



DPC: 15 / 30304561 DC

BSI Group Headquarters

389 Chiswick High Road London W4 4AL

Tel: +44 (0)20 8996 9000

Fax: +44 (0)20 8996 7400

www.bsigroup.com

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

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Responsible Committee Secretary: **Mr Manjit Matharu (BSI)**
Direct tel: **020 8996 7127**
E-mail: manjit.matharu@bsigroup.com

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Introduction

This draft standard is based on international discussions in which the UK has taken an active part. Your comments on this draft are welcome and will assist in the preparation of the consequent standard. There is a high probability that this text could be adopted by CENELEC as a reference document for harmonization or as a European Standard. Recipients of this draft are requested to comment on the text bearing in mind this possibility.

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1	2	(3)	4	5	(6)	(7)
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/ Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	

**105/541/CDV****COMMITTEE DRAFT FOR VOTE (CDV)
PROJET DE COMITÉ POUR VOTE (CDV)**

Project number Numéro de projet		IEC 62282-3-400 Ed.1				
IEC/TC or SC: CEI/CE ou SC: 105		Secretariat / Secrétariat Germany				
☒ Submitted for parallel voting in CENELEC Soumis au vote parallèle au CENELEC	Date of circulation Date de diffusion 2015-09-11	Closing date for voting (Voting mandatory for P-members) Date de clôture du vote (Vote obligatoire pour les membres (P)) 2015-12-11				
Also of interest to the following committees Intéresse également les comités suivants		Supersedes document Remplace le document 105/508/CD & 105/517A/CC				
Proposed horizontal standard Norme horizontale suggérée ☐ Other TC/SCs are requested to indicate their interest, if any, in this CDV to the TC/SC secretary Les autres CE/SC sont requis d'indiquer leur intérêt, si nécessaire, dans ce CDV à l'intention du secrétaire du CE/SC						
Functions concerned Fonctions concernées ☒ Safety Sécurité				☐ EMC CEM	☐ Environment Environnement	☐ Quality assurance Assurance qualité

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Title:

IEC 62282-3-400: Fuel cell technologies -

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

Introductory note

-

**ATTENTION
IEC – CENELEC
PARALLEL VOTING**

The attention of IEC National Committees, members of CENELEC, is drawn to the fact that this Committee Draft for Vote (CDV) for an International Standard is submitted for parallel voting.

The CENELEC members are invited to vote through the CENELEC online voting system.

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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**

Foreword

This CDV of IEC 62282-3-400 Ed.1 consolidates the meeting results of all the WG12 meetings held in Tokyo 2014-11 and Frankfurt 2015-01 based on comments received to **105/508/CD**.

This draft has a common main part and shows specific regional requirements in the relevant Annex B, Annex C and Annex D.

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1 Scope

This standard applies to small stationary fuel cell power systems serving as a heating appliance providing both electrical 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). Connection to the mains directly (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 power systems 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 C.1 for Japan.

This standard applies to systems as shown in Figure 1.

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

In case of the system 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 does not have to be applied to the supplementary heat generator.

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: Other fuels such as alcohols (methanol, ethanol), kerosene, or hydrogen for the supplementary heat generator may be added in future amendments or revisions.

The following points also apply:

- The heat transfer fluid (heat output) shall be 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) shall not exceed 100 °C, respectively the value given in B.1 for Europe and in D.1 for US.
- The maximum pressure of the heat transfer fluid (heat output) circuit shall not exceed 0,3 MPa, respectively the limits as given in B.1 for Europe, C.4.3 for Japan and D.1 for the US.
- The maximum pressure of the domestic hot water circuit, if installed, shall not exceed 0,1 MPa, respectively the limits as given in D.1 for the US.

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)
- without ducts (Type A)

NOTE 3: Duct systems are shown in Annex F and the chimney in the figures is part of the building and is not subject to this standard.

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

This standard applies to both indoor and outdoor installations.

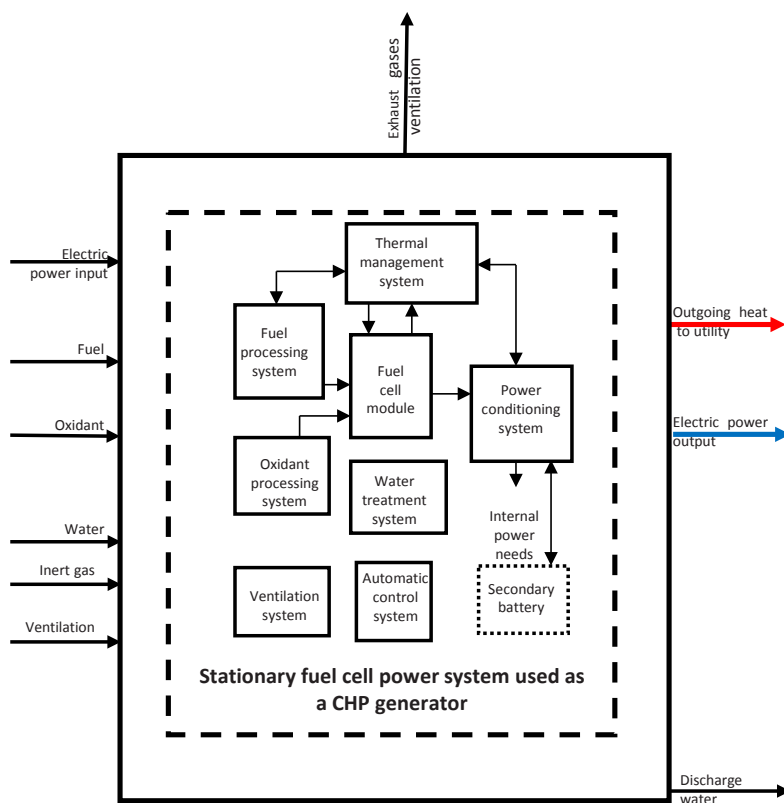
This standard applies to systems with or without integrated batteries.

339 This standard applies to Type Testing only.

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

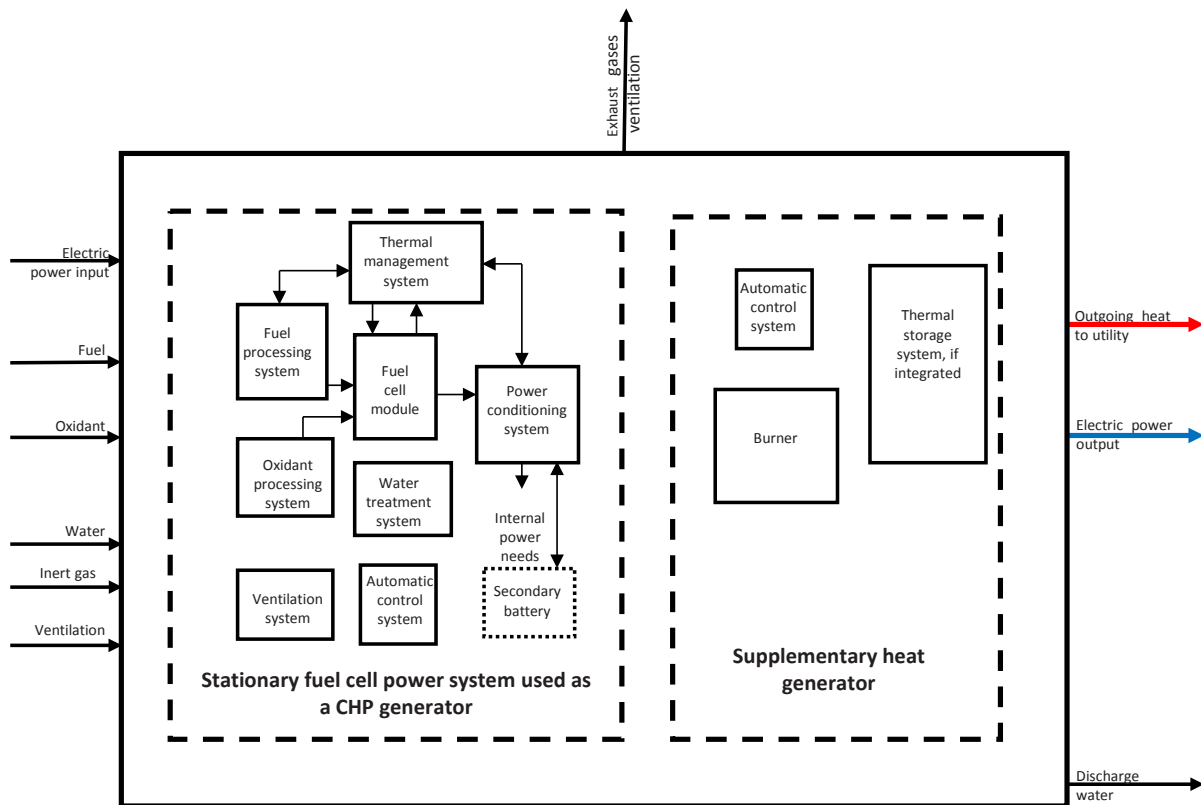
342 This Standard also provides regional and country specific requirements to facilitate the worldwide
343 application of this IEC standard. These essential regional and country specific requirements are given
344 in Annex B for Europe, in Annex C for Japan and Annex D for the US and will facilitate that the
345 essential requirements for applications are given clearly.

346 If the user or manufacturer chooses a regional specific annex to apply this standard, then that annex
347 shall be apply to the appliance entirely. It is not permissible to mix requirements between annexes.



