harmonic currents in low-voltage power supply systems for equipment with rated current greater than 16 A*

IEC 61000-3-11, *Electromagnetic Compatibility (EMC) – Part 3-11: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems – Equipment with rated current ≤ 75 A and subject to conditional connection*

IEC 61000-3-12, *Electromagnetic compatibility (EMC) – Part 3-12: Limits – Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current >16 A and ≤ 75 A per phase*

IEC 61000-6-1, *Electromagnetic compatibility (EMC) – Part 6-1: Generic standards – Immunity for residential, commercial and light-industrial environments*

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

IEC TS 62282-1:2013, *Fuel cell technologies – Part 1: Terminology*

IEC 62282-2:2012, *Fuel cell technologies – Part 2: Fuel cell modules*

IEC 62282-3-201:2013, *Fuel cell technologies – Part 3-201: Stationary fuel cell power systems – Performance test methods for small fuel cell power systems*

CISPR 14-1, *Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus – Part 1: Emission*

CISPR 14-2, *Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus – Part 2: Immunity – Product family standard;*

ISO 7-1, *Pipe threads where pressure-tight joints are made on the threads – Part 1: Dimensions, tolerances and designation*

ISO 228-1, *Pipe threads where pressure-tight joints are not made on the threads – Part 1: Dimensions, tolerances and designation*

ISO 262, *ISO general purpose metric screw threads – Selected sizes for screws, bolts and nuts*

ISO 3166-1 *Codes for the representation of names of countries and their subdivisions – Part 1: Country codes*

ISO 4126-1, *Safety devices for protection against excessive pressure – Part 1: Safety valves*

ISO 23550:2011, *Safety and control devices for gas burners and gas-burning appliances – General requirements*

ISO 23551-1, *Safety and control devices for gas burners and gas burning appliances – Particular requirements – Part 1: Automatic and semi-automatic valves*

ISO 23551-2, *Safety and control devices for gas burners and gas-burning appliances – Particular requirements – Part 2: Pressure regulators*

ISO 23551-3, *Safety and control devices for gas burners and gas-burning appliances – Particular requirements – Part 3: Gas/air ratio controls, pneumatic type*

ISO 23552-1, *Safety and control devices for gas and/or oil burners and gas and/or oil appliances – Particular requirements – Part 1: Fuel/air ratio controls, electronic type*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>

- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1.1

supply gas

gas, supplied externally to the small fuel cell CHP appliance

3.1.2

supply gas circuit

assembly of parts of the small fuel cell CHP appliance that carry or contain the supply gas between the gas inlet connection and the outlet of the safety shut-off valves

3.1.3

gas carrying circuit

assembly of parts of the small fuel cell CHP appliance that carry or contain supplied gas or process gas excluding the combustion circuit

3.1.4

process gas

gas, transformed from supplied gas to a gas containing predominantly hydrogen

3.1.5

air supply circuit

assembly of parts of the small fuel cell CHP appliance that carry or contain supplied oxidant air to the fuel processing system, fuel cell stack or combustion air to the burner

3.1.6

combustion circuit

circuit consisting of the air supply circuit and the combustion products circuit

3.1.7

combustion products circuit

circuit including the combustion chamber, the heat exchanger, the combustion products evacuation duct and either the fitting piece or the connection to the duct terminal, if any

3.1.8

combustion chamber

enclosure inside which combustion of the air-gas mixture takes place

3.1.9

air supply duct

means for transporting oxidant air to the fuel processing system, the fuel cell stack, combustion air to the burner, and the ventilation air

3.1.10

combustion products evacuation duct

means for transporting the combustion products, the cathode air from the fuel cell stack and the ventilation air

3.1.11

completely surrounded by combustion air

constructional concept of internal parts of the small fuel cell CHP appliance, which surrounds the parts with flowing supplied air for the purpose of sweeping away potential leakages in the direction of the combustion process

3.1.12

air proving

method by which air availability is verified for a combustion or oxidation process

Note 1 to entry: A function of the air proving method is to check if the correct volume of air is available and to show the volume only when air is available.

3.1.13

semi-outdoor small fuel cell CHP appliance

small fuel cell CHP appliance intended to be installed in the open air but in a partially protected place only, not exposed to the direct exterior surrounding and infiltration of rain, snow or hail

3.1.14

duct terminal

part of the combustion circuit fitted outside the building which has the function of air supply inlet and/or combustion products outlet of the appliance

Note 1 to entry: See Figure F.1.

3.1.15

fitting piece

intermediate piece that connects the duct system to the small fuel cell CHP appliance

Note 1 to entry: See Figure F.1.

3.1.16

duct terminal guard

device that protects the duct terminal from mechanical damage from outside influences

Note 1 to entry: See Figure F.1.

3.1.17

recycling

automatic process by which, after loss of flame during operation, the gas supply is interrupted and the full start procedure is re-initiated automatically

3.1.18

maximum water side operating pressure

maximum pressure of the water on the small fuel cell CHP appliance outlet which provides the heat for the heating water circuit, declared by the manufacturer for which the appliance is designed

3.1.19

CHP

combined heat and power

simultaneous generation of thermal and electric energy in one process

Note 1 to entry: This note applies to the French language only.

3.1.20

small fuel cell CHP appliance

appliance which delivers both heat and electric power (and which can also provide domestic hot water service) and is comprised of a stationary fuel cell power system used as a CHP generator and the following components as relevant:

- supplementary heat generator
- flue ducts
- thermal storage

Note 1 to entry: See Figure 1.

Note 2 to entry: The appliance is either delivered or specified by the manufacturer's instructions as a complete package.

3.1.21

CHP generator

system that includes a fuel cell power system producing thermal and electric energy and is the preferential source of heat

Note 1 to entry: See Figure 1.

3.1.22

supplementary heat generator

non-preferential heat source providing peak load

Note 1 to entry: See Figure 1.

3.1.23

states and phases of operation

3.1.23.1

cold state

state of a CHP generator at ambient temperature with no power input or output

3.1.23.2

operational state

state of a CHP generator with the ability to generate nominal electric active power output, or state of the supplementary heat generator with the ability to produce nominal heat output, if demanded

3.1.23.3

storage state

state of a CHP generator being non-operational and possibly requiring, under conditions specified by the manufacturer, the input of thermal and/or electric energy and/or an inert atmosphere in order to prevent deterioration of the components and/or to energize the control systems

3.1.23.4

lockout state

state of operation in which the small fuel cell CHP appliance, or the CHP generator or the supplementary heat generator is shut down and a restart can only be accomplished by a manual reset

3.1.23.5

start-up

sequence of operations, specified by the manufacturer, which occurs to transition a CHP generator from cold state or storage state to operational state

3.1.23.6

shutdown

sequence of operations, specified by the manufacturer, which occurs to transition a CHP generator from operational state to cold state or storage state

3.1.24

heat input

amount of heat expressed as a function of time released by the small fuel cell CHP appliance at a given throughput

Note 1 to entry: Heat input is expressed in kilowatts (kW) and is calculated as fuel flow rate multiplied by the lower heating value of the fuel.

3.1.25

nominal heat input

value of the heat input, to provide nominal output

Note 1 to entry: Nominal heat input is the needed heat input to operate the small fuel cell CHP appliance to reach nominal heat output and nominal electric power output.

3.1.26

nominal output

useful output (thermal and electric power) declared by the manufacturer, corresponding to the operation of the small fuel cell CHP appliance in a specified water temperature regime or at a specified domestic hot water temperature condition

Note 1 to entry: Nominal output is expressed in kW.

3.1.27

purge circuit

circuit of the CHP generator that contains process gas or anode off gas during generating mode

3.1.28

internal cooling circuit

assembly of parts of the small fuel cell CHP appliance that carry or contain liquids intended to maintain the internal components of the appliance at their operating temperature and that are not connected to supplies or circuits outside of the appliance

3.1.29

heating water

water or mixtures of water and other liquids (such as glycol) contained in the heating water circuit intended to transfer useful heat to the building or external heat storing devices

3.1.30

heating water circuit

assembly of parts of the small fuel cell CHP appliance that carry or contain water or mixtures of water and other liquids (such as glycol) intended to transfer useful heat to the building or external heat storing devices

3.1.31

protected nature

design of a combustion chamber and combustion products evacuation ducts such that an ignition in the combustion chamber does not cause ignition in the combustion products evacuation ducts, even if a flammable mixture exists in the combustion products evacuation ducts

Note 1 to entry: This may be achieved by any suitable design.

3.1.32

electric efficiency

ratio of the average net electric power output of a fuel cell power system at a given duration to the average fuel power fed to the same fuel cell power system at the same duration

3.1.33

heat recovery efficiency

ratio of the average thermal power recovered at a given duration from a fuel cell power system to the average fuel power fed to the same fuel cell power system at the same duration

3.1.34

overall energy efficiency

sum of the electric efficiency and heat recovery efficiency

3.1.35

range-rating device

component on the small fuel cell CHP appliance intended to be used by the installer to adjust the nominal heat input of the small fuel cell CHP appliance within the range of maximum and

minimum heat inputs stated by the manufacturer, to suit the actual heat requirements of the installation

3.1.36

range-rated small fuel cell CHP appliance

small fuel cell CHP appliance which is adjustable by the range-rating device

3.1.37

domestic hot water

water delivered by the small fuel cell CHP appliance, raised to a certain temperature in order to use it for domestic needs, such as kitchen, bathroom

3.1.38

appliance category

means of identifying the type of gas which a gas appliance is designed to utilize safely and to the desired performance level

Note 1 to entry: See 5.4.1.2.

3.1.39

gas family

gas type

group of gaseous fuels with similar burning behaviour linked together by a range of Wobbe indices

Note 1 to entry: The gas families are specified in the regional specific annexes as given in 4.1, if relevant.

3.1.40

gas group

specified range of Wobbe index within that of the gas type concerned

Note 1 to entry: This range is determined on the general principle that appliances utilizing this gas group would operate safely when burning all gases within this range without adjustments.

Note 2 to entry: The gas groups are specified in the regional specific annexes as given in 4.1, if relevant.

3.1.41

test gases

gases intended for the verification of the operational characteristics of gas appliances

Note 1 to entry: Test gases consist of reference gases and limit gases.

Note 2 to entry: The test gases are specified in the regional specific annexes as given in 4.1, if relevant.

3.1.42

reference gases

test gases with which appliances operate under nominal conditions when they are supplied at the corresponding normal pressure

Note 1 to entry: The reference gases are specified in the regional specific annexes as given in 4.1, if relevant.

3.1.43

limit gases

test gases representative of the extreme variations in the characteristics of the gases for which appliances have been designed

Note 1 to entry: The limit gases are specified in the regional specific annexes as given in 4.1, if relevant.