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

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Functional blocks of a small fuel cell CHP appliance with an
integrated supplementary heat generator

Figure 1: Configuration with and without integrated supplementary heat generator

2 Normative References

- 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 60335-2-102:2012, *Household and similar electrical appliances - Safety - Part 2-102: Particular requirements for gas, oil and solid-fuel burning appliances having electrical connections*
- IEC 60529, *Degrees of protection provided by enclosures (IP Code)*
- IEC 60730-1, *Automatic electrical controls for household and similar use – Part 1: General requirements*

- 369 IEC 60730-2-5, *Automatic electrical controls for household and similar use – Part 2-5:*
370 *Particular requirements for automatic electrical burner control systems*
- 371 IEC 60730-2-9, *Automatic electrical controls for household and similar use - Part 2-9:*
372 *Particular requirements for temperature sensing controls*
- 373 CISPR 14-1, *Electromagnetic compatibility - Requirements for household appliances, electric*
374 *tools and similar apparatus - Part 1: Emission;*
- 375 CISPR 14-2 *Electromagnetic compatibility - Requirements for household appliances, electric*
376 *tools and similar apparatus - Part 2: Immunity - Product family standard;*
- 377 IEC 61000-3-2, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic*
378 *currents emissions (equipment input current ≤ 16 A per phase)*
- 379 IEC 61000-3-3, *Electromagnetic compatibility (EMC) – Part 3-3: Limits – Limitation of voltage*
380 *changes, voltage fluctuations and flicker in public low-voltage supply systems for equipment*
381 *with rated current ≤ 16 A per phase and not subject to conditional connection*
- 382 IEC 61000-3-4, *Electromagnetic compatibility (EMC) – Part 3-4: Limits – Limitation of*
383 *emission of harmonic currents in low-voltage power supply systems for equipment with rated*
384 *current greater than 16 A*
- 385 IEC 61000-3-11, *Electromagnetic Compatibility (EMC) – Part 3-11: Limits – Limitation of*
386 *voltage changes, voltage fluctuations and flicker in public low-voltage supply systems –*
387 *Equipment with rated current ≤ 75 A and subject to conditional connection*
- 388 IEC 61000-3-12 *Electromagnetic compatibility (EMC) - Part 3-12: Limits - Limits for*
389 *harmonic currents produced by equipment connected to public low-voltage systems with input*
390 *current > 16 A and ≤ 75 A per phase;*
- 391 IEC 61000-6-1, *Electromagnetic compatibility (EMC) – Part 6-1: Generic standards –*
392 *Immunity for residential, commercial and light-industrial environments*
- 393 IEC 61000-6-3, *Electromagnetic compatibility (EMC) – Part 6-3: Generic standards –*
394 *Emission standard for residential, commercial and light-industrial environments*
- 395 IEC/TS62282-1:2013 *Fuel cell technologies - Part 1: Terminology*
- 396 IEC 62282-2:2012 *Fuel cell technologies - Part 2: Fuel cell modules*
- 397 IEC 62282-3-201:2013 *Fuel cell technologies - Part 3-201: Stationary fuel cell power systems -*
398 *Performance test methods for small fuel cell power systems*
- 399 ISO 7-1, *Pipe threads where pressure-tight joints are made on the threads -- Part 1:*
400 *Dimensions, tolerances and designation*
- 401 ISO 228-1, *Pipe threads where pressure-tight joints are not made on the threads -- Part 1:*
402 *Dimensions, tolerances and designation*
- 403 ISO 262, *ISO general purpose metric screw threads -- Selected sizes for screws, bolts and*
404 *nuts*
- 405 ISO 3166-1 *Codes for the representation of names of countries and their subdivisions -*
406 *Part 1: Country codes*
- 407 ISO 4126-1, *Safety devices for protection against excessive pressure - Part 1: Safety valves*
- 408 ISO 23550, *Safety and control devices for gas burners and gas-burning appliances -- General*
409 *requirements*
- 410 ISO 23551-1, *Safety and control devices for gas burners and gas burning appliances –*
411 *Particular requirements – Part 1: Automatic valves*

- 412 ISO 23551-2, *Safety and control devices for gas burners and gas-burning appliances --*
413 *Particular requirements -- Part 2: Pressure regulators*
- 414 ISO 23551-3, *Safety and control devices for gas burners and gas-burning appliances --*
415 *Particular requirements -- Part 3: Gas/air ratio controls, pneumatic type*
- 416 ISO 23552-1, *Safety and control devices for gas and/or oil burners and gas and/or oil*
417 *appliances -- Particular requirements -- Part 1: Fuel/air ratio controls, electronic type*
- 418 Regional specific standards are given in B.2 for Europe, in C.2 for Japan and in D.2 for the
419 US.
- 420

3 Terms and definitions and symbols

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

3.1

supply gas

gas, supplied externally to the small fuel cell CHP appliance

3.2

supply gas circuit

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

3.3

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

Note 1 to entry: This circuit includes the gas circuit

3.4

process gas

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

3.5

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

3.6

combustion circuit

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

3.7

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

3.8

combustion chamber

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

3.9

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

3.10

combustion products evacuation duct

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

3.11

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

3.12

air proving

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

NOTE 1 to entry: A function that checks, if the correct volume of air is available and shows it only when air is available.

- 470 **3.13**
 471 **Semi-outdoor small fuel cell CHP appliance**
 472 Small fuel cell CHP appliance intended to be installed in the open air but in a partially
 473 protected place only, not exposed to the direct exterior surrounding and infiltration of rain,
 474 snow or hail.
- 475 **3.14**
 476 **duct terminal**
 477 part of the combustion circuit fitted external to the building which has the function of the air supply inlet
 478 and/or combustion products outlet of the appliance
 479 NOTE 1 to entry: see **Figure 19**
- 480 **3.15**
 481 **fitting piece**
 482 intermediate piece that connect the duct system to the small fuel cell CHP appliance
 483 NOTE 1 to entry: see **Figure 19**
- 484 **3.16**
 485 **duct terminal guard**
 486 device that protects the duct terminal from mechanical damage from outside influences
 487 NOTE 1 to entry: see **Figure 19**
- 488 **3.17**
 489 **recycling**
 490 automatic process by which, after loss of flame during operation, the gas supply is interrupted
 491 and the full start procedure is re-initiated automatically
- 492 **3.19**
 493 **maximum water side operating pressure**
 494 maximum pressure of the water on the small fuel cell CHP appliance outlet which provides the heat for
 495 the heating circuit, declared by the manufacturer for which the appliance is designed.
- 496 **3.20**
 497 **CHP**
 498 simultaneous generation of thermal and electrical energy in one process
 499 NOTE 1 to entry: CHP= combined heat and power
- 500 **3.21**
 501 **small fuel cell CHP appliance**
 502 appliance which delivers both heat and electric power, and can also provide domestic hot water
 503 service; and is comprised of a stationary fuel cell power system used as a CHP generator and the
 504 following components as relevant:
 505 – supplementary heat generator;
 506 – flue ducts;
 507 – thermal storage
 508 NOTE 1 to entry: see Figure 1
 509 NOTE 2 to entry: the appliance is either delivered or specified by the manufacturer's instructions as a complete
 510 package
- 511 **3.22**
 512 **CHP generator**
 513 system that includes a fuel cell power system that produces thermal and electrical energy and
 514 is the preferential source of heat
 515 NOTE 1 to entry: see Figure 1
- 516 **3.23**
 517 **supplementary heat generator**
 518 non-preferential heat source providing peak load
 519 NOTE 1 to entry: see Figure 1

- 520 **3.24**
521 **states and phases of operation**
- 522 **3.24.1**
523 **cold state**
524 state of a CHP generator at ambient temperature with no power input or output
525 [IEC/TS62282-1:2013 definition 3.110.1 modified]
- 526 **3.24.2**
527 **operational state**
528 state of a CHP generator with the ability to generate nominal electric active power output , or state of
529 the supplementary heat generator with the ability to produce nominal heat output, if demanded
530 [IEC/ TS62282-1:2013 definition 3.110.2 modified]
- 531 **3.24.3**
532 **storage state**
533 state of a CHP generator being non-operational and possibly requiring, under conditions specified by
534 the manufacturer, the input of thermal and/or electric energy and/or an inert atmosphere in order to
535 prevent deterioration of the components and/or to energize the control systems
536 [IEC/ TS62282-1:2013 definition 3.110.6 modified]
- 537 **3.24.4**
538 **lockout state**
539 state of operation in which the small fuel cell CHP appliance, or the CHP generator or the
540 supplementary heat generator is shut down and a restart can only be accomplished by a manual reset
- 541 **3.24.5**
542 **start-up**
543 sequence of operations, specified by the manufacturer, that occurs to transition a CHP generator from
544 cold state or storage state to operational state
- 545 **3.24.6**
546 **shutdown**
547 sequence of operations, specified by the manufacturer, that occurs to transition a CHP generator from
548 operational state to cold state or storage state
549 [IEC/ TS62282-1:2013 definition 3.101 modified]
- 550 **3.25**
551 **heat input (P_{inf})**
552 amount of heat expressed as a function of time released by the small fuel cell CHP appliance at a
553 given throughput
554 NOTE 1 to entry: Heat input is expressed in kilowatts (kW) and is calculated as fuel flow rate multiplied by the
555 lower heating value of the fuel.
- 556 **3.26**
557 **nominal heat input ($P_{inf,nom}$)**
558 value of the heat input, to provide nominal output
559 NOTE 1 to entry: $P_{inf,nom}$ is the needed heat input to operate the small fuel cell CHP appliance to reach nominal
560 heat output and nominal electric power output
- 561 **3.27**
562 **nominal output**
563 useful output (thermal and electrical power) in kW declared by the manufacturer, corresponding to the
564 operation of the small fuel cell CHP appliance in a specified water temperature regime or at a
565 specified domestic hot water temperature condition

- 566 **3.28**
 567 **purge circuit**
 568 circuit of the CHP generator that contains process gas or anode off gas during generating mode
- 569 **3.29**
 570 **internal cooling circuit**
 571 assembly of parts of the small fuel cell CHP appliance that carry or contain liquids intended to
 572 maintain the internal components of the appliance at their operating temperature and being
 573 not connected to supplies or circuits outside of the appliance
- 574 **3.30**
 575 **heating water circuit**
 576 assembly of parts of the small fuel cell CHP appliance that carry or contain water intended to
 577 transfer useful heat to the building or external heat storing devices
- 578 **3.31**
 579 **protected nature**
 580 design of a combustion chamber and combustion products evacuation ducts such that an
 581 ignition in the combustion chamber does not cause ignition in the combustion products
 582 evacuation ducts, even if a flammable mixture exists in the combustion products evacuation
 583 ducts.
 584 NOTE 1 to entry: This may be achieved by any suitable design.
- 585 **3.32**
 586 **electric efficiency**
 587 ratio of the average net electric power output of a fuel cell power system at a given duration to the
 588 average fuel power fed to the same fuel cell power system at the same duration
 589 [SOURCE: IEC/TS 62282-1:2013, definition 3.30.1 modified]
- 590 **3.33**
 591 **heat recovery efficiency**
 592 ratio of the average thermal power recovered at a given duration from a fuel cell power system to the
 593 average fuel power fed to the same fuel cell power system at the same duration
 594 [SOURCE: IEC/TS 62282-1:2013, definition 3.30.3, modified]
- 595 **3.34**
 596 **overall energy efficiency**
 597 sum of the electric efficiency and heat recovery efficiency
 598 [SOURCE: IEC/TS 62282-1:2013 definition 3.30.4, modified]
- 599 **3.35**
 600 **range-rating device**
 601 component on the small fuel cell CHP appliance intended to be used by the installer to adjust the
 602 nominal heat input of the small fuel cell CHP appliance within the range of maximum and minimum
 603 heat inputs stated by the manufacturer, to suit the actual heat requirements of the installation
- 604 **3.36**
 605 **range-rated small fuel cell CHP appliance**
 606 small fuel cell CHP appliance which is adjustable by the range-rating device

607 3.37**608 domestic hot water**

609 water delivered by the small fuel cell CHP appliance, raised to a certain temperature in order to use it
610 for domestic needs, e.g. kitchen, bathroom, etc.

611 3.38**612 appliance category**

613 means of identifying the type of gas that a gas appliance is designed to utilize safely and to the
614 desired performance level.

615 Note 1 to entry: see 5.4.1.2

616 3.39**617 gas family****618 gas type**

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

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

621 3.40**622 gas group**

623 specified range of Wobbe index within that of the gas type concerned; this range is determined on the
624 general principle that appliances utilising this gas group would operate safely when burning all gases
625 within this range without adjustments

626 Note 1 to entry: the gas groups are specified in the regional specific annexes are given in 4.1, if relevant

627 3.40**628 test gases**

629 gases intended for the verification of the operational characteristics of gas appliances. They consist of
630 reference gases and limit gases

631 Note 1 to entry: the test gases are specified in the regional specific annexes are given in 4.1, if relevant

632 3.42**633 reference gases**

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

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

637 3.43**638 limit gases**

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

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

642 3.44**643 adjuster**

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

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

647 3.44 Symbols

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

650 **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 heat recovery fluid	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
$p_{\text{w,max}}$	Maximum water side operating pressure	

Symbol	Definition	Unit
$p_{w,sat}$	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	m³/h
$q_{V,HR}$	Volumetric flow rate of the heating recovery fluid	m³/h
$q_{V,leak}$	Leakage flow rate	m³/h
$q_{V,vent}$	Ventilation flow rate	m³/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 circuit	°C
T_2	Return temperature of the heating 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	m³
$V_{ex,th,dr}$	Theoretical reference flue gas volume, dry	m³/m³
ε	Emission	
ε_{NO_x}	NO _x emission referring to the energy input	mg/kWh
$\varepsilon_{NO_x,c}$	Value of ε_{NO_x} corrected to the reference conditions (10 g/kg for humidity and 20 °C for temperature)	mg/kWh
$\varepsilon_{NO_x,CHP}$	Weighted value of NO _x emission of the CHP part	mg/kWh
$\varepsilon_{NO_x,meas}$	Measured NO _x emission at partial heat input	mg/kWh
$\varepsilon_{NO_x,pond}$	Weighted value of NO _x emission	mg/kWh
$\varepsilon_{NO_x,SUP}$	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	%

Symbol	Definition	Unit
η_{son}	Seasonal space heating energy efficiency in active mode	%
ρ	Density	
ρ_{HR}	Density of the heat recovery fluid	kg/m ³
μ	Viscosity	
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.
$\varphi_{\text{ex,CO,th}}$	CO volume fraction in the dry air-free combustion products	% vol.
$\varphi_{\text{ex,CO,m}}$	Measured CO volume fraction in dry combustion products	% vol.
$\varphi_{\text{ex,CO,w}}$	Weighted CO volume fraction in dry combustion products	% vol.
$\varphi_{\text{at,O}_2,\text{m}}$	Measured O ₂ volume fraction in the dry atmosphere	% vol.
$\varphi_{\text{ex,O}_2,\text{m}}$	Measured O ₂ volume fraction in dry combustion products	% vol.
$\varphi_{\text{ex,CO}_2,\text{th}}$	CO ₂ volume fraction in the theoretical dry air-free combustion products	% vol.
$\varphi_{\text{ex,CO}_2,\text{m}}$	Measured CO ₂ volume fraction in dry combustion products	% vol.
$\varphi_{\text{at,CO}_2,\text{m}}$	Measured CO ₂ volume fraction in the dry atmosphere	% vol.
$\varphi_{\text{ex,NO}_x,\text{m}}$	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/Categories

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

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 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 as a systematic approach for the choice of the manufacturer.

Note: Annex F offers for, the choice of the manufacturer, 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.4.2 for the US.

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 are not considered under the classification, e.g. internal cooling circuits for heat exchange in small fuel cell CHP appliances.

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 no. 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 practical possible through
 - 1) inherently safe design of the construction and its methods, or
 - 2) passive control of energy releases without endangering the surrounding environment (for example, burst disks, release valves, thermal cut-off devices) or by safety related control functions,
 - 3) and for residual risks which could not have been reduced by the measures according to 1) and 2) provision of labels, warnings, or requirements of special training shall be taken, considering that such measures need to be understood by the persons which are in the area of the hazards.

If not elsewhere in this standard safety related measures are explicitly given 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 appliance level
- IEC 60730-1 on controls level

Note For failure mode and effects analysis (FMEA) and fault tree analysis methods the standards IEC 60812, SAE J1739, 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 in- 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 US.

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.

762 Every small fuel cell CHP appliance shall be provided with at least one device to enable the
763 user to close the gas supply to the burner, supplementary burner, ignition burner or similar
764 oxidation devices, and the process circuit, as relevant to the design of the small fuel cell CHP
765 appliance.

766 The shut-off shall be effected without delay.

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

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

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

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

780 **5.2.2.2 Conversion to different gases**

781 The following actions are allowed, if the manufacturer so permits in the installation
782 instructions, in order to convert from a gas of one family or group to a gas of another family or
783 group:

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

796 For each of the operations mentioned above that are allowed by the manufacturer in the
797 installation manual, the appliance shall be type-tested with each of the gases. These
798 operations shall be possible without having to interfere with the connections of the small fuel
799 cell CHP appliance to its connecting pipe-work, i.e. gas supply, water supply and air inlet and
800 combustion product evacuation ducts.

801 Requirements specific for Japan are given in C.5.2.2.2

802 **5.2.3 Connections to the supply systems**

803 **5.2.3.1 Connection to the gas and water pipes**

804 **5.2.3.1.1 General**

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

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

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

811 **5.2.3.1.2 Connection to the gas pipe**

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

814 Gas connections shall comply with ISO 23550

815 Requirements specific for Japan are given in C.5.2.3.1.2

816 **5.2.3.1.3 Connection to the water pipes**

817 **5.2.3.1.3.1 General**

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

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

826 NOTE: If the small fuel cell CHP appliance is installed outdoor, earthquake loads may be considered too!

827 Requirements specific for Japan are given in C.5.2.3.1.3.1.

828 **5.2.3.1.3.2 For the heating circuit**

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

830 Requirements specific for Japan are given in C.5.2.3.1.3.2

831 If copper connections are used, the connecting end of the tube shall comply with the appropriate
832 national or regional standard, see B.5.2.3.1.3.2.

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

835 **5.2.3.1.3.3 For process water (if applicable)**

836 The connections shall comply with the local connection code.

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

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

840 **5.2.3.1.3.4 Drainage**

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

844 Methods for drainage can be found in the B.5.2.3.1.3.4 for Europe.

845 **5.2.3.2 Connection to the combustion air and flue duct system (if any)**

846 **5.2.3.2.1 Air supply and combustion products evacuation ducts**

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

851 It shall be possible to connect the small fuel cell CHP appliance, the air supply and
852 combustion products evacuation ducts and the duct terminal or fitting piece using ordinary

853 tools if necessary. All necessary accessories and the fitting instructions shall be supplied or
854 specified by the manufacturer.

855 Duct terminal guard if it exists and fitting pieces have to be installed in accordance with the
856 manufacturer's instructions.