3.1.44

adjuster

component allowing to set or bring a value to a predetermined value according to the technical instructions

Note 1 to entry: The action of operating this device is called "adjustment".

3.2 Symbols

The symbols and their meanings used in this part of IEC 62282 are given in Table 1 with the appropriate units.

Table 1 – Symbols and their meanings

Symbol	Definition	Unit
<i>A</i>	Area	
A_{duct}	Cross-sectional area of a combustion products evacuation duct	mm ²
<i>c</i>	Specific heat	
c_{HR}	Specific heat capacity of heating water	kJ/(kg·K)
<i>F</i>	Weighting factor	
F_{CHP}	Weighting factor for NO _x emission calculation	
F_{pi}	Weighting factor for NO _x emission calculation corresponding to partial heat input	
<i>H</i>	Heating value	
$H_{\text{i,V}}$	Lower heating value (LHV) of fuel gas based on volume	MJ/m ³
$H_{\text{i,m}}$	Lower heating value (LHV) of fuel gas based on mass	MJ/kg
$H_{\text{s,V}}$	Higher heating value (HHV) of fuel gas based on volume	MJ/m ³
$H_{\text{s,m}}$	Higher heating value (HHV) of fuel gas based on mass	MJ/kg
<i>h</i>	Humidity	
h_{at}	Combustion air humidity	g/kg
<i>l</i>	Length	
l_{c}	Circumference of a rectangular combustion products evacuation duct	mm
l_{d}	Diameter of a combustion products evacuation duct	mm
l_{s}	Distance of the combustion products' sampling point to the extreme end of the combustion products' duct	mm
<i>P</i>	Power, heat input	
P_{el}	Net electric power output	kW
$P_{\text{el,nom}}$	Nominal electric power output	kW
$P_{\text{el,max}}$	Maximum electric power output	kW
$P_{\text{el,min}}$	Minimum electric power output	kW
P_{inf}	Heat input (of the appliance)	kW
$P_{\text{inf,nom}}$	Nominal heat input (of the appliance)	kW
$P_{\text{inf,nom,SUP}}$	Nominal heat input of the supplementary heat generator	kW
$P_{\text{inf,max}}$	Maximum heat input (of the appliance)	kW
$P_{\text{inf,min}}$	Minimum heat input (of the appliance)	kW
$P_{\text{inf,DHW}}$	Nominal heat input (of the appliance) in the domestic hot water mode	kW
$P_{\text{inf,ign}}$	Heat input during ignition	kW
$P_{\text{inf,part}}$	Partial heat input, expressed in percent of $P_{\text{inf,nom}}$	%
$P_{\text{th,nom}}$	Nominal useful thermal power output	kW
$P_{\text{th,max}}$	Maximum useful thermal power output	kW
$P_{\text{th,min}}$	Minimum useful thermal power output	kW
<i>p</i>	Pressure	
p_{a}	Atmospheric pressure	kPa
p_{g}	Gas pressure	kPa

Symbol	Definition	Unit
$p_{w,max}$	Maximum water side operating pressure	MPa
$p_{w,sat}$	Saturated vapour pressure of water	kPa
Q	Energy	
Q_{loss}	Heat loss of the test rig	kJ
q_m	Mass flow rate	
$q_{m,g}$	Mass flow rate of gas	kg/h
q_v	Volumetric flow rate	
$q_{v,g}$	Volumetric flow rate of gas	m ³ /h
$q_{v,HR}$	Volumetric flow rate of the heating water	m ³ /h
$q_{v,leak}$	Leakage flow rate	m ³ /h
$q_{v,vent}$	Ventilation flow rate	m ³ /h
SG	Specific gravity	
SG_{tg}	Test gas specific gravity	
SG_{fg}	Fuel gas specific gravity	
T	Temperature	
T_{at}	Combustion air temperature	°C
T_g	Gas temperature	°C
T_1	Flow temperature of the heating water circuit	°C
T_2	Return temperature of the heating water circuit	°C
t	Time	
t_{sa}	Ignition safety time	s
$t_{sa,max}$	Maximum ignition safety time, under the conditions as given in IEC 60730-2-5	s
Δt	Test duration	s
V	Volume	
V_g	Consumed gas volume	m ³
$V_{ex,th,dr}$	Theoretical reference flue gas volume, dry	m ³ /m ³
ε	Emission	
$\varepsilon(NO_x)$	NO _x emission referring to the energy input	mg/kWh
$\varepsilon_c(NO_x)$	Value of $\varepsilon(NO_x)$ corrected to the conditions 10 g/kg for humidity and 20 °C for temperature	mg/kWh
$\varepsilon_{CHP}(NO_x)$	Weighted value of NO _x emission of the CHP part	mg/kWh
$\varepsilon_{meas}(NO_x)$	Measured NO _x emission at partial heat input	mg/kWh
$\varepsilon_{pond}(NO_x)$	Weighted value of NO _x emission	mg/kWh
$\varepsilon_{SUP}(NO_x)$	Weighted value of NO _x emission of the supplementary heat generator	mg/kWh
η	Efficiency	
η_{total}	Overall energy efficiency (of the appliance)	%
η_{el}	Electrical efficiency (of the appliance)	%
η_{th}	Heat recovery efficiency (of the appliance)	%
η_{eq}	Equivalent space heating efficiency (of the appliance)	%
η_s	Seasonal space heating energy efficiency	%
η_{son}	Seasonal space heating energy efficiency in active mode	%
ρ	Density	
ρ_{HR}	Density of the heating water	kg/m ³
μ	Viscosity	

Symbol	Definition	Unit
μ_{tg}	Test gas absolute viscosity	Pa·s
μ_{fg}	Fuel gas absolute viscosity	Pa·s
φ	Volume fraction	
φ_{fuel}	Volume fraction of combustibles	% vol.
$\varphi_{ex,th}(CO)$	CO volume fraction in the dry air-free combustion products	% vol.
$\varphi_{ex,m}(CO)$	Measured CO volume fraction in dry combustion products	% vol.
$\varphi_{ex,w}(CO)$	Weighted CO volume fraction in dry combustion products	% vol.
$\varphi_{at,m}(O_2)$	Measured O_2 volume fraction in the dry atmosphere	% vol.
$\varphi_{ex,m}(O_2)$	Measured O_2 volume fraction in dry combustion products	% vol.
$\varphi_{ex,th}(CO_2)$	CO_2 volume fraction in the theoretical dry air-free combustion products	% vol.
$\varphi_{ex,m}(CO_2)$	Measured CO_2 volume fraction in dry combustion products	% vol.
$\varphi_{at,m}(CO_2)$	Measured CO_2 volume fraction in the dry atmosphere	% vol.
$\varphi_{ex,m}(NO_x)$	Measured NO_x volume fraction in dry combustion products	ml/m ³

4 Appliance classification

Additional requirements are given in C.4.101 for Japan.

4.1 Gases and gas categories

Small fuel cell CHP appliances are classified by the used gas families and gas groups.

For gases and gas categories regional specific requirements are given in B.4.1 for Europe and C.4.1 for Japan.

4.2 Mode of air supply and evacuation of combustion products

Small fuel cell CHP appliances are classified into several types according to the mode of evacuation of the combustion products and supply of the combustion air.

Type A small fuel cell CHP appliance is an appliance intended to be installed semi-outdoors or outdoors in open air. For Type A small fuel cell CHP appliance no flue duct systems are specified.

Type B small fuel cell CHP appliance is an appliance intended to be connected to a flue system evacuating the combustion products to the outside of the room containing the appliance, with the combustion air being drawn directly from the room where the appliance is installed.

Type C small fuel cell CHP appliance is an appliance in which the combustion circuit is sealed with respect to the room in which the appliance is installed.

Different types of configuration of the air supply and combustion products evacuation ducts are provided in Annex F in order to allow a systematic approach for the manufacturer to make his own choice.

NOTE Annex F offers the manufacturer the choice of a large variety of different types of flue duct system as part of the small fuel cell CHP appliance, including a solution where no flue duct system is included.

Regional specific requirements are given in C.4.2 for Japan and in D.4. for the USA.

4.3 Maximum water side operating pressure

Small fuel cell CHP appliance classification according to the maximum water side operating pressure. The pressure class limits are given in the regional annexes, see B.4.3 for Europe and C.4.3 for Japan.

NOTE Internal cooling circuits in small fuel cell CHP appliances, for example internal cooling circuits for heat exchange in small fuel cell CHP appliances, are not considered under this classification,

4.4 Expansion system

Small fuel cell CHP appliances which are intended to be used for the central heating circuit are classified according to the expansion system:

- open vented system: intended exclusively for a central heating system with an open expansion vessel;
- sealed system: suitable for a central heating system with an open or sealed expansion vessel.

Requirements specific for Japan are given in C.4.4.

4.5 Output power characteristic

Small fuel cell CHP appliances are classified according to the output power characteristic:

- DC or AC output power;
- voltage/frequency;
- phases and number of lines (e.g. single phase three lines);
- grid connection;
- island mode.

5 Safety requirements and protective measures

5.1 General safety strategy

The manufacturer shall perform in written form a risk analysis to ensure that

- a) all reasonably foreseeable hazards, hazardous situations and events throughout the anticipated small fuel cell CHP appliance's lifetime, have been identified (see Annex A for a listing of typical hazards);
- b) the risk for each of these hazards has been estimated from the combination of probability of occurrence of the hazard and of its foreseeable severity;
- c) the two factors which determine each one of the estimated risks (probability and severity) have been eliminated or reduced to a level not exceeding the acceptable risk level as far as practically possible through
 - 1) inherently safe design of the construction and its methods, or
 - 2) passive control of energy releases without endangering the surrounding environment (e.g. burst disks, release valves, thermal cut-off devices) or by safety related control functions, and
 - 3) for residual risks which could not have been reduced by the measures according to 1) and 2) the provision of labels, warnings, or requirements of special training, considering that such measures need to be understood by the persons which are in the area of the hazards.

If not stated elsewhere in this standard safety related measures are explicitly given in the measures required for functional safety and the allocation of the class of control function shall be determined and designed in accordance with

- IEC 60335-2-102 in conjunction with IEC 60335-1, on an appliance level, and
- IEC 60730-1 on a control level.

NOTE For failure mode and effects analysis (FMEA) and fault tree analysis methods, the standards IEC 60812, SAE J1739 and IEC 61025 can be used as guidance.

5.2 Construction requirements for safety

Additional requirements are given in C.5.2.101 to C.5.2.103 for Japan.

5.2.1 General

The small fuel cell CHP appliance shall be designed in accordance with a risk assessment performed by the small fuel cell CHP appliance manufacturer according to 5.1.