857 The duct terminal outlets from separate ducts for the supply of combustion air and the
858 evacuation of combustion products: the manufacturer shall declare if the duct terminal inlet
859 and outlet need to be positioned in the same pressure zone or if it is permitted to position the
860 two duct terminal (in- and outlet) terminates in zones of different pressure; possible
861 configurations of duct systems are given in Annex F

862 Requirements specific for Europe are given in B.5.2.3.2.1

863 **5.2.3.2.2 Duct terminal**

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

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

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

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

872 **5.2.3.2.3 Duct terminal guard**

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

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

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

882 **5.2.3.2.4 Fitting piece**

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

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

891 **5.2.3.3 Connection to the condensing discharge pipe system**

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

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

896 Requirements specific for Japan are given in C.5.2.3.3.

897 **5.2.3.4 Connection to the electrical supply system**

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

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

901 Requirements apply as given in B.5.2.3.4 for Europe and in C.5.2.3.4 for Japan.

902 **5.2.4 Soundness**

903 **5.2.4.1 General**

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

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

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

909 **5.2.4.2 Soundness of the gas circuits**

910 The supply gas circuit shall consist of metallic parts.

911 Where the internal pressure for a gas circuit is at or above ambient air pressure during
912 conditions when supplied gas or process gas is carried by that circuit, the following apply:

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

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

928 If a control function ensures that a gas circuits operates below ambient air pressure, and the
929 above requirements have not been taken into account and the tests according 5.3.2 have not
930 been performed, the

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

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

938 Requirements specific for Japan are given in C.5.2.4.2.

939 **5.2.4.3 Soundness of the combustion circuit**

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

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

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

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

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

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

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

960 **5.2.4.4 Soundness of the water circuits**

961 The water circuits shall be sound.

962 Requirements specific for Japan are given in C.5.2.4.4.

963 **5.2.5 Material**

964 Additional requirements are given in C.5.2.5.101 for Japan

965 **5.2.5.1 General**

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

972 a) suitable for the range of temperatures, pressures, flow rates, voltages and currents to which
973 they are subjected during intended usage, and

974 b) resistant to the reactions, processes and other conditions to which they are exposed during
975 intended usage.

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

980 For small fuel cell CHP appliance intended to be installed outdoors or semi-outdoors, all
981 materials employed in the construction, including seals, gaskets and sealing pastes, if any,
982 shall function properly in the environmental conditions under which they are expected to
983 operate. The manufacturer shall declare in the technical instructions the minimum and
984 maximum ambient temperatures at which it is designed to operate.

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

986 **5.2.5.2 Thermal insulation**

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

990 Requirements specific for Europe are given in B.5.2.5.2.

991 5.2.6 Electrical safety

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

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

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

1000 Wiring shall not contact a moving part when subjected to a force of 2 N respectively the
1001 values given in the regional annexes in the direction of the moving part.

1002 When an internal wire that is fixed in place or passing through a hole or passing through a
1003 bulkhead or can contact another part when a force of 2 N respectively the values given in the
1004 regional annexes is applied it shall not have its insulation damaged by such a force of 2 N
1005 respectively the values given in the regional annexes.

1006 When internal wiring is connected with a connector it shall not become disconnected when it
1007 is subjected to the normal stresses and vibration associated with transportation, storage and
1008 use.

1009 Misalignment of male and female connectors, insertion of a multipin male connector in a
1010 female connector other than one intended to receive it, and other manipulations of parts that
1011 are accessible without the use of a tool shall not result in a hazardous condition.

1012 Each conductor shall be identifiable at each termination in accordance with the technical
1013 documentation for maintenance.

1014 Overcurrent protection shall be provided using fuses, overcurrent protective devices, other
1015 protective devices or other means which operate when abnormalities such as short circuit
1016 occur, if such a short circuit would result in a hazardous situation.

1017 The fuel cell designer shall also consider the following fuel cell specific issues:

- 1018 a) residual charge on the fuel cell stack;
- 1019 b) energy hazard between cells.

1020 If the manufacturer states, on the data plate, the nature of the electrical protection of the
1021 small fuel cell CHP appliance, this statement shall comply with IEC 60529:

- 1022 c) to give the degree of personal protection against contact with dangerous electrical
1023 components inside the small fuel cell appliance case,
- 1024 d) to give the degree of electrical protection, inside the small fuel cell CHP appliance case,
1025 against harmful actions affecting safety due to water penetration,

1026 The technical requirements for connection and operation in parallel with public low voltage distribution
1027 networks shall comply with regional or country specific requirements, see B.5.2.6 for Europe and
1028 D.5.2.6 for the US.

1029 For appliances intended to be installed outdoors or semi-outdoors,

- 1030 e) the enclosure protection degree shall be at least IPX4D;
- 1031 f) the electrical and/or electronic equipment temperature range must be suitable for the specified
1032 temperature range of the appliance.

1033 Additional requirements, specific for Japan, are given in C.5.2.6.101 to C.5.2.6.108.

1034 5.2.7 Subsystems and safety related Control functions**1035 5.2.7.1 Circuit conveying combustible gases****1036 5.2.7.1.1 General**

1037 The minimum requirements for the gas circuit of the small fuel cell CHP appliance are

- 1038 • prevention or control of unintended flow back of process gas into the combustion product
1039 circuit,
- 1040 • no unintended excess pressure can arise in the process gas,
- 1041 • no unintended air can enter the fuel gas and/or the process gas,
- 1042 • no unintended outflow of process gas within the unit or into the atmosphere.

1043 Screwed fastenings that have to be removed for servicing of the device shall have a metric
1044 thread complying with ISO 262, unless a different thread is essential for the correct
1045 functioning and adjustment of the device.

1046 Thread-forming screws that form a thread and do not produce swarf may be used. It shall be
1047 possible to replace them by metric machine screws complying with ISO 262.

1048 Self-tapping screws that cut a thread and produce swarf shall not be used for the assembly of
1049 gas-carrying parts or of parts that may be removed for servicing.

1050 Measures shall be taken to avoid particulate matter greater than a 1 mm pin gauge
1051 respectively the values given in the regional annexes from interfering with the operation of the
1052 fuel gas inlet shutoff valve. Such measures might be a particulate filter, a drop leg, or other
1053 means. Compliance is checked by inspection or demonstration by the manufacturer.

1054 Exception: If the gas supply to the appliance has been shown to be free of particulate matter
1055 larger than a 1 mm pin gauge this requirement does not apply.

1056 5.2.7.1.2 Composition of the gas circuit

1057 The gas circuit, from the gas supply inlet terminal up to the safety shut-off valve, shall be of
1058 metallic material.

1059 The gas circuit shall be fitted with a safety shut-off valve consisting of two independent shut-
1060 off functions according ISO 23551-1. It is permitted that both functions are combined in one
1061 valve body.

1062 Safety devices which require non-volatile lockout to occur shall give rise to simultaneous
1063 signal to close the two valves.

1064 In the case of direct ignition of the main burner and if the order to close in response to a
1065 control device is not given simultaneously to the two valves, the two valves shall be at least
1066 class C.

1067 In response to a control device, if the delay between the signals to close the two valves is not
1068 greater than 5 s respectively the values given in the regional annexes, the signals are
1069 considered to be simultaneous.

1070 The composition of the gas circuit shall be according to Table 2.

1071 Illustrations of the composition of the gas circuit are given in Annex E.

1072 Table 2 – Composition of the gas circuit according on the valve classification of ISO 23551-1

Heat input of the individual gas line within the 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 which meet the criteria of **5.3.4.2.2.1**, fourth paragraph, only one class C valve is needed.

1073 Requirements specific for Japan are given in C.5.2.7.1.2.

1074 **5.2.7.1.3 Gas circuit downstream of the safety shut-off valve**

1075 The circuit and its components shall be sound according ISO 23550 for the fuel being used.

1076 If components of non-metallic material is used the manufacturer shall provide evidence that these
 1077 materials withstand the environmental conditions to which they are exposed during the operation of
 1078 the appliance if it is installed and used according the manufacturer instructions through the expected
 1079 lifetime and that the components are still sound at the end of the lifetime.

1080 If this evidence can't be provided, measures to avoid or control the hazards of a possible leakage, of
 1081 such a component, of combustible gases shall be implemented. This can be achieved by complying
 1082 with the measures as given in 5.2.4.2 and 5.3.2.1.3.1.

1083 **5.2.7.1.4 Process gas circuit**

1084 The circuit and its components shall be sound according ISO 23550 by considering the effects
 1085 of the composition of the process gas such as high concentration of H₂, high humidity content
 1086 (even water) to the material and the elastomers used in e.g. valves, reformers, stacks.

1087 If components of non-metallic material is used the manufacturer shall provide evidence that
 1088 these materials withstand the environmental conditions to which they are exposed during the
 1089 operation of the appliance if it is installed and used according the manufacturer instructions
 1090 through the expected lifetime and that the components are still sound at the end of the
 1091 lifetime.

1092 If this evidence can't be provided, measures to avoid or control the hazards of a possible
 1093 leakage, of such a component, of combustible gases shall be implemented. This can be
 1094 achieved by complying with the measures as given in 5.2.4.2 and 5.3.2.1.3.1.

1095 Requirements specific for Japan are given in C.5.2.7.1.4.

1096 **5.2.7.1.5 Purge circuit (if any)**

1097 If the amount of released flammable gas exceeds the limit as specified in 5.3.3.5, then the purge
 1098 circuit (e.g. anode outlet gas), which allows the release of flammable gas to the environment (e.g. via
 1099 the exhaust gas system) by opening valves, shall be fitted with at least two valves of class C.

1100 Alternative valve arrangement is possible, if the valve class is higher (this could be either two valves in
 1101 parallel to the safety shut off valve(s) or one valve downstream of the safety shut off valve)

1102 **5.2.7.1.6 Burners (including catalytic burners) and its control systems**

1103 **5.2.7.1.6.1 Burners**

1104 The cross-section of the flame ports and also the burner and ignition burner injectors shall not
1105 be adjustable (manually).

1106 Every removable injector and removable restrictor shall carry an indelible means of
1107 identification preventing any confusion. In the case of non-removable injectors and/or
1108 restrictors, the marking may be on the manifold.

1109 It shall be possible to change injectors and restrictors without the need to disconnect the
1110 small fuel cell CHP appliance. When the injectors and restrictors are removable, their position
1111 shall be well defined and their method of fixing shall be such that it is difficult to position them
1112 incorrectly.

1113 If the burners or a part of the burners are removable, their position shall be well defined and
1114 their method of fixing shall be such that it is difficult to position them incorrectly.

1115 The start-up procedure of the burner as well as the flame monitoring shall be according IEC
1116 60730-2-5.

1117 The ignition of the gas air mixture shall be without significant delay and without generating a
1118 significant pressure in the combustion chamber and under the conditions of delayed ignition
1119 no dangerous situation for the user or damage to the small fuel cell CHP appliance occurs.

1120 There shall be not flame lift off or back fire by using the extreme compositions of the gases
1121 used (supply gas or for process gas).

1122 Requirements specific for Japan are given in C.5.2.7.1.6.1.

1123 **5.2.7.1.6.2 Automatic burner control system**

1124 For the safe operation of a burner including catalytic oxidation an automatic control system
1125 according IEC 60730-2-5 shall be used.

1126 The sequence of this burner control system shall provide the safety related functions
1127 according to this standard by considering the risk assessment according 5.1.

1128 If the temperature of the combustion compartment and the parts of the combustion
1129 compartment directly in touch with the gas/air mixture is above the self-ignition temperature
1130 flame supervision may be substituted by the temperature monitoring to ensure that the signal
1131 to the safety shut-off valves will be disconnected if the temperature falls below self-ignition
1132 temperature. Furthermore the release of gas flow shall only be released after the self-ignition
1133 temperature is ensured. The control function shall be according on the safety level given in
1134 IEC 60730-2-5.

1135 For burners which are intended to operate longer than 24 h without interruption respectively
1136 the values given in the regional annexes the burner control system shall comply with the
1137 requirements for permanent operation according IEC 60730-2-5.

1138 Requirements specific for Japan are given in C.5.2.7.1.6.2.

1139 **5.2.7.1.6.3 Gas/air ratio controls**

1140 Gas/air ratio controls shall be designed and constructed so that reasonably foreseeable
1141 damage does not give rise to a change capable of affecting safety.

1142 Mechanical linkage for operating the fuel and air controls, if used, shall be designed to
1143 reliably maintain the correct fuel-air ratio and to resist accidental breakage and
1144 disengagement.

1145 Pneumatic gas/air ratio controls shall comply with ISO 23551-3.

1146 Pressure tubing used for pneumatic gas/air ratio control may be made of metal with suitable
1147 mechanical connection or of other materials with at least equivalent properties. In this case,

1148 they are considered immune to breakage, accidental disconnection and leakage after initial
1149 soundness checks. As such they are not subject to the tests in 5.3.4.4.3.2.

1150 If pressure tubing for air or combustion products is used, it shall have a minimum cross-
1151 sectional area sufficient to provide unrestricted flow under all foreseeable conditions,
1152 additional requirements for Europe are given in B.5.2.7.1.6.3. They shall be located and fixed
1153 so that any retention of condensate is avoided and positioned such that creasing, leakage or
1154 breakage is prevented. Where more than one pressure tube is used, the relevant connection
1155 position for each shall be obvious. Compliance is checked by the manufacturer or by using
1156 an accepted minimum diameter.

1157 Electronic gas/air ratio controls shall comply with ISO 23552-1.

1158 **5.2.7.1.7 Supply of air and evacuation of combustion products**

1159 Small fuel cell CHP appliances shall be designed so that there is an adequate supply of air
1160 during ignition and over the whole range of possible heat inputs stated by the manufacturer. A
1161 gas/air ratio control is permitted.

1162 Small fuel cell CHP appliances shall be designed so that there is an adequate supply of air to
1163 the stack over the whole operating range stated by the manufacturer.

1164 Unless otherwise stated, small fuel cell CHP appliances using fan assisted combustion may
1165 be fitted with a means of adjustment in the combustion circuit intended to adapt the small fuel
1166 cell CHP appliance to the pressure losses in the installed ducts. Either restrictors or a means
1167 of setting the adjustment to predetermined positions in accordance with detailed instructions
1168 from the manufacturer may be used.

1169 According to the small fuel cell CHP appliance type, the manufacturer shall supply any duct
1170 terminal and/or fitting piece, with the small fuel cell CHP appliance for testing.

1171 **5.2.7.1.8 Requirements for a fan incorporated in a small fuel cell CHP appliance**

1172 Direct access to the rotating parts of a fan shall be prevented. The parts of a fan in contact
1173 with combustion products shall be effectively protected against corrosion unless they are of
1174 corrosion resistant material; furthermore they shall withstand the temperature of the
1175 combustion products.

1176 **5.2.7.1.9 Air proving**

1177 Appliances with fans in the combustion air circuit shall be fitted with a system for air proving.

1178 Before each fan start, the availability of air shall be verified. There shall be no indication of air
1179 availability when air is not available.

1180 Air availability checks are not required for the combustion air with gas/air ratio controls if the gas/air
1181 ratio controls are sufficient to ensure that emissions do not exceed limits in the event of air blockage or
1182 duct blockage.

1183 The supply of combustion air shall be checked by one of the following methods:

- 1184 a) supervision of the combustion air flow rate or the combustion products flow rate. In this system,
1185 the supervision device is activated directly by the flow of combustion air or combustion products.
1186 This is also valid for small fuel cell CHP appliance with more than one fan speed for the
1187 combustion air in which the flows associated with each fan speed are monitored by separate
1188 supervision devices;
- 1189 b) gas/air ratio control.

1190 Only for appliances where the combustion products circuit is completely surrounded by the air supply
1191 circuit or for separate ducts when the leakage rates of the combustion products evacuation ducts
1192 meets the requirements of 5.3.2.2.2.2, the following two indirect supervision methods are also allowed
1193 only if the fuel cell power system starts up at least once per day:

1194 c) indirect supervision (e.g. fan speed supervision) when there is an air proving device which proves
1195 the supply of combustion air at least once at each start up;

1196 d) supervision of the minimum and maximum air or combustion products rates with two rate
1197 supervision devices. (Monitoring of the full range of flows is not required)

1198 **5.2.7.1.10 Separate combustion products evacuation duct**

1199 **5.2.7.1.10.1 Stability under mechanical loading**

1200 The duct shall be capable of withstanding horizontal and vertical loads. The following aspects shall be
1201 considered:

- 1202 • compressive strength;
- 1203 • tensile strength;
- 1204 • Resistance to wind pressure, see additional requirement in B.5.2.7.1.10.1 for Europe.

1205 **5.2.7.1.10.2 Stability under exposure to heat**

1206 The stability of the walls of the duct shall be ensured during and after exposure to heat occurring
1207 under all operating conditions of the small fuel cell CHP appliance.

1208 **5.2.7.1.10.3 Corrosion resistance**

1209 The duct shall keep its essential characteristics in the presence of the corrosion load corresponding to
1210 all operating conditions of the small fuel cell CHP appliance.

1211 **5.2.7.1.10.4 Resistance to condensate and moisture under normal operating 1212 conditions**

1213 The duct shall keep its essential characteristics in the presence of condensate and moisture under all
1214 operating conditions.

1215 **5.2.7.1.11 Common flue evacuation duct**

1216 In the event of common flue ducts, backflow shall be prevented by the use of a backflow valve or other
1217 means.

1218 **5.2.7.1.12 Removal of condensate**

1219 The manufacturer shall take measures to avoid condensate accumulation that results in an unsafe
1220 situation.

1221 The manufacturer shall take measures to ensure that vent gas does not escape through condensate
1222 drain lines or escape into the room where the small fuel cell CHP appliance is installed.

1223 Condensate produced during operation of the small fuel cell CHP appliance, including the condensate
1224 formed in the flue and its connecting pipes, shall be removed by means of a discharge pipe (or pipes)
1225 or other constructions resulting in safe removal of condensate.

1226 A fuel cell power system having a condensate disposal system(s) shall, under conditions of a blocked
1227 condensate drain line(s), continue to operate satisfactorily or shall shut down safely without unsafe
1228 emissions.

1229 Means shall be provided to ensure that combustion products or other hazardous materials are not
1230 passed through the condensate removal line by use of a water trap or other means. Such means shall
1231 be sufficient to limit passage of combustion products or other hazardous materials at the maximum
1232 pressure in the combustion chamber including when the flue gas discharge is partly blocked in steps
1233 up to fully blocked while, repeatedly switching on and off the heat demand signal as long as the
1234 appliance is still operable under the most unfavourable conditions at the maximum flue length
1235 specified by the manufacturer.

1236 If the small fuel cell CHP appliance incorporates some form of pump assisted condensate disposal the
1237 size of the discharge from the small fuel cell CHP appliance and connection to any point of gravity
1238 discharge shall be specified by the small fuel cell CHP appliance manufacturer.

1239 The disposal system, forming part of the small fuel cell CHP appliance supplied with the small
1240 fuel cell CHP appliance, shall be such that

- 1241 • it can be easily inspected and cleaned in accordance with the manufacturer's
1242 instructions,
- 1243 • a water trap has a seal at the maximum pressure in the combustion chamber at the
1244 maximum flue gas length specified by the manufacturer.