All components used shall be selected so that they are appropriate for the intended specification of the safe operation of the appliance. This is also applicable to inverters concerning their power input and output, voltage and frequencies.

Component parts of covers, operating controls and safety devices and electrical accessories shall be arranged in such a way that their environmental temperatures under steady state conditions do not exceed those specified by the component part standard or the small fuel cell CHP appliance manufacturer if the manufacturer's specified temperatures are greater/lower than those given in the component part standard.

The use of asbestos-containing materials is forbidden.

Solder containing cadmium in its formulation shall not be used in the construction of the appliance.

For small fuel cell CHP appliances intended to be installed semi-outdoors or outdoors, all materials employed in the construction, including seals, gaskets and sealing pastes, if any, shall function properly in the environmental conditions under which they are expected to operate.

The manufacturer shall declare in the technical instructions for the installer the minimum and maximum ambient temperatures at which the appliance is designed to operate.

For the following components of a small fuel cell CHP appliance, measures such as housed in enclosures or venting shall be taken to prevent unintended discharge of fuel gas, process gas, or flue gas into the room where it is installed:

- fuel gas and combustion air supply;
- fuel cell stack;
- internal flue system;
- fuel processing (if existing);
- internal cooling circuits (if existing).

Regional specific requirements are given in C.5.2.1 for Japan and in D.5.2.1 for the USA.

5.2.2 Use and servicing

5.2.2.1 General

The user shall be able to gain access to and operate all control knobs and buttons necessary for normal use of the small fuel cell CHP appliance without having to remove any part of the case.

However, part of the case may be removed provided that this part can be handled safely by the user, that this part can be removed without the use of tools and that incorrect replacement is difficult (e.g. by the provision of stops).

All markings intended for the user shall be easily visible and shall be made in a clear and indelible manner.

Parts which are required to be inspected or removed for servicing shall be easily accessible, possibly after removal of the case, in accordance with the manufacturer's instructions.

Removable parts shall be designed or marked so that they are difficult to re-assemble incorrectly.

Every small fuel cell CHP appliance shall be provided with at least one device to enable the user to close the gas supply to the burner, supplementary burner, ignition burner or similar oxidation devices as relevant to the design of the small fuel cell CHP appliance. The shut-off of such a gas supply shall be effected without delay.

Any control and setting device shall be clearly marked and give appropriate instruction so as to prevent any error in handling. No markings are required if incorrect operation is impossible.

If the manufacturer's instructions require parts of the small fuel cell CHP appliance to be cleaned it shall be possible to do this easily and/or remove them easily for servicing with the use of commercially available tools. This shall not involve disconnection of the small fuel cell CHP appliance from the gas or water pipes.

For small fuel cell CHP appliances connected to an air supply system and/or combustion products evacuation system that forms part of the construction of the building, it shall be possible to carry out servicing of the small fuel cell CHP appliance without dismantling the permanent connections to the duct.

The soundness of the combustion circuit shall be maintained after reassembly and, if necessary, in accordance with the manufacturer's instructions, after replacement of the seal(s) following cleaning and servicing operations.

5.2.2.2 Conversion to different gases

If allowed in the installation instructions provided by the manufacturer, the following actions may be taken in order to convert from a gas of one family or group to a gas of another family or group:

- electronic adjustment to ensure correct maximum heat input and/or combustion quality;
- adjustment of the gas rate of the main burner, supplementary burner and ignition burner;
- change of restrictor or injector;
- change of ignition burner or its components;
- change of gas rate modulation system;
- adjustment of the ignition point;
- putting out of service and sealing a gas rate adjuster and/or a pressure regulator;
- changes of configuration parameters by data exchange (for requirements see IEC 60730-1);
- use of combustion control system methods taking the requirements of ISO 23552-1 into account.

For each of the operations mentioned above that are allowed by the manufacturer in the installation manual, the appliance shall be type-tested with each of the gases. These operations shall be possible without having to interfere with the connections of the small fuel

cell CHP appliance to its connecting pipe-work, i.e. gas supply, water supply and air inlet and combustion product evacuation ducts.

Requirements specific for Japan are given in C.5.2.2.2.

5.2.3 Connections to the supply systems

5.2.3.1 Connection to the gas and water pipes

5.2.3.1.1 General

The small fuel cell CHP appliance connections shall be easily accessible. They shall be clearly identified in the installation instructions and possibly on the small fuel cell CHP appliance.

The clearance around the connections, after removing the case if necessary, shall be adequate to allow easy use of the tools required to make the connection.

It shall be possible to make all the connections without special tools.

5.2.3.1.2 Connection to the gas pipe

The small fuel cell CHP appliance shall be designed to be able to be connected to the gas supply pipe with a rigid or flexible metallic means.

Gas connections shall comply with ISO 23550.

Requirements specific for Japan are given in C.5.2.3.1.2.

5.2.3.1.3 Connection to the water pipes

5.2.3.1.3.1 General

The connection of the small fuel cell CHP appliance to the external water pipes shall be as follows.

- a) For the piping, a suitable bore diameter shall be provided according to a use purpose and a use location.
- b) The end connection shall be provided normally to be exposed to the outside, or provided at the position where it is easily viewed from the outside.
- c) The piping shall be resistant to various stresses generated by vibration in accordance with the declaration based on IEC 60721-3-1, IEC 60721-3-2 and IEC 60721-3-3.

NOTE If the small fuel cell CHP appliance is installed outdoors, earthquake loads can also be considered.

Requirements specific for Japan are given in C.5.2.3.1.3.1.

5.2.3.1.3.2 For the heating water circuit or domestic hot water circuit

Threaded connections shall comply with ISO 228-1 or ISO 7-1.

Requirements specific for Japan are given in C.5.2.3.1.3.2.

If copper connections are used, the connecting end of the tube shall comply with the appropriate national or regional standard. Requirements specific for Europe are given in B.5.2.3.1.3.2.

If other than metallic materials are used, the manufacturer shall provide the appropriate justification for their suitability of use.

5.2.3.1.3.3 For process water (if applicable)

The connections shall comply with the local connection code.

The material and the connection shall withstand the water pressure including the surge pressure which occurs in the public water system.

Means shall be used so that no internal process water can contaminate the public water system.

5.2.3.1.3.4 Drainage

For the purpose of service and maintenance, the appliance shall carry a device that enables it to be drained. Suitable directions for drainage, without the discharge of water compromising electrical safety, shall be included in the instructions.

Methods for drainage are given in B.5.2.3.1.3.4 for Europe.

5.2.3.2 Connection to the combustion air and flue duct system (if any)

5.2.3.2.1 Air supply and combustion products evacuation ducts

The assembly of the various parts during installation shall be such that no work is necessary other than adjusting the length of the air supply and combustion products evacuation ducts (possibly by cutting them). Such adaptation shall not impair the correct operation of the appliance.

It shall be possible to connect the small fuel cell CHP appliance, the air supply and combustion products evacuation ducts and the duct terminal or fitting piece using ordinary tools if necessary. All necessary accessories and the fitting instructions shall be supplied or specified by the manufacturer.

Duct terminal guard, if it exists, and fitting pieces shall be installed in accordance with the manufacturer's instructions.

For the duct terminal outlets from separate ducts for the supply of combustion air and the evacuation of combustion products, the manufacturer shall declare if the duct terminal inlet and outlet need to be positioned in the same pressure zone or if it is permitted to position the two duct terminals (inlet and outlet) in zones of different pressure. Possible configurations of duct systems are given in Annex F.

Requirements specific for Europe are given in B.5.2.3.2.1.

5.2.3.2.2 Duct terminal

Duct terminals on appliances without a fan shall prevent the intrusion of external objects by having no opening in the external surfaces of the duct terminal which may permit the entry of a 16 mm diameter ball when applied with a force of 5 N.

Regional specific requirements are given in C.5.2.3.2.2 for Japan.

Any horizontal duct terminal for non-condensing small fuel cell CHP appliances shall be designed in such a way that condensate is discharged away from the wall.

Any horizontal duct terminal for condensing small fuel cell CHP appliances shall be designed in such a way that condensate is directed towards the appliance.

5.2.3.2.3 Duct terminal guard

If the manufacturer prescribes in the installation instructions a protective guard for the duct terminal for use when the outlets for evacuation of the combustion products open on to a walkway, this device shall be supplied to the laboratory for testing.

The dimensions of the duct terminal guard, when installed in accordance with the manufacturer's instructions, shall be such that the distance between any part of the guard and the duct terminal, except the wall plate, is sufficiently large to ensure that the function of the duct terminal is not degraded. The guard shall not have any sharp edges likely to cause injury.

Regional specific requirements are given in B.5.2.3.2.3 for Europe and in C.5.2.3.2.3 for Japan.

5.2.3.2.4 Fitting piece

For small fuel cell CHP appliances which are connected with a duct to a chimney, the fitting piece shall be designed so that it is possible to obtain the distances specified by the manufacturer for the projection of the ends of the combustion air supply and combustion products discharge ducts into the chimney, whatever the total thickness (flue and cladding) of the chimney is. Possible configurations of duct systems are given in Annex F showing a chimney.

Regional specific requirements are given in B.5.2.3.2.4 for Europe and in C.5.2.3.2.4 for Japan.

5.2.3.3 Connection to the condensing discharge pipe system

The connection from the internal condensing discharge pipe to the external system shall allow discharging of the condensate without producing suction in the condensate pipe such that the water trap continues to function.

The diameter of the pipe shall be such that the water flow occurs without blocking.

Requirements specific for Japan are given in C.5.2.3.3.

5.2.3.4 Connection to the electrical supply system

The connection to the electrical supply system shall be according to IEC 60335-1.

National requirements for small fuel cell CHP appliances to be connected in parallel with low-voltage distribution networks apply.

Regional specific requirements as given in B.5.2.3.4 for Europe and in C.5.2.3.4 for Japan.

5.2.4 Soundness

5.2.4.1 General

The passage of a piping system shall be tight for the type of gas conveyed and the structure shall be such that tightness is not lost in the usual transportation, installation, use, etc.

In addition, the open part (aeration, a fuel chamber, etc.) in the passage of a liquid fuel shall be excluded.

The allowed leakage rates as well as the compliance criteria are given in 5.3.2 and 5.4.2.

5.2.4.2 Soundness of the gas carrying circuits

The supply gas circuit shall consist of metallic parts.

Where the internal pressure for a gas carrying circuit is at or above ambient air pressure during conditions when supply gas or process gas is carried by that circuit, the following apply.