1245 Regional specific requirements are given in B.5.2.7.1.12 for Europe.

1246 **5.2.7.2 Checking the state of operation**

1247 **5.2.7.2.1 General**

1248 Means shall be provided for the installer to determine the burner(s) operational status of the small fuel
1249 cell CHP appliance, including:

- 1250 • CHP generator state of operation: storage state, start-up, operational state, or shutdown;
- 1251 • supplementary heat generator state of operation: storage state, start-up, operational state, or
1252 shutdown;
- 1253 • lockout state

1254 Means of determining the state of operation can include both direct means and indirect means for
1255 confirming the presence of the flame.

1256 Indirect means are dependent on the specific solution of the manufacturer. If the indirect signal of
1257 flame presence is only available on a remote control, this remote control shall be supplied and tested
1258 with the small fuel cell CHP appliance.

1259 It shall be possible to check at any time (e.g. opening a door without tools) that the small fuel cell CHP
1260 appliance is operating, either by visual observation of the flame or by some indirect means.

1261 **5.2.7.2.2 State of operation of the stationary fuel cell power system used as a CHP generator**

1262 The state of operation of the CHP generator shall be shown by an indicator, e.g. by detecting the
1263 electric power output.

1264 The presence of flame shall be detected indirectly by means such as flame sensor or thermocouples.

1265 **5.2.7.2.3 State of operation of the supplementary heat generator**

1266 Means of determining the state of operation can include indicating lights, visual verification of the
1267 flame using a sightglass, or other suitable means.

1268 If used, mirrors, sight glasses, etc., shall continue to retain their optical properties for the intended
1269 lifetime of the supplementary heat generator.

1270 **5.2.7.3 Requirements for adjusting, control and safety devices (if applicable)**

1271 **5.2.7.3.1 General**

1272 The small fuel cell CHP appliance shall be equipped with control and safety devices for start,
1273 operation and control of the gas supply.

1274 These devices shall ensure the automatic start and the automatic monitoring device for the operating
1275 functions of the small fuel cell CHP appliance as well as the gas supply.

1276 In case of failure of the normal operating functions (malfunctions), the gas supply shall be cut off, if
1277 need be, with lock-out in accordance with the operating programme.

1278 The manufacturer shall be obliged to define the minimum mandatory requirements for control and
1279 supervision as well as for the automatic restart.

1280 The operation of safety devices shall not be overruled by adjusting and control devices.

1281 The design of the control and safety system shall be such that it is not possible to perform two or more
1282 actions which are unacceptable in combination. The order of the actions shall be fixed in such a
1283 manner that it is not possible to change it.

1284 All the following devices in 5.2.7.3 or the multifunctional control in which they might be fitted shall be
1285 removable or exchangeable if this is necessary for cleaning or replacement of the device. Controls
1286 (e.g. adjusters) shall not be interchangeable if this can result in confusion.

1287 When there are several control knobs (taps, thermostats, etc.), they shall not be interchangeable if this
1288 could lead to confusion and their function shall be clearly indicated.

1289 Elastomers used in adjusting, supervision, control and safety devices shall be suitable for the usage
1290 considering the material, the temperature, the pressure and the lifetime, and shall prevent leakage.
1291 Regional specific requirements are given in B.5.2.7.3.1 for Europe.

1292 Adjusting, supervision, control and safety devices shall comply with the relevant requirements of
1293 relevant international Standards, as appropriate.

1294 NOTE 1 ISO 23551-1, ISO 23551-2, ISO 23551-3, ISO 23552-1 and IEC 60730-2-5 are presumed to comply with the relevant
1295 requirements of this international Standard, as appropriate.

1296 At least the following functions not covered in the above mentioned product standards shall be
1297 classified as class A, B or C according to IEC 60730-1 and meet the applicable requirements
1298 according to 5.1 based on a risk analysis of

1299

- reaction monitoring,

1300 NOTE 2 Depending on the type of small fuel cell CHP appliance, this may be air-gas ratio control / fuel processing
1301 system / stack).

1302

- heating water circuit supervision,

1303

- internal cooling circuit supervision,

1304

- safeguard of the gas purge circuit,

1305

- avoidance of reverse power operation,

1306

- avoidance of hydrogen explosion

1307 Requirements specific for Japan are given in C.5.2.7.3.1.

1308 5.2.7.3.2 Adjusters

1309 Any parts of a small fuel cell CHP appliance which are not intended to be altered by the user or the
1310 installer shall be protected in an appropriate manner. Suitable locking varnish may be used for this
1311 purpose provided that it withstands the temperature to which it is subjected during normal operation of
1312 the small fuel cell CHP appliance.

1313 The adjusting screws shall be arranged in such a way that they cannot fall into the gas ways.

1314 The soundness of the gas circuit shall not be put at risk by the presence of adjusters and range-rating
1315 devices.

1316 Adjustment of the adjuster and/or of the range-rating device may be continuous (e.g. use of an
1317 adjusting screw) or discrete (e.g. change of restrictors).

1318 5.2.7.3.3 Thermostats and water temperature limiting devices

1319 5.2.7.3.3.1 General

1320 Small fuel cell CHP appliance shall be fitted with a fixed setting or user adjustable control thermostat
1321 complying with IEC 60730-2-9 type 1 and a temperature limiting device as specified below

1322 Alternatively an electronic temperature control system comprising the thermostat and limiter control
1323 function can be used. Such a system shall comply with requirements for a class B device according
1324 IEC 60730-2-9.

1325 Requirements specific for Japan are given in C.5.2.7.3.3.1.

1326 **5.2.7.3.3.2 Small fuel cell CHP appliance intended exclusively for central heating**
1327 **systems with an open expansion vessel**

1328 Temperature limiting devices are not required when the small fuel cell CHP appliance is designed to
1329 be installed exclusively with an open expansion vessel and when a failure of the control thermostat
1330 does not cause a dangerous situation for the user or damage to the small fuel cell CHP appliance.
1331 Appropriate information shall be given in the technical instructions.

1332 Requirements specific for Japan are given in C.5.2.7.3.3.2.

1333 **5.2.7.3.4 Small fuel cell CHP appliance intended for central heating systems with open**
1334 **or sealed expansion vessels**

1335 Requirements specific for Japan are given in C.5.2.7.3.4.

1336 **5.2.7.3.4.1 Small fuel cell CHP appliance with electromechanical controls**

1337 Small fuel cell CHP appliance shall be fitted with one of the following:

1338 a) A set of

1339 • a temperature limiter complying with IEC 60730-2-9 type 1, having a preset limit of
1340 maximum 100 °C. Instead of a temperature limiter, another device (e.g. water rate
1341 monitoring device, low water detector safety device) is permitted if all the
1342 requirements of 5.3.3.2 and 5.2.7.3 are met, and,

1343 • an overheat cutout device complying with IEC 60730-2-9 type 2, having a preset limit
1344 that causes non-volatile lockout before the small fuel cell CHP appliance is damaged
1345 and/or before a dangerous situation occurs.

1346 or

1347 b) an overheat cut-out complying with IEC 60730-2-9 type 2, having a preset limit of maximum
1348 100 °C causing non-volatile lockout before the small fuel cell CHP appliance is damaged
1349 and/or before a dangerous situation occurs.

1350 The temperature limiter shall cause at least safety shut-down before the water flow temperature
1351 exceeds the preset value. When the water temperature falls below the preset value, the gas supply to
1352 the burner may be restored automatically. The overheat cut-out device shall cause non-volatile lockout
1353 before the small fuel cell CHP appliance is damaged and/or a dangerous situation for the user
1354 occurs.

1355 Regional specific requirements are given in B.5.2.7.3.4.1 for Europe and in D.5.2.7.3.4.1 for the US.

1356 **5.2.7.3.4.2 Small fuel cell CHP appliance with electronic controls**

1357 Small fuel cell CHP appliance shall be fitted with systems either a) or b) , considering regional specific
1358 requirements as given in B.5.2.7.3.4.2 for Europe:

1359 a) An electronic temperature control system can be used to control and limit the temperature in
1360 combination with an electromechanical overheat cut-out according the requirements from this
1361 standard. This electronic temperature control system shall have two different settings, being:
1362 control temperature and limiting temperature, and should meet the requirements for a class A
1363 device according IEC 60730-2-9. At a limit temperature set point of maximum 100°C the
1364 system shall shut down, restoring normal operation when the temperature drops below the
1365 limit value.

1366 b) An electronic temperature control system can be used to control and limit the temperature and
1367 provide the overheat cut-out function. Such a control system shall meet the requirements of
1368 the class C Temperature Control Function as specified in IEC 60730-2-9. The system shall

1369 have at least three levels of temperature setting, being: control temperature, limit temperature
1370 and overheat cut-out temperature. At limit temperature set point of maximum 100 °C the
1371 system shall shut down, restoring normal operation when the temperature drops below the
1372 limit value. The system shall go in non-volatile lockout at overheat cut-out temperature set
1373 point, being the set point before the small fuel cell CHP appliance is damaged and/or before a
1374 dangerous situation for the user occurs.

1375 **5.2.7.3.5 Protection against over-pressure**

1376 Small fuel cell CHP appliance intended for central heating systems with a sealed expansion vessel
1377 shall be fitted with a relief valve to avoid exceeding maximum operating pressure.

1378 The relief valve shall comply with ISO 4126-1

1379 Regional specific requirements are given in C.5.2.7.3.5 for Japan and in D.5.2.7.3.5 for the US.

1380 **5.2.7.3.6 Remote control functions**

1381 Remote control functions shall comply with IEC 60730-1.

1382 Requirements specific for Japan are given in C.5.2.7.3.6.

1383 **5.3 Operational requirements for safety**

1384 **5.3.1 General requirements**

1385 Except where otherwise stated, the operational requirements are verified by test of the small fuel cell
1386 CHP appliance as defined in Clause 5.4.

1387 Possible operational states of individual components have to be safe. Failures of individual
1388 components, the possibility of an uncontrolled formation of flammable mixtures, the uncontrolled
1389 ignition of inflammable mixtures as well as the uncontrolled leakage of flammable mixtures or process
1390 gases have to be avoided by using sufficient measures.

1391 The odorant (e.g. sulphur compounds, mercaptans, thiophenes) in the fuel gas shall not cause any
1392 safety concerns.

1393 Requirements specific for Japan are given in C.5.3.1.

1394 **5.3.2 Soundness**

1395 **5.3.2.1 Soundness of the gas circuits**

1396 **5.3.2.1.1 General**

1397 Soundness is verified before and after all the tests of this International Standard.

1398 The gas carrying circuits shall be sound in operation and in stand-by.

1399 The method of verifying the soundness of the supply gas system and the process gas system are
1400 given in the following clauses.

1401 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
1402 carrying circuit complies with 5.3.2.1.3.2, it is not necessary to comply with 5.3.2.1.3.1.

1403 **5.3.2.1.2 Prevention against fire and explosion hazards arising from the supply gas** 1404 **circuit**

1405 Soundness of the supply gas circuit is assured when, tested under the conditions of 5.4.2.1.1, the leak
1406 rate of air does not exceed 3,5 times the maximum leakage rates for external tightness as given in
1407 ISO 23550.

5.3.2.1.3 Prevention against fire and explosion hazards in fuel cell power systems provided with cabinets

5.3.2.1.3.1 General

For parts of the gas carrying circuit where the internal gas pressure is above the ambient air pressure the following applies:

a) The integrated systems of the fuel cell power system 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 % (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

1) Controlled oxidation of normal internal releases

This may be accomplished by the provision of a continuous and reliable ignition and oxidant sources 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

- 1462 Detection of gas leakage by means of a class C control function according IEC 60730-
1463 1. If the leakage limit, which ensures not exceeding 25 % LFL, is reached the safety
1464 shut-off valves shall be de-energized.
- 1465 e) Within areas classified as hazardous in 5.3.2.1.3.1 b), except for units that use the
1466 protection method described in 5.3.2.1.3.1 d)1) or d)3), the manufacturer shall eliminate
1467 ignition sources by ensuring that the
- 1468 – installed electrical equipment is suitable for the area classification according to
1469 IEC 60079-0 and other applicable parts of the IEC 60079 series;
 - 1470 – installed electrical resistance trace heating, if available, complies with IEC 60079-30-1;
 - 1471 – surface temperatures do not exceed 80 % of the auto-ignition temperature, expressed
1472 in degrees Celsius, of the flammable gas or vapour. See IEC 60079-20-1 for guidance
1473 regarding auto-ignition temperatures of various flammable fluids;
 - 1474 – equipment containing materials capable of catalysing the reaction of flammable fluids
1475 with air shall be capable of suppressing the propagation of the reaction from the
1476 equipment to the surrounding flammable atmosphere.
 - 1477 – Potential for static discharge has been eliminated by proper bonding and grounding,
1478 and by proper material selection.
- 1479 f) Compartments that contain electrical or mechanical equipment shall be maintained at
1480 positive pressure relative to adjacent compartments with sources of flammable gas or
1481 vapour according to IEC 60079-2, unless the equipment meets the requirements specified
1482 in 5.3.2.1.3.1 e).
- 1483 g) The fuel cell power system shall be provided with passive and active means, or a
1484 combination thereof, to maintain abnormal internal releases below 25 % (LFL), except in
1485 dilution boundaries.
- 1486 Sudden and catastrophic failures are not necessary to be considered as a release
1487 scenario in this analysis when protection against such failures has already been
1488 contemplated in the pressure equipment and piping design (see also 5.2.4.2).
- 1489 “Passive” means include, but are not limited to, the mechanical limitation of releases of
1490 flammable gases or vapours to a maximum value by using pipe orifices and similar
1491 methods of flow restriction or joints permanently secured and so constructed that they
1492 limit the release rate to a predictable maximum value.
- 1493 “Active” means may include flow measurements and controls or the provision of safety
1494 devices such as combustible gas sensors. These means shall meet the requirements
1495 specified in 5.1, and shall cause a fuel cell power system shutdown upon occurrence of
1496 conditions under which the concentration of any flammable gas in the ventilation exhaust
1497 exceeds 25 % of the LFL of that gas.
- 1498 h) The fuel cell power system shall be designed for the safe dispersal of the ventilation and
1499 process exhaust streams. In particular, for indoor installations the ventilation and process
1500 exhaust shall be designed for connection to a flue or venting system.
- 1501 i) Potential for static discharge has been eliminated by proper bonding and grounding of
1502 metallic parts by selecting appropriate materials that do not generate charges which
1503 could result in a spark capable to ignite an ignitable gas/air mixture. The effect of flow
1504 rates within pipes generating possible charges shall also be considered.
- 1505 j) A control function whose purpose is to avoid exceeding 25 % LFL by e.g. dilution with air
1506 and/or measuring the concentration and shut-off if exceeding the limit, shall be designed
1507 according to the requirements specified in 5.1.

1508 NOTE 2 Non-metallic tubing carrying hydrogen gas may accumulate electrostatic charge along its surface.
1509 Discharges from the surface of this tube may be sufficient to ignite a flammable mixture of gas or vapour in the
1510 surrounding environment. When used in Zone 1 or Zone 2 (according to IEC 60079-10-1) locations, measures to
1511 eliminate electrostatic discharges shall be taken. This may be achieved by specifying a tube material with sufficient
1512 conductivity, or by limiting gas flow velocity to values below which electrostatic charge does not accumulate.
1513 Tubing that relies on a protective system to eliminate electrostatic discharge (i.e., a grounding wire or braid) shall
1514 not be used in a Zone 0 location.

1515 NOTE 3 Metal braid coverings, or conductive wires within the non-metallic tubing wall may increase the chance of
1516 electrostatic discharge if those conductors become disconnected from their bonding conductor. In Zone 1 and 2
1517 areas, such conductors should be mechanically secured with positive means.
1518

5.3.2.1.3.2 Soundness of parts according ISO 23550 and the like

If parts of the gas carrying circuit are complying with the following then the requirements of this sub-clause are an alternative to 5.3.2.1.3.1:

- a) according ISO 23550, or
- b) which are designed according to the design rules for pressure equipment, or
- c) according ISO 23550 with other material as 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 the incoming air used for the combustion and the electrochemical conversion then the soundness of this part of the circuit which carries process gas 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. Clauses 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 respectively, those given in D.5.3.2.2.2.1 for the US.

Table 3 – Maximum admissible leakage rates

Test No.	Test object	Surrounding of the combustion products circuit by the combustion air circuit	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	completely not completely	$5 (u)$ $1 (v)$	$5 \cdot P_{\text{inf,nom}}/40$ $1 \cdot P_{\text{inf,nom}}/40$
2	small fuel cell CHP appliance and the joint to the air supply and combustion products evacuation duct	completely not completely	$3 (w)$ $0,6 (x)$	$3 \cdot P_{\text{inf,nom}}/40$ $0,6 \cdot P_{\text{inf,nom}}/40$
3	Combustion products evacuation ducts with all its joints excluding the joint tested above	not completely	$0,4 (y)$	$0,4 \cdot P_{\text{inf,nom}}/40$
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 $v=x+y$				