- Holes for screws, studs, etc., intended for the assembly of parts shall not open into gas paths. The wall thickness between drillings and gas paths shall be at least 1 mm. This does not apply to orifices used for measurement purposes.
- The soundness of parts and assemblies making up a gas carrying circuit and likely to be dismantled during a normal routine servicing operation in situ or during gas conversion shall be achieved by means of mechanical joints, for example metal to metal joints, gaskets or toroidal seals. These sealing materials shall remain effective under normal conditions of small fuel cell CHP appliance use. The use of sealing materials such as tape, paste, glue or liquid is not acceptable, although this type of sealing material may be used for permanent assemblies.
- Where parts of a gas carrying circuit are assembled without threads, soundness of the assembly shall not be achieved by means of soft solder.

There are no specific requirements for parts or segments of the gas carrying circuit that operate at all operating conditions below ambient air pressure.

If a control function ensures that a gas carrying circuit operates below ambient air pressure, and the above requirements have not been taken into account and the tests according to 5.3.2 have not been performed,

- the mechanical/pneumatic control shall comply with ISO 23551-3 or the relevant clauses of ISO 23550, or
- the control function shall be a class C control function according to IEC 60730-1.

Gas carrying circuit parts according to ISO 23550 are not considered as contributing to normal internal releases into the compartment where they are located. The compartment around such components is not considered as being a fuel compartment therefore such components are not part of dilution requirements.

Requirements specific for Japan are given in C.5.2.4.2.

5.2.4.3 Soundness of the combustion circuit

The combustion circuit shall be constructed so as to prevent any leakage of combustion products.

Any means used to achieve soundness of the combustion circuit shall be such that it remains effective under normal conditions of use and servicing.

Parts, which need to be removed during routine service and affect the soundness of the small fuel cell CHP appliance and/or its ducts, shall be sealed by mechanical means, excluding pastes, liquids and tapes. The need for replacement of the seal(s), following a cleaning or servicing operation as stated by the manufacturer, is permitted.

Where the small fuel cell CHP appliance case forms part of the combustion circuit and it can be removed without the use of tools, either the appliance shall not operate, or there shall be no leakage of combustion products into the room where the small fuel cell CHP appliance is installed when the case is replaced incorrectly.

However, parts of the assembly not intended to be dismantled for maintenance may be joined in such a way, that permanent soundness is assured during continuous service, under normal conditions of use.

The ducts, bends, if any, and the duct terminal or fitting piece shall fit together correctly and shall form a stable assembly. Parts intended to be dismantled for periodic servicing shall be designed and arranged so that soundness is assured after reassembly.

Any fitting piece shall allow a sound connection to be made to the system intended for the evacuation of combustion products and supply of air.

Requirements specific for Japan are given in C.5.2.4.3.

5.2.4.4 Soundness of the water circuits

The water circuits shall be sound.

Requirements specific for Japan are given in C.5.2.4.4.

5.2.5 Material

Additional requirements are given in C.5.2.5.101 for Japan.

5.2.5.1 General

The quality and thickness of all materials used in the small fuel cell CHP appliance, their fitting pieces and duct terminals and the method of assembling the various parts, shall be such that the constructional and operational characteristics are not significantly altered during a reasonable life and under normal conditions of transportation, installation and use. All parts of the small fuel cell CHP appliance shall withstand the mechanical, chemical, electrical and thermal conditions to which they may be subjected when the appliance is used normally. All parts shall be

- a) suitable for the range of temperatures, pressures, flow rates, voltages and currents to which they are subjected during intended usage, and
- b) resistant to the reactions, processes and other conditions to which they are exposed during intended usage.

All parts of the small fuel cell CHP appliance likely to come into contact with condensate shall be constructed of sufficiently corrosion resistant materials or materials protected by suitable coating in order to ensure a reasonable life for a small fuel cell CHP appliance which is installed, used and maintained in accordance with the manufacturer's instructions.

Additional requirements specific for Japan are given in C.5.2.5.1.

5.2.5.2 Thermal insulation

The insulation shall withstand the normally expected thermal and mechanical stresses, without deformation and shall retain its insulating properties under the influences of heat and ageing.

Requirements specific for Europe are given in B.5.2.5.2.

5.2.6 Electrical safety

The electrical equipment of the small fuel cell CHP appliance shall comply with IEC 60335-2-102, except where reference is made to another electrical standard.

The electrical wiring used in the small fuel cell CHP appliance shall be such that the covering of the wiring is not damaged during a reasonable life and under normal conditions of transportation, storage, installation and use.

Electrical wire lengths shall be kept as short as possible, and where electrical insulation or thermal insulation for thermal protection, or fixation, etc., is required they shall be applied as necessary.

Wiring shall not contact a moving part when subjected to a force in the direction of the moving part of 2 N.

When an internal wire that is fixed in place or passing through a hole or passing through a bulkhead or can contact another part when a force of 2 N is applied, it shall not have its insulation damaged by such a force of 2 N.

When internal wiring is connected with a connector it shall not become disconnected when it is subjected to the normal stresses and vibration associated with transportation, storage and use.

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

Overcurrent protection shall be provided using fuses, overcurrent protective devices, other protective devices or other means which operate when abnormalities such as short circuit occur, if such a short circuit would result in a hazardous situation.

If the manufacturer states, on the data plate, the nature of the electrical protection of the small fuel cell CHP appliance, this statement shall comply with IEC 60529

- a) to give the degree of personal protection against contact with dangerous electrical components inside the small fuel cell appliance case, and
- b) to give the degree of electrical protection, inside the small fuel cell CHP appliance case, against harmful actions affecting safety due to water penetration.

The technical requirements for connection and operation in parallel with low-voltage distribution networks shall comply with regional or country specific requirements, see B.5.2.6 for Europe and D.5.2.6 for the USA.

For appliances intended to be installed outdoors or semi-outdoors,

- a) the enclosure protection degree shall be at least IPX4D according to IEC 60529;
- b) the electrical and/or electronic equipment temperature range shall be suitable for the specified temperature range of the appliance.

Additional requirements, specific for Japan, are given in C.5.2.6.101.

5.2.7 Subsystems and safety related control functions

5.2.7.1 Circuit conveying combustible gases

5.2.7.1.1 General

The minimum requirements for the gas carrying circuit of the small fuel cell CHP appliance are the following:

- prevention or control of unintended flow back of process gas into the combustion product circuit;
- no unintended excess pressure can arise in the process gas;
- no unintended air can enter the supply gas and/or the process gas;
- no unintended outflow of process gas within the unit or into the atmosphere.

Screwed fastenings that need to be removed for servicing of the device shall have a metric thread complying with ISO 262, unless a different thread is essential for the correct functioning and adjustment of the device.

Thread-forming screws that form a thread and do not produce swarf may be used. It shall be possible to replace them by metric machine screws complying with ISO 262.

Self-tapping screws that cut a thread and produce swarf shall not be used for the assembly of gas-carrying parts or of parts that may be removed for servicing.

Breather holes shall be according to ISO 23550:2011, 6.2.3.

Measures shall be taken to avoid particulate matter greater than a 1 mm pin gauge from interfering with the operation of the supply gas inlet shut-off valve. Such measures might be a particulate filter, a drop leg, or other means. Compliance is checked by inspection or demonstration by the manufacturer.

Exception: if the gas supply to the appliance has been shown to be free of particulate matter larger than a 1 mm pin gauge this requirement does not apply.

5.2.7.1.2 Composition of the supply gas circuit

The supply gas circuit shall be of metallic material.

The supply gas circuit shall be fitted with a safety shut-off valve consisting of two independent shut-off functions according to ISO 23551-1. It is permitted that both functions are combined in one valve body.

Safety devices which require non-volatile lockout to occur shall give rise to simultaneous signal to close the two shut-off valves.

In the case of direct ignition of the main burner and if the order to close in response to a control device is not given simultaneously to the two valves, the two valves shall be at least class C.

In response to a control device, if the delay between the signals to close the two valves is not greater than 5 s, the signals are considered to be simultaneous.

The composition of the supply gas circuit shall be according to Table 2.

Illustrations of the composition of the supply gas circuit are given in Annex E.

**Table 2 – Composition of the supply gas circuit
according on the valve classification of ISO 23551-1**

Heat input of the individual gas line within the supply gas circuit	Burner without fan	Burner with fan		
		With pre-purge	Without pre-purge but with a valve proving system or permanent or alternating ignition flame	Without pre-purge
Input ≤ 0,250 kW	C ^a			C ^a
Input ≤ 70 kW	C ^{a,b} + J			C ^{a,b} + C or B + J
^a Or the valve of the flame supervision device.				
^b For ignition burners with a heat input ≤ 1 000 W where $T_{SA,max}$ exceeds 10 s and it has been proved that no hazardous situation can occur, (see 5.3.4.2.2.1) only one class C valve is needed.				

Requirements specific for Japan are given in C.5.2.7.1.2.

5.2.7.1.3 Gas carrying circuit downstream of the safety shut-off valve

The circuit and its components shall be sound according to ISO 23550 for the fuel being used.

For the fuel, being the process gas, the effects of the composition such as high concentration of H_2 , high humidity content (even water) to the material and the elastomers used in for example valves, reformers, stacks shall be considered when ensuring soundness.

If components of non-metallic material are used, the manufacturer shall provide evidence that these materials withstand the environmental conditions to which they are exposed during the operation of the appliance, if it is installed and used according to the manufacturer's instructions through the expected lifetime and that the components are still sound at the end of the lifetime.

If this evidence cannot be provided, measures to avoid or control the hazards of a possible leakage of combustible gases of such a component shall be implemented. This can be achieved by complying with the measures as given in 5.2.4.2 and 5.3.2.1.3.1.

Requirements specific for Japan are given in C.5.2.7.1.3.

5.2.7.1.4 Purge circuit (if any)

If the amount of released flammable gas exceeds the limit as specified in 5.3.3.5, then the purge circuit (e.g. anode outlet gas), which allows the release of flammable gas to the environment (e.g. via the exhaust gas system) by opening valves, shall be fitted with at least two valves of class C.

Alternative valve arrangement is possible, if the valve class is higher (this could be either two valves in parallel to the safety shut-off valve(s) or one valve downstream of the safety shut-off valve).

5.2.7.2 Burners (including catalytic burners) and their control system

5.2.7.2.1 Burners

The cross-section of the flame ports and also the burner and ignition burner injectors shall not be adjustable (manually).

Every removable injector and removable restrictor shall carry an indelible means of identification preventing any confusion. In the case of non-removable injectors and/or restrictors, the marking may be on the manifold.

It shall be possible to change injectors and restrictors without the need to disconnect the small fuel cell CHP appliance. When the injectors and restrictors are removable, their position shall be well defined and their method of fixing shall be such that it is difficult to position them incorrectly.

If the burners or a part of the burners are removable, their position shall be well defined and their method of fixing shall be such that it is difficult to position them incorrectly.

The start-up procedure of the burner as well as the flame monitoring shall be according to IEC 60730-2-5.

The ignition of the gas air mixture shall be without significant delay and without generating a significant pressure in the combustion chamber and under the conditions of delayed ignition, no dangerous situation for the user or damage to the small fuel cell CHP appliance occurs.

There shall be no flame lift-off or back fire by using the extreme compositions of the gases used (supply gas or process gas).

Requirements specific for Japan are given in C.5.2.7.2.1.

5.2.7.2.2 Automatic burner control system

For the safe operation of a burner including catalytic oxidation, an automatic control system according to IEC 60730-2-5 shall be used.

The sequence of this burner control system shall provide the safety related functions according to this standard by considering the risk assessment according to 5.1.

If the temperature of the combustion compartment and the parts of the combustion compartment directly in touch with the gas/air mixture is above the self-ignition temperature, flame supervision may be substituted by the temperature monitoring to ensure that the signal to the safety shut-off valves will be disconnected, if the temperature falls below self-ignition temperature. Furthermore, the release of gas flow shall only be released after the self-ignition temperature is ensured. The control function shall be according to the safety level given in IEC 60730-2-5.

For burners which are intended to operate longer than 24 h without interruption the burner control system shall comply with the requirements for permanent operation according to IEC 60730-2-5.

Requirements specific for Japan are given in C.5.2.7.2.2.

5.2.7.2.3 Gas/air ratio controls

Gas/air ratio controls shall be designed and constructed so that reasonably foreseeable damage does not give rise to a change capable of affecting safety.

Mechanical linkage for operating the fuel and air controls, if used, shall be designed to reliably maintain the correct fuel/air ratio and to resist accidental breakage and disengagement.

Pneumatic gas/air ratio controls shall comply with ISO 23551-3.

Pressure tubing used for pneumatic gas/air ratio control may be made of metal with suitable mechanical connection or of other materials with at least equivalent properties. In this case, they are considered immune to breakage, accidental disconnection and leakage after initial soundness checks. As such, they are not subject to the tests given in 5.3.4.4.3.2.

If pressure tubing for air or combustion products is used, it shall have a minimum cross-sectional area sufficient to provide unrestricted flow under all foreseeable conditions. Additional requirements for Europe are given in B.5.2.7.2.3. They shall be located and fixed so that any retention of condensate is avoided and positioned such that creasing, leakage or breakage is prevented. Where more than one pressure tube is used, the relevant connection position for each shall be obvious. Compliance is checked by the manufacturer or by using an accepted minimum diameter.

Electronic gas/air ratio controls shall comply with ISO 23552-1.

5.2.7.3 Supply of air and evacuation of combustion products

Small fuel cell CHP appliances shall be designed so that there is an adequate supply of air during ignition and over the whole range of possible heat inputs stated by the manufacturer. A gas/air ratio control is permitted.

Small fuel cell CHP appliances shall be designed so that there is an adequate supply of air to the stack over the whole operating range stated by the manufacturer.

Unless otherwise stated, small fuel cell CHP appliances using fan assisted combustion may be fitted with a means of adjustment in the combustion circuit intended to adapt the small fuel cell CHP appliance to the pressure losses in the installed ducts. Either restrictors or a means of setting the adjustment to predetermined positions in accordance with detailed instructions from the manufacturer may be used.

According to the small fuel cell CHP appliance type, the manufacturer shall supply any duct terminal and/or fitting piece, with the small fuel cell CHP appliance for testing.

5.2.7.4 Requirements for a fan incorporated in a small fuel cell CHP appliance

Direct access to the rotating parts of a fan shall be prevented. The parts of a fan in contact with combustion products shall be effectively protected against corrosion unless they are of corrosion resistant material; furthermore they shall withstand the temperature of the combustion products.

5.2.7.5 Air proving

Appliances with fans in the combustion air circuit shall be fitted with a system for air proving.

Before each fan start, the availability of air shall be verified. There shall be no indication of air availability when air is not available.

Air availability checks are not required for the combustion air with gas/air ratio controls if the gas/air ratio controls are sufficient to ensure that emissions do not exceed limits in the event of air blockage or duct blockage.

The supply of combustion air shall be checked by one of the following methods:

- a) supervision of the combustion air flow rate or the combustion products flow rate. In this system, the supervision device is activated directly by the flow of combustion air or combustion products. This is also valid for a small fuel cell CHP appliance with more than one fan speed for the combustion air in which the flows associated with each fan speed are monitored by separate supervision devices;
- b) gas/air ratio control.

Only for appliances where the combustion products circuit is completely surrounded by the air supply circuit or for separate ducts when the leakage rates of the combustion products evacuation ducts meet the requirements of 5.3.2.2.2.2, the following two indirect supervision methods are also allowed, but only if the small fuel cell fuel cell CHP appliance starts up at least once per day:

- c) indirect supervision (e.g. fan speed supervision) when there is an air proving device which proves the supply of combustion air at least once at each start-up;
- d) supervision of the minimum and maximum air or combustion products rates with two rate supervision devices (monitoring of the full range of flows is not required).

5.2.7.6 Combustion products evacuation duct

5.2.7.6.1 Stability under mechanical loading

The duct shall be capable of withstanding horizontal and vertical loads. The following aspects shall be considered:

- compressive strength;
- tensile strength;

- resistance to wind pressure (see additional requirement in B.5.2.7.6.1 for Europe).

5.2.7.6.2 Stability under exposure to heat

The stability of the walls of the duct shall be ensured during and after exposure to heat occurring under all operating conditions of the small fuel cell CHP appliance.

5.2.7.6.3 Corrosion resistance

The duct shall keep its essential characteristics in the presence of the corrosion load corresponding to all operating conditions of the small fuel cell CHP appliance.

5.2.7.6.4 Resistance to condensate and moisture under normal operating conditions

The duct shall keep its essential characteristics in the presence of condensate and moisture under all operating conditions.

5.2.7.6.5 Common flue evacuation duct

In the event of common flue ducts, backflow shall be prevented by the use of a backflow valve or other means.

5.2.7.7 Removal of condensate

The manufacturer shall take measures to avoid condensate accumulation that results in an unsafe situation.

The manufacturer shall take measures to ensure that vent gas does not escape through condensate drain lines or escape into the room where the small fuel cell CHP appliance is installed.

Condensate produced during operation of the small fuel cell CHP appliance, including the condensate formed in the flue and its connecting pipes, shall be removed by means of a discharge pipe (or pipes) or other constructions resulting in safe removal of condensate.

A small fuel cell CHP appliance having (a) condensate disposal system(s) shall, under conditions of (a) blocked condensate drain line(s), continue to operate satisfactorily or shall shut down safely without unsafe emissions.

Means shall be provided to ensure that combustion products or other hazardous materials are not passed through the condensate removal line by use of a water trap or other means. Such means shall be sufficient to limit passage of combustion products or other hazardous materials at the maximum pressure in the combustion chamber, including when the flue gas discharge is partly blocked in steps up to fully blocked, while repeatedly switching on and off the heat demand signal as long as the appliance is still operable under the most unfavourable conditions at the maximum flue length specified by the manufacturer.

If the small fuel cell CHP appliance incorporates some form of pump assisted condensate disposal, the size of the discharge from the small fuel cell CHP appliance and connection to any point of gravity discharge shall be specified by the small fuel cell CHP appliance manufacturer.

The disposal system, forming part of the small fuel cell CHP appliance supplied with the small fuel cell CHP appliance, shall be such that

- it can be easily inspected and cleaned in accordance with the manufacturer's instructions,
- a water trap has a seal at the maximum pressure in the combustion chamber at the maximum flue gas length specified by the manufacturer.

Regional specific requirements are given in B.5.2.7.7 for Europe.

5.2.7.8 Checking the state of operation

5.2.7.8.1 General

Means shall be provided for the installer to determine the burner(s) operational status of the small fuel cell CHP appliance, including:

- CHP generator state of operation: storage state, start-up, operational state, or shutdown;
- supplementary heat generator state of operation: storage state, start-up, operational state, or shutdown;
- lockout state.

Means of determining the state of operation can include both direct means and indirect means for confirming the presence of the flame.

Indirect means are dependent on the specific solution of the manufacturer. If the indirect signal of flame presence is only available on a remote control, this remote control shall be supplied and tested with the small fuel cell CHP appliance.

It shall be possible to check at any time (e.g. opening a door without tools) that the small fuel cell CHP appliance is operating, either by visual observation of the flame or by some indirect means.

5.2.7.8.2 State of operation of the stationary fuel cell power system used as a CHP generator

The state of operation of the CHP generator shall be shown by an indicator, for example by detecting the electric power output.

The presence of flame shall be detected indirectly by means such as flame sensor or thermocouples.

5.2.7.8.3 State of operation of the supplementary heat generator

Means of determining the state of operation can include indicating lights, visual verification of the flame using a sight glass, or other suitable means.

If used, mirrors, sight glasses, etc., shall continue to retain their optical properties for the intended lifetime of the supplementary heat generator.

5.2.7.9 Requirements for adjusting, control and safety devices (if applicable)

5.2.7.9.1 General

The small fuel cell CHP appliance shall be equipped with control and safety devices for start, operation and control of the gas supply.

These devices shall ensure the automatic start and the automatic monitoring device for the operating functions of the small fuel cell CHP appliance as well as the gas supply.

In case of failure of the normal operating functions (malfunctions), the gas supply shall be cut off, if need be, with lock-out in accordance with the operating programme.

The manufacturer shall be obliged to define the minimum mandatory requirements for control and supervision as well as for the automatic restart.

The operation of safety devices shall not be overruled by adjusting and control devices.

The design of the control and safety system shall be such that it is not possible to perform two or more actions which are unacceptable in combination. The order of the actions shall be fixed in such a manner that it is not possible to change it.

All the following devices in 5.2.7.9 or the multifunctional control in which they might be fitted shall be removable or exchangeable if this is necessary for cleaning or replacement of the device. Controls (e.g. adjusters) shall not be interchangeable if this can result in confusion.

When there are several control knobs (taps, thermostats, etc.), they shall not be interchangeable if this could lead to confusion and their function shall be clearly indicated.

Elastomers used in adjusting, supervision, control and safety devices shall be suitable for the usage considering the material, the temperature, the pressure and the lifetime, and shall prevent leakage. Regional specific requirements are given in B.5.2.7.9.1 for Europe.

Adjusting, supervision, control and safety devices shall comply with the relevant requirements of relevant international standards, as appropriate.