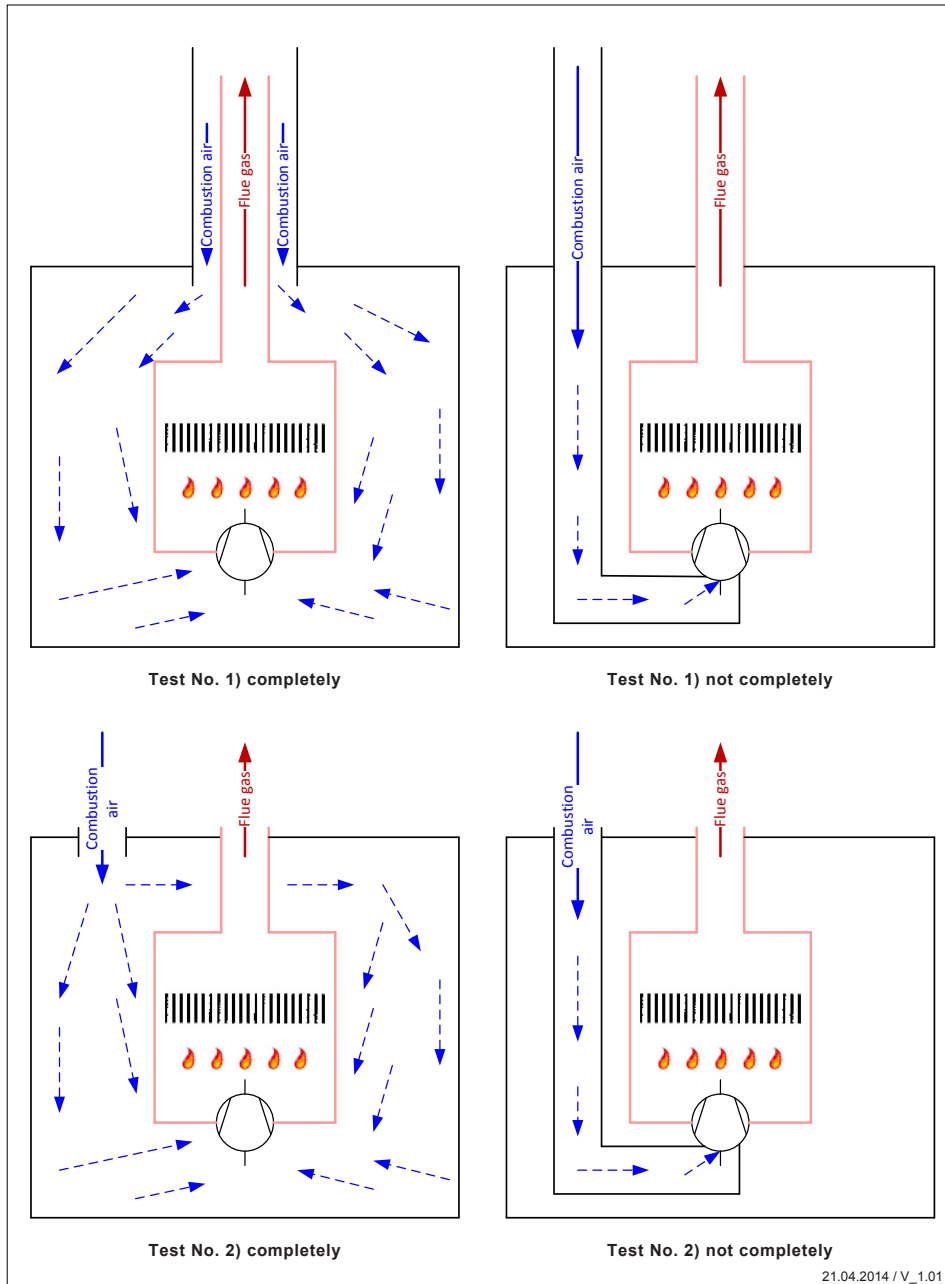


Figure 2: for illustrating Table 3: Surrounding of the combustion products circuit by the combustion air circuit

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 $0,006 \text{ l}/(\text{s}\cdot\text{m}^2)$, respectively the values given in the regional Annex.

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 5.4.2.2.2.3, the leak rate (l/s) per surface area (m^2) of the duct does not exceed $0,006 \text{ l}/(\text{s}\cdot\text{m}^2)$ respectively the values given in the regional Annex.

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 5.4.2.2.2.4 the leak rate per surface area of the duct does not exceed $0,5 \text{ l/(s}\cdot\text{m}^2)$ respectively the values given in the regional Annex.

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 appliance 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 appliances incorporating a fan shall be sound with respect to the room where the small fuel cell CHP appliances 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 appliance

Soundness of type B₃ small fuel cell CHP appliance 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 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

$3 \cdot P_{\text{inf,nom}}/40 \text{ (m}^3\text{/h)}$ for small fuel cell CHP appliances of nominal heat input $> 40 \text{ kW}$ respectively the values given in the regional Annex;

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 $\leq 40 \text{ kW}$ respectively the values given in the regional Annex or

$5 \cdot P_{\text{inf,nom}}/40 \text{ (m}^3\text{/h)}$ for small fuel cell CHP appliances of nominal heat input $> 40 \text{ kW}$ respectively the values given in the regional Annex.

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 $0,006 \text{ l/(s}\cdot\text{m}^2)$ respectively the values given in the regional Annex.

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 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 have 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 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 °C
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	35
- of metal	
- of porcelain	
- of moulded material (plastic), rubber or wood	60
NOTE 1 Maximum surface temperature rises above ambient of external surfaces that may be contacted during operation by people without personal protective equipment. The above values are referenced in IEC 60335-1:2010.	
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

1643 appliance shall not, at any point, exceed the ambient temperature by more than 80 K
1644 respectively the values given in the regional annexes under the test conditions of 5.4.3.1.4.

1645 When this temperature rise is between 50 K and 80 K, respectively the values given in
1646 B.5.3.3.1.4 for Europe the manufacturer shall state in the technical instructions for the
1647 installer the nature of the protection which has to be applied between the small fuel cell CHP
1648 appliance and the floor or walls when these latter are made of inflammable materials.

1649 This protection shall be supplied to the test laboratory which shall check that, with the small
1650 fuel cell CHP appliance fitted with it, the floor and panel temperatures measured under the
1651 test conditions of 5.4.3.1.4 do not exceed the ambient temperature by more than 50 K
1652 respectively the values given in B.5.3.3.1.4 for Europe.

1653 **5.3.3.1.5 External temperature of the ducts**

1654 The temperature of the ducts in contact with or passing through the walls of the dwelling shall
1655 not exceed the ambient temperature by more than 50 K respectively the values given in
1656 B.5.3.3.1.5 for Europe under the test conditions of 5.4.3.1.5.

1657 If this temperature rise exceeds 50 K respectively the values given in B.5.3.3.1.5 for Europe,
1658 the manufacturer shall state in the technical instructions for the installer the nature of the
1659 protection which has to be applied between the ducts and the walls when they are constructed
1660 from inflammable materials.

1661 This protection shall be supplied to the test laboratory which shall check that, with the
1662 protection fitted, the external surface temperature in contact with the wall measured under the
1663 test conditions of 5.4.3.1.5 does not exceed the ambient temperature by more than 50 K
1664 respectively the values given in B.5.3.3.1.5 for Europe.

1665 **5.3.3.2 Thermostats and temperature limiting devices**

1666 Requirements specific for Japan are given in C.5.3.3.2

1667 **5.3.3.2.1 General**

1668 To protect a small fuel cell CHP appliance against the basic risks of fire and explosion as a
1669 result of overheating, a Temperature Control Function is required.

1670 Scope of the Temperature Control Function is to control the temperature (control thermostat
1671 and temperature limiter) and to prevent the risk of excessive temperature (overheat cut-out)
1672 which could lead to the hazard of overheating for a small fuel cell CHP appliances. The
1673 Temperature Control Function is a system which consists of temperature sensing, signal
1674 processing, switching actions (on/off or protective action) and reset.

1675 Practical realization of the temperature control function can be done with one control
1676 (electronic systems) or more controls, specifying control thermostats, temperature limiters and,
1677 overheat cut-outs. Also constructional measures, like an open expansion vessel system, can
1678 cover part of the risk

1679 Thermostats, temperature limiters and overheat cut-out devices shall have independent
1680 temperature sensing elements.

1681 With an electronic system, thermostats and temperature limiters may have the same
1682 temperature sensing element provided that its failure cannot give rise to a dangerous situation
1683 for the user or damage to the small fuel cell CHP appliance.

1684 For electronic temperature control systems, the terms:

- 1685 a) control thermostat should be read as control temperature set point;
- 1686 b) temperature limiter should be read as temperature limit set point;
- 1687 c) overheat cut-out device should be read as overheat cut-out set point.

1688 The temperature sensing elements shall withstand the thermal overload resulting from an
1689 overheat condition specified in this standard without the predetermined set point being
1690 affected.

1691 Under the test conditions of 5.4.3.2.1 the opening and closing temperatures of the
1692 thermostats shall not differ from those stated by the manufacturer by more than the tolerance
1693 given in the regional Annex. For adjustable thermostats, this requirement is checked at the
1694 minimum and maximum temperatures of the control range.

1695 Regional specific requirements are given in B.5.3.3.2.1 for Europe.

1696 **5.3.3.2.2 Water control thermostats**

1697 The control thermostat shall comply with the requirements of IEC 60730-2-9 for type 1 devices.

1698 If the control thermostat is adjustable, the manufacturer shall at least state the maximum
1699 temperature in the instructions. The positions of the temperature selector shall be easy to
1700 establish and it shall be possible to ascertain in which direction the water temperature rises or
1701 falls. If numbers are used for this purpose, the highest number shall correspond to the highest
1702 temperature.

1703 At its maximum setting, it shall cause at least controlled shut-down.

1704 **5.3.3.2.2.1 Accuracy of adjustment**

1705 For electronic temperature control systems, the terms:

- 1706 a) fixed setting thermostat should be read as fixed control temperature setpoint;
- 1707 b) adjustable thermostat should be read as user adjustable control temperature setpoint.

1708 Under the test conditions of 5.4.3.2.2.1,

- 1709 • the maximum water temperature of small fuel cell CHP appliance fitted with a fixed
1710 setting thermostat shall be within ± 10 K of the temperature stated by the
1711 manufacturer,
- 1712 • for small fuel cell CHP appliances fitted with an adjustable thermostat, it shall be
1713 possible to select, within ± 10 K, respectively the values given in the regional annexes
1714 the water flow temperatures stated by the manufacturer,
- 1715 • the flow temperature shall not exceed the maximum temperature declared by the
1716 manufacturer; however, when the control thermostat is located on the return, this
1717 requirement may be satisfied by action of the limit thermostat located on the water
1718 flow,
- 1719 • the limit thermostat (unless the control thermostat is on the return), overheat cut-off
1720 device and safety temperature limiter shall not operate.

1721 **5.3.3.2.2.2 Endurance**

1722 Thermostats shall withstand the endurance requirements given in the regional annex under
1723 the test conditions of 5.4.3.2.2.2. At the end of the tests, their operation shall comply with the
1724 requirements of 5.3.3.2.2.1.

1725 Regional specific requirements are given in B.5.3.3.2.2.2 for Europe.

1726 **5.3.3.2.3 Water temperature limiting devices**

1727 The temperature limiter shall comply with the requirements of IEC 60730-2-9 for type 1
1728 devices.

1729 The maximum set point temperature of this device shall not be able to be adjusted.

1730 The temperature limiter contacts shall open before the temperature exceeds a pre-set limit
1731 and close again when the temperature falls below that pre-set limit.