ISO 23551-1, ISO 23551-2, ISO 23551-3, ISO 23552-1 and IEC 60730-2-5 are presumed to comply with the relevant requirements of this International Standard, as appropriate.

At least the below listed functions if not covered in the above mentioned product standards shall be classified as class A, B or C according to IEC 60730-1 and meet the applicable requirements according to 5.1 based on a risk analysis of

- reaction monitoring,

NOTE Depending on the type of small fuel cell CHP appliance, this can be air-gas ratio control/fuel processing system/stack).

- heating water circuit supervision,
- internal cooling circuit supervision,
- safeguard of the gas purge circuit,
- avoidance of reverse power operation,
- avoidance of hydrogen explosion.

Requirements specific for Japan are given in C.5.2.7.9.1.

5.2.7.9.2 Adjusters

Any parts of a small fuel cell CHP appliance which are not intended to be altered by the user or the installer shall be protected in an appropriate manner. Suitable locking varnish may be used for this purpose, provided that it withstands the temperature to which it is subjected during normal operation of the small fuel cell CHP appliance.

The adjusting screws shall be arranged in such a way that they cannot fall into the gas ways.

The soundness of the gas carrying circuit shall not be put at risk by the presence of adjusters and range-rating devices.

Adjustment of the adjuster and/or of the range-rating device may be continuous (e.g. use of an adjusting screw) or discrete (e.g. change of restrictors).

5.2.7.9.3 Thermostats and water temperature limiting devices

5.2.7.9.3.1 General

A small fuel cell CHP appliance shall be fitted with a fixed setting or user adjustable control thermostat complying with IEC 60730-2-9 type 1 and a temperature limiting device as specified below.

Alternatively an electronic temperature control system comprising the thermostat and limiter control function can be used. Such a system shall comply with requirements for a class B device according to IEC 60730-2-9.

Requirements specific for Japan are given in C.5.2.7.9.3.1.

5.2.7.9.3.2 Small fuel cell CHP appliance intended exclusively for central heating systems with an open expansion vessel

Temperature limiting devices are not required when the small fuel cell CHP appliance is designed to be installed exclusively with an open expansion vessel and when a failure of the control thermostat does not cause a dangerous situation for the user or damage to the small fuel cell CHP appliance. Appropriate information shall be given in the technical instructions.

Requirements specific for Japan are given in C.5.2.7.9.3.2.

5.2.7.9.3.3 Small fuel cell CHP appliance intended for central heating systems with open or sealed expansion vessels

Requirements specific for Japan are given in C.5.2.7.9.3.3.

5.2.7.9.3.3.1 Small fuel cell CHP appliance with electromechanical controls

Small fuel cell CHP appliances shall be fitted with one of the following:

a) a set of

- a temperature limiter complying with IEC 60730-2-9 type 1, having a preset limit of maximum 100 °C (instead of a temperature limiter, another device, for example a water rate monitoring device or a low water detector safety device is permitted if all the requirements of 5.3.3.2 and 5.2.7.9 are met), and
- an overheat cutout device complying with IEC 60730-2-9 type 2, having a preset limit that causes non-volatile lockout before the small fuel cell CHP appliance is damaged and/or before a dangerous situation occurs,

or

b) an overheat cut-out complying with IEC 60730-2-9 type 2, having a preset limit of maximum 100 °C causing non-volatile lockout before the small fuel cell CHP appliance is damaged and/or before a dangerous situation occurs.

The temperature limiter shall cause at least safety shut-down before the water flow temperature exceeds the preset value. When the water temperature falls below the preset value, the gas supply to the burner may be restored automatically. The overheat cut-out device shall cause non-volatile lockout before the small fuel cell CHP appliance is damaged and/or a dangerous situation for the user occurs.

Regional specific requirements are given in B.5.2.7.9.3.3.1 for Europe and in D.5.2.7.9.3.3.1 for the USA.

5.2.7.9.3.3.2 Small fuel cell CHP appliance with electronic controls

Small fuel cell CHP appliances shall be fitted with either system a) or system b) , considering regional specific requirements as given in B.5.2.7.9.3.3.2 for Europe:

- a) An electronic temperature control system can be used to control and limit the temperature in combination with an electromechanical overheat cut-out according to the requirements of this standard. This electronic temperature control system shall have two different settings: control temperature and limiting temperature, and should meet the requirements for a class A device according to IEC 60730-2-9. At a limit temperature set point of maximum 100 °C the system shall shut down, restoring normal operation when the temperature drops below the limit value.
- b) An electronic temperature control system can be used to control and limit the temperature and provide the overheat cut-out function. Such a control system shall meet the requirements of the class C temperature control function as specified in IEC 60730-2-9. The system shall have at least three levels of temperature setting, being: control temperature, limit temperature and overheat cut-out temperature. At a limit temperature set point of maximum 100 °C the system shall shut down, restoring normal operation when the temperature drops below the limit value. The system shall go into non-volatile lockout at the overheat cut-out temperature set point, this being the set point before the small fuel cell CHP appliance is damaged and/or before a dangerous situation for the user occurs.

5.2.7.9.4 Protection against over-pressure

Small fuel cell CHP appliances intended for central heating systems with a sealed expansion vessel shall be fitted with a relief valve to avoid exceeding maximum operating pressure.

The relief valve shall comply with ISO 4126-1.

Regional specific requirements are given in C.5.2.7.9.4 for Japan and in D.5.2.7.9.4 for the USA.

5.2.7.9.5 Remote control functions

Remote control functions shall comply with IEC 60730-1.

Requirements specific for Japan are given in C.5.2.7.9.5.

5.3 Operational requirements for safety

5.3.1 General requirements

Except where otherwise stated, the operational requirements are verified by test of the small fuel cell CHP appliance as defined in 5.4.

Possible operational states of individual components shall be safe. Failures of individual components, the possibility of an uncontrolled formation of flammable mixtures, the uncontrolled ignition of inflammable mixtures as well as the uncontrolled leakage of flammable mixtures or process gases shall be avoided by using sufficient measures.

The odorant (e.g. sulphur compounds, mercaptans, thiophenes) in the supply gas shall not cause any safety concerns.

Requirements specific for Japan are given in C.5.3.1.

5.3.2 Soundness

5.3.2.1 Soundness of the gas circuits

5.3.2.1.1 General

Soundness is verified before and after all the tests of this International Standard.

The gas carrying circuits shall be sound in operation and in stand-by.

The method of verifying the soundness of the supply gas system and the process gas system are given in the following subclauses.

The small fuel cell CHP appliance shall comply with 5.3.2.1.2 and 5.3.2.1.3.1. However if the gas carrying circuit complies with 5.3.2.1.3.2, it is not necessary to comply with 5.3.2.1.3.1.

5.3.2.1.2 Prevention against fire and explosion hazards arising from the supply gas circuit

Soundness of the supply gas circuit is assured when, tested under the conditions of 5.4.2.1.1, the leak rate of air does not exceed 3,5 times the maximum leakage rates for external tightness as given in ISO 23550.

5.3.2.1.3 Prevention against fire and explosion hazards in small fuel cell CHP appliance provided with cabinets

5.3.2.1.3.1 General

For parts of the gas carrying circuit where the internal gas pressure is above its surrounding pressure of the gas carrying circuit the following applies.

- a) The integrated systems of the small fuel cell CHP appliance shall be assembled so as to prevent hazards associated with flammable atmosphere accumulations within the fuel cell power system.
- b) The boundary for dilution of normal internal releases to below 25 % lower flammability limit (LFL) may be determined by computational fluid dynamic analysis, tracer gas, or similar methods, such as those given in IEC 60079-10-1. All devices installed within dilution boundaries shall meet the requirements specified in 5.3.2.1.3.1 e). The volume within dilution boundaries shall be classified according to IEC 60079-10-1. The LFL of typical gases are provided in IEC 60079-20-1.
- c) Cabinet compartments with internal sources of flammable gas/vapour release are defined as fuel compartments. Fuel compartments shall be designed to
 - maintain gas mixtures below 25 % (LFL), except in dilution boundaries, and
 - limit the extent of dilution boundaries to within the fuel compartment.
- d) Methods to maintain normal internal releases below 25 % (LFL), except within dilution boundaries, include the following.
 - 1) Controlled oxidation of normal internal releases

This may be accomplished by the provision of a continuous and reliable ignition and oxidant source that ensures the combustion of the released gases or the utilization of catalytic oxidation units.

The manufacturer shall ensure that the maximum credible release, when reacted, produces pressures and temperatures that can be contained within the fuel compartment and tolerated by the components exposed to such conditions.
 - 2) Air dilution of normal internal releases

This may be accomplished by the provision of mechanical ventilation to dilute with air the concentration of normal releases to less than 25 % (LFL), except within dilution

boundaries. In all cases, the minimum ventilation rate shall be consistent with the allowable leakage rate test given in 5.4.2.1.2.1.

Ventilated fuel compartments shall be designed to operate at negative pressure relative to other types of compartments in the fuel cell power system and its surroundings. This negative pressure in the fuel compartment is established by means such as induced or exhaust ventilation. Proper operation of the ventilation system shall be confirmed by measuring either flow or pressure. Failure of ventilation shall cause a shutdown of the process equipment. Control functions to ensure this ventilation shall be according to the standard for functional safety as given in 5.1. Alternatively, fuel compartments of fuel cell power systems need not be ventilated at negative pressures if adequate means are provided to limit the concentration of flammable gas below 25 % (LFL) under all conditions of use except within dilution boundaries or as described in 5.3.2.1.3.1 g).

Fuel compartments that rely on ventilation for protection against accumulation of flammable atmospheres shall be purged in such a way that the atmosphere will be brought below 25 % of the LFL.

NOTE 1 One method of accomplishing this is with at least four air exchanges within an appropriate time interval to ensure this result.

The purging will take place prior to the energization of any devices that are not suitable for the area classification according to 5.3.2.1.3.1 b). Purging is not required if the atmosphere within the compartment and associated ducts can be demonstrated by design to be non-hazardous. All devices, which shall be energized prior to purging or in order to accomplish purging, shall meet the requirements specified in 5.3.2.1.3.1 e).

3) Use of safety related gas leakage detection

Detection of gas leakage by means of a class C control function shall be according to IEC 60730-1. If the leakage limit, which shall not exceed 25 % LFL, is reached, the safety shut-off valves shall be de-energized.

- e) Within areas classified as hazardous in 5.3.2.1.3.1 b), except for units that use the protection method described in 5.3.2.1.3.1 d)1) or d)3), the manufacturer shall eliminate ignition sources by ensuring that the
 - installed electrical equipment is suitable for the area classification according to IEC 60079-0 and other applicable parts of the IEC 60079 series;
 - installed electrical resistance trace heating, if available, complies with IEC 60079-30-1;
 - surface temperatures do not exceed 80 % of the auto-ignition temperature, expressed in degrees Celsius, of the flammable gas or vapour (see IEC 60079-20-1 for guidance regarding auto-ignition temperatures of various flammable fluids);
 - equipment containing materials capable of catalysing the reaction of flammable fluids with air shall be capable of suppressing the propagation of the reaction from the equipment to the surrounding flammable atmosphere;
 - potential for static discharge has been eliminated by proper bonding and grounding, and by proper material selection.
- f) Compartments that contain electrical or mechanical equipment shall be maintained at positive pressure relative to adjacent compartments with sources of flammable gas or vapour according to IEC 60079-2, unless the equipment meets the requirements specified in 5.3.2.1.3.1 e).
- g) The small fuel cell CHP appliance shall be provided with passive and active means, or a combination thereof, to maintain abnormal internal releases below 25 % (LFL), except in dilution boundaries.

Sudden and catastrophic failures are not necessary to be considered as a release scenario in this analysis when protection against such failures has already been contemplated in the pressure equipment and piping design (see also 5.2.4.2).

“Passive” means include, but are not limited to, the mechanical limitation of releases of flammable gases or vapours to a maximum value by using pipe orifices and similar methods of flow restriction or joints permanently secured and so constructed that they limit the release rate to a predictable maximum value.

“Active” means may include flow measurements and controls or the provision of safety devices such as combustible gas sensors. These means shall meet the requirements specified in 5.1, and shall cause a small fuel cell CHP appliance shutdown upon occurrence of conditions under which the concentration of any flammable gas in the ventilation exhaust exceeds 25 % of the LFL of that gas.

- h) The small fuel cell CHP appliance shall be designed for the safe dispersal of the ventilation and process exhaust streams. In particular, for indoor installations the ventilation and process exhaust shall be designed for connection to a flue or venting system.
- i) Potential for static discharge has been eliminated by proper bonding and grounding of metallic parts by selecting appropriate materials that do not generate charges which could result in a spark capable of igniting an ignitable gas/air mixture. The effect of flow rates within pipes generating possible charges shall also be considered.
- j) A control function whose purpose is to avoid exceeding 25 % LFL by, for example, dilution with air and/or measuring the concentration and shut-off if exceeding the limit, shall be designed according to the requirements specified in 5.1.

NOTE 2 Non-metallic tubing carrying hydrogen gas may accumulate electrostatic charge along its surface. Discharges from the surface of this tube can be sufficient to ignite a flammable mixture of gas or vapour in the surrounding environment. When used in Zone 1 or Zone 2 (according to IEC 60079-10-1) locations, measures to eliminate electrostatic discharges can be taken. This can be achieved by specifying a tube material with sufficient conductivity, or by limiting gas flow velocity to values below which electrostatic charge does not accumulate. Tubing that relies on a protective system to eliminate electrostatic discharge (i.e., a grounding wire or braid) cannot be used in a Zone 0 location.

NOTE 3 Metal braid coverings, or conductive wires within the non-metallic tubing wall can increase the chance of electrostatic discharge if those conductors become disconnected from their bonding conductor. In Zone 1 and 2 areas, such conductors can be mechanically secured with positive means.

5.3.2.1.3.2 Soundness of parts according to ISO 23550 and the like

The requirements of 5.3.2.1.3.2 are an alternative to 5.3.2.1.3.1 if parts of the gas carrying circuit

- a) comply with ISO 23550, or
- b) are designed according to the design rules for pressure equipment, or
- c) comply with ISO 23550 but use material other than given in ISO 23550. In this case the manufacturer shall provide evidence that it will remain tight considering all chemical, thermal and mechanical conditions which will occur throughout the intended lifetime.

Soundness of the gas carrying circuit is assured when, tested under the conditions of 5.4.2.1.2.2, the leak rate of air does not exceed 3,5 times the maximum leakage rates for external tightness as given in ISO 23550.

If the gas carrying circuit is completely surrounded by combustion air then the soundness of this part of the circuit is assured when, tested under the conditions of 5.4.2.1.2.2, the leak rate of air does not exceed 3 l/h, provided that the flowing air ensures that no ignitable mixture will occur around any electrical supplied components.

Additional information is given in B.5.3.2.1.3.2 for Europe.

5.3.2.2 Soundness of the combustion circuit

5.3.2.2.1 General

The combustion circuit of a small fuel cell CHP appliance shall be sound with respect to the room where the small fuel cell CHP appliance is installed when tested in accordance with 5.3.2.2.2 or 5.3.2.2.3.

If the duct system is not part of the small fuel cell CHP appliance only test No. 2 of Table 3 is applicable. Subclauses 5.3.2.2.2.2 to 5.3.2.2.2.4 do not apply.

Ducts shall be sound in accordance with 5.3.2.2.2.3 and 5.3.2.2.2.4.

Soundness is verified before and after all the tests of this standard.

5.3.2.2.2 Air supply and combustion product circuit Type C small fuel cell CHP appliance

Requirements specific for Japan are given in C.5.3.2.2.2.

5.3.2.2.2.1 General requirements

Soundness with respect to the room where the system is installed is ensured if, under the specified test conditions as given in 5.4.2.2.2.1 the leak rates do not exceed the values given in Table 3.

Table 3 – Maximum admissible leakage rates

Test No.	Test object ^a	Combustion products circuit completely surrounded by combustion air	Maximum leak rate m ³ /h	
			Heat input ≤ 40 kW	Heat input > 40 kW
1	Small fuel cell CHP appliance with its air supply and combustion products evacuation ducts and all their joints	YES	5 (u)	$5 \cdot P_{\text{inf,nom}}/40$
		NO	1 (v)	$1 \cdot P_{\text{inf,nom}}/40$
2	Small fuel cell CHP appliance and the joint to the air supply and combustion products evacuation duct	YES	3 (w)	$3 \cdot P_{\text{inf,nom}}/40$
		NO	0,6 (x)	$0,6 \cdot P_{\text{inf,nom}}/40$
3	Combustion products evacuation ducts with all its joints excluding the joint tested above	NO	0,4 (y)	$0,4 \cdot P_{\text{inf,nom}}/40$
4	Air supply duct with all its joints excluding the joint tested above		2 (z)	$2 \cdot P_{\text{inf,nom}}/40$
The limits are given in the regional specific requirements taking care that the following equations are covered: $u = w + z$ and $v = x + y$.				
^a See also Figure 2.				

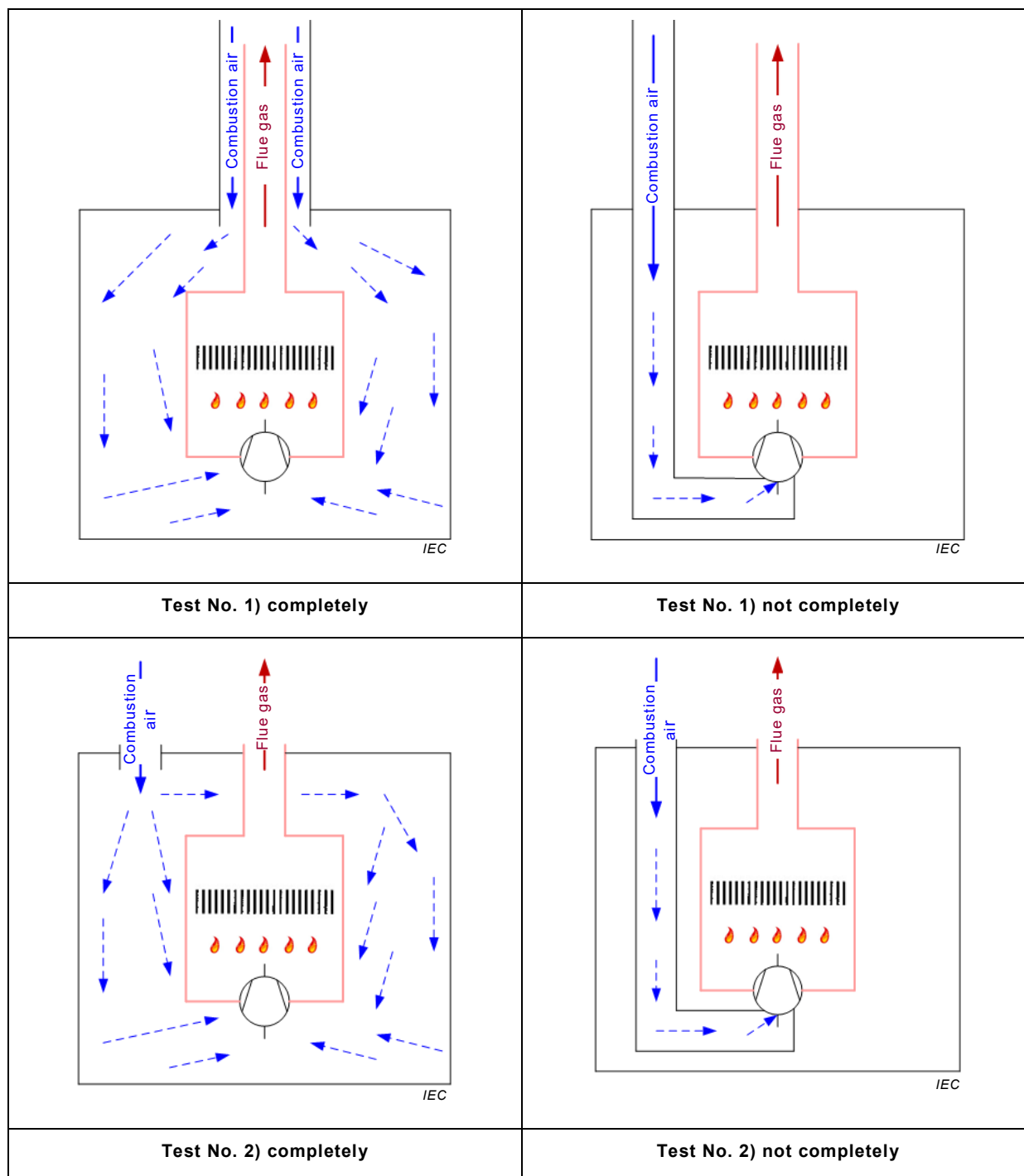


Figure 2 – Illustration of Table 3: Surrounding of the combustion products circuit by the combustion air circuit

5.3.2.2.2.2 Combustion products evacuation duct for small fuel cell CHP appliances with indirect air proving

The soundness of the combustion products evacuation duct for installation both inside and outside the room where the small fuel cell CHP appliance is installed, permitted for small fuel cell CHP appliances with indirect air proving, is ensured when tested under the conditions of 5.4.2.2.2.2, the leak rate (l/s) per surface area (m^2) of the duct does not exceed 0,006 l/(s· m^2).

5.3.2.2.2.3 Separate duct for evacuation of combustion products

The soundness of a separate combustion products evacuation duct with respect to areas other than the room where the small fuel cell CHP appliance is installed is ensured when

tested under the conditions of 5.4.2.2.3, the leak rate (l/s) per surface area (m^2) of the duct does not exceed $0,006 \text{ l}/(\text{s}\cdot\text{m}^2)$.

5.3.2.2.2.4 Air supply duct as separate or part of a concentric duct

The soundness of separate air supply ducts or concentric ducts with respect to all areas other than the room where the small fuel cell CHP appliance is installed is ensured when tested under the conditions of 5.4.2.2.4 the leak rate per surface area of the duct does not exceed $0,5 \text{ l}/(\text{s}\cdot\text{m}^2)$.

5.3.2.2.3 Soundness of the combustion product circuit of Type B

Requirements specific for Japan are given in C.5.3.2.2.3.

5.3.2.2.3.1 General requirements

This requirement is applicable for small fuel cell CHP appliances where the combustion air is drawn directly from the room.

Small fuel cell CHP appliances shall comply with 5.3.2.2.3.2 or 5.3.2.2.3.3. Ducts of Type B₅ small fuel cell CHP appliances shall comply with 5.3.2.2.3.4. Soundness shall be verified before and after all the tests.

5.3.2.2.3.2 Type B₂ and Type B₅ small fuel cell CHP appliances

The combustion products circuit of a small fuel cell CHP appliance incorporating a fan shall be sound with respect to the room where the small fuel cell CHP appliance is installed. This soundness is ensured if, under the test conditions of 5.4.2.2.3.2, combustion products only escape from the flue outlet. Additionally the ducts of Type B₅ small fuel cell CHP appliances should also meet the requirements of 5.3.2.2.3.4.

5.3.2.2.3.3 Type B₃ small fuel cell CHP appliances

Soundness of Type B₃ small fuel cell CHP appliances is ensured if under the test conditions of 5.4.2.2.3.3, by choice of the manufacturer:

- a) the leakage rate of the combustion products circuit (with all the duct and joints) does not exceed
 - $3 \text{ (m}^3/\text{h)}$ for small fuel cell CHP appliances with a nominal heat input $\leq 40 \text{ kW}$; or
 - $3 \times P_{\text{inf,nom}}/40 \text{ (m}^3/\text{h)}$ for small fuel cell CHP appliances of nominal heat input $> 40 \text{ kW}$;
- b) the leakage rate of the combustion circuit (with all the duct and joints) does not exceed
 - $5 \text{ (m}^3/\text{h)}$ for small fuel cell CHP appliances with a nominal heat input $\leq 40 \text{ kW}$; or
 - $5 \times P_{\text{inf,nom}}/40 \text{ (m}^3/\text{h)}$ for small fuel cell CHP appliances of nominal heat input $> 40 \text{ kW}$.

5.3.2.2.3.4 Combustion products evacuation ducts of Type B₅ small fuel cell CHP appliance

The soundness of a combustion products evacuation duct supplied by the manufacturer, not completely surrounded by combustion air, with respect to areas other than where the small fuel cell CHP appliances is installed, is ensured if under the test conditions of 5.4.2.2.3.4 the leakage rate (l/s) per square metre surface (m^2) of the duct does not exceed $0,006 \text{ l}/(\text{s}\cdot\text{m}^2)$.

5.3.2.2.4 Type A small fuel cell CHP appliance

There are no requirements for the soundness of the combustion product circuit.

5.3.2.3 Soundness of the heating water circuit

Under the test conditions of 5.4.2.3, there shall be neither leakage nor permanent visible distortion.

5.3.2.4 Soundness of the internal cooling circuit (if applicable)

Under the test conditions of 5.4.2.4, there shall be neither leakage nor permanent visible distortion.

5.3.3 Safety of operation (temperature/limit gas)

5.3.3.1 Limiting temperatures

Requirements specific for Japan are given in C.5.3.3.1.

5.3.3.1.1 General test setup

The requirements given in 5.3.3.1.2 to 5.3.3.1.5 are related to the test setup according to 5.4.3.1.1.

5.3.3.1.2 Limiting temperatures of components, wiring, materials and surfaces, adjusting, control and safety devices

Under the test conditions of 5.4.3.1.2, the temperature of the adjusting, control and safety devices shall not exceed the value stated by the manufacturer and their operation shall remain satisfactory.

The temperatures of components, wiring, and materials shall not exceed the temperature ratings provided by the manufacturer.

The surface temperatures of the control knobs and of all the parts that need to be touched during normal use of the small fuel cell CHP appliance, measured only in the zones intended to be gripped, and under the conditions stated in 5.4.3.1.2, shall not exceed the ambient temperature by more than the values given in Table 4. Additional requirements are given in B.5.3.3.1.2 for Europe.

Table 4 – Allowable surface temperatures rises

Part	Temperature rise K
External enclosures, except handles held in normal use	60
Surfaces of handles, knobs, grips and similar parts which are held for short periods only in normal use	
– of metal	35
– of porcelain	45
– of moulded material (plastic), rubber or wood	60
NOTE 1 The values are maximum surface temperature rises above the ambient temperature of external surfaces that can be touched during operation by people without personal protective equipment. The above values are referenced in IEC 60335-1.	
NOTE 2 The values in the table are based on an ambient temperature not normally exceeding 25 °C but occasionally reaching 35 °C. However, the temperature rise values specified are based on 25 °C.	

5.3.3.1.3 Limiting temperatures of the side walls, the front and the top

The temperature of the side walls, front and top of the small fuel cell CHP appliance shall not exceed the ambient temperature by more than 50 K when measured under the test conditions of 5.4.3.1.3. Requirements specific for Europe are given in B.5.3.3.1.3.

Nevertheless, parts of the case within 5 cm of the edge of the lighting hole or sight glass, if any, and within 15 cm of the flue gas outlet or fitting piece are exempt from this requirement.

5.3.3.1.4 Limiting temperature of the test panels and the floor

The temperature of the floor on which the small fuel cell CHP appliance is placed, where appropriate, and that of the panels placed at the side of and behind the small fuel cell CHP appliance shall not, at any point, exceed the ambient temperature by more than 80 K under the test conditions of 5.4.3.1.4.

When this temperature rise is between 50 K and 80 K, or the values given in B.5.3.3.1.4 for Europe, the manufacturer shall state in the technical instructions for the installer the nature of the protection which has to be applied between the small fuel cell CHP appliance and the floor or walls when these latter are made of inflammable materials.

This protection shall be supplied to the test laboratory which shall check that, with the small fuel cell CHP appliance fitted with it, the floor and panel temperatures measured under the test conditions of 5.4.3.1.4 do not exceed the ambient temperature by more than 50 K or the values given in B.5.3.3.1.4 for Europe.

5.3.3.1.5 External temperature of the ducts

The temperature of the ducts in contact with or passing through the walls of the dwelling shall not exceed the ambient temperature by more than 50 K or the values given in B.5.3.3.1.5 for Europe under the test conditions of 5.4.3.1.5.

If this temperature rise exceeds 50 K or the values given in B.5.3.3.1.5 for Europe, the manufacturer shall state in the technical instructions for the installer the nature of the protection which has to be applied between the ducts and the walls when they are constructed of inflammable materials.

This protection shall be supplied to the test laboratory which shall check that, with the protection fitted, the external surface temperature in contact with the wall measured under the test conditions of 5.4.3.1.5 does not exceed the ambient temperature by more than 50 K or the values given in B.5.3.3.1.5 for Europe.

5.3.3.2 Thermostats and temperature limiting devices

Requirements specific for Japan are given in C.5.3.3.2.

5.3.3.2.1 General

To protect a small fuel cell CHP appliance against the basic risks of fire and explosion as a result of overheating, a temperature control function is required.

The purpose of the temperature control function is to control the temperature (control thermostat and temperature limiter) and to prevent the risk of excessive temperature (overheat cut-out) which could lead to the hazard of overheating for a small fuel cell CHP appliance. The temperature control function is a system which consists of temperature sensing, signal processing, switching actions (on/off or protective action) and reset.

Practical realization of the temperature control function can be carried out with one control (electronic systems) or more controls, specifying control thermostats, temperature limiters and

overheat cut-outs. Constructional measures, such as an open expansion vessel system, can also cover part of the risk.

Thermostats, temperature limiters and overheat cut-out devices shall have independent temperature sensing elements.

With an electronic system, thermostats and temperature limiters may have the same temperature sensing element provided that its failure cannot give rise to a dangerous situation for the user or damage to the small fuel cell CHP appliance.

For electronic temperature control systems

- a) the term control thermostat should be read as control temperature set point;
- b) the term temperature limiter should be read as temperature limit set point;
- c) the term overheat cut-out device should be read as overheat cut-out set point.

The temperature sensing elements shall withstand the thermal overload resulting from an overheat condition specified in this standard, without the predetermined set point being affected.

Under the test conditions of 5.4.3.2.1 the opening and closing temperatures of the thermostats shall not differ from those stated by the manufacturer by more than the tolerance given in the regional annexes. For adjustable thermostats, this requirement is checked at the minimum and maximum temperatures of the control range.

Regional specific requirements are given in B.5.3.3.2.1 for Europe.

5.3.3.2.2 Water control thermostats

5.3.3.2.2.1 General

If the control thermostat is adjustable, the manufacturer shall at least state the maximum temperature in the instructions. The positions of the temperature selector shall be easy to establish and it shall be possible to ascertain in which direction the water temperature rises or falls. If numbers are used for this purpose, the highest number shall correspond to the highest temperature.

At its maximum setting, it shall cause at least a controlled shut-down.

5.3.3.2.2.2 Accuracy of adjustment

For electronic temperature control systems

- a) the term fixed setting thermostat should be read as fixed control temperature setpoint;
- b) the term adjustable thermostat should be read as user adjustable control temperature setpoint.

Under the test conditions of 5.4.3.2.2.1,

- the maximum water temperature of a small fuel cell CHP appliance fitted with a fixed setting thermostat shall be within ± 10 K of the temperature stated by the manufacturer;
- for small fuel cell CHP appliances fitted with an adjustable thermostat, it shall be possible to select, within ± 10 K, the water flow temperatures stated by the manufacturer;
- the flow temperature shall not exceed the maximum temperature declared by the manufacturer; however, when the control thermostat is located on the return, this requirement may be satisfied by action of the limit thermostat located on the water flow;