

PAS 67:2013

Incorporating corrigendum No. 1



BSI Standards Publication

Laboratory tests to determine the heating and electrical performance of heat-led micro-cogeneration packages primarily intended for heating dwellings

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Foreword

Publishing information

This PAS was sponsored by the Energy Saving Trust (EST). Its development was facilitated by BSI Standards Limited and it was published under licence from The British Standards Institution. It came into effect on 28 June 2013.

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The PAS process enables a specification to be rapidly developed in order to fulfil an immediate need in industry. A PAS may be considered for further development as a British Standard, or constitute part of the UK input into the development of a European or International Standard.

Supersession

This PAS supersedes PAS 67:2008, which is withdrawn.

Use of this document

It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its requirements are expressed in sentences in which the principal auxiliary verb is "shall".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the provisions that may be needed to form the basis of a contract. Users are responsible for its correct application.

Compliance with this PAS does not itself confer immunity from legal obligations.

Introduction

The purpose of PAS 67 is to determine, by measurement, under a variety of load conditions, the data needed to calculate the energy performance of a micro-cogeneration package. It is restricted to packages whose function is the production of heat and electricity and in which all heat is usefully employed. The tests are designed to be reproducible.

Micro-cogeneration unit (MCG) (also known as micro-combined heat and power units) require a substantially different test procedure from that for boilers, and the laboratory tests specified in PAS 67 have been designed to take account of these differences.

The results obtained from testing to the requirements of PAS 67 are not intended for use as a direct comparative assessment of micro-cogeneration packages. However, the results obtained from testing to the requirements of PAS 67 can be used for calculating one or more indices of performance, such as estimating annual system energy requirements and system efficiencies. This could be utilized as part of a heating system design and also for comparative assessments.

PAS 67 contains a number of test modes and test regimes (see Table 2) and manufacturers are cautioned to consider carefully how their packages are to be used when choosing the modes and test regimes under which they wish their product to be tested.

NOTE 1 Attention is drawn to Directive 2004/8/EC [2] on the promotion of cogeneration, which excludes MCGs from the need to meet the minimum thermal efficiency requirements that are specified in the hot-water boiler Directive, 92/42/EEC [3], commonly referred to as the Boiler Efficiency Directive (BED).

NOTE 2 This PAS has been and will be affected by particular editions and revisions of the UK Building Standard Assessment Procedure (SAP) which is being reviewed by the government with increasing frequency and with respect to the corresponding Annual Performance Method. This does not affect the validity of the tests contained within this PAS but users and potential users might wish to understand the latest regulatory procedure before embarking upon large test programmes.

1 Scope

This PAS specifies a set of test conditions for determining the heating and electrical performance of heat-led micro-cogeneration packages that are primarily intended for use in dwellings. The PAS is applicable for:

- testing micro-cogeneration packages that provide space and water heating with a thermal output up to 70 kW (252 MJ/h); or
- testing micro-cogeneration units (MCGs) designed to produce electricity and simultaneously heat a domestic hot water storage tank (DHWPK).

The full output test might also be suitable for packages up to 400 kW (1 440 MJ/h).

This PAS also specifies a reporting format (Results Tables) for the test results.

This PAS does not cover how to evaluate the annual energy performance of a MCG, but it is intended that the data obtained through testing to PAS 67 can be used for these purposes.

NOTE 1 A suitable method that can be used to evaluate the annual energy performance of a MCG is given in Method to evaluate the annual energy performance of micro-cogeneration heating systems in dwellings [1]. This method treats the DHW load as additional space heating load. This enables the estimation of the annual energy performance and derivation of the single index of performance for product comparison.

NOTE 2 An estimate of annual energy performance is necessary for the SAP (The UK Government's Standard Assessment Procedure for Energy Rating of Dwellings) [4] and

other energy rating schemes. The document Method to evaluate the annual energy performance of micro-cogeneration heating systems in dwellings [1] specifies such a method. An extension of the annual energy performance method is used to derive a single index of performance for product comparison, similar in principle to Seasonal Efficiency of Domestic Boilers in the UK (SEDBUK) [5] already used for boilers.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Standard references

BS 845-1:1987, *Methods for assessing thermal performance of boilers for steam, hot water and high temperature heat transfer fluids – Part 1: Concise procedure*

BS 1566-1:2002+A1:2011, *Copper indirect cylinders for domestic purposes – Part 1: Open vented copper cylinders – Requirements and test methods*

BS EN 304:1992+A2:2003, *Heating boilers – Test code for heating boilers for atomizing oil burners*

BS EN 437:2003+A1:2009, *Test gases – Test pressures – Appliance categories*

BS EN 483:1999+A4:2007, *Gas-fired central heating boilers – Type C boilers of nominal heat input not exceeding 70kW*

BS EN 13203-2:2006, *Gas-fired domestic appliances producing hot water – Appliances not exceeding 70 kW heat input and 300 L water storage capacity – Part 2: Assessment of energy consumption*

BS EN 60751:2008, *Industrial platinum resistance thermometers and platinum temperature sensors*

Other references

[N1] UKAS M3003, Edition 2, 2007. *The Expression of Uncertainty and Confidence in Measurement.*

[N2] Engineering Recommendation G83-1, *Recommendations for the connection of small scale embedded generators (up to 16A per phase) in parallel with Public Low-Voltage Distribution Networks.* (see Energy Networks Association).

[N3] Engineering Recommendation G59/2, *Recommendations for the connection of generating plant to the distribution systems of licensed distribution network operators* (see Energy Networks Association).

3 Terms and definitions

For the purposes of this PAS the following terms and definitions apply.

3.1 case loss

heat lost from all surfaces (whether by radiation, natural or forced ventilation) of the micro-cogeneration package to the surroundings, including that from the flue pipe

3.2 cogeneration

simultaneous generation in one process of thermal energy and electrical and/or mechanical energy

- 3.3 cogeneration unit**
unit that is capable of cogeneration
- 3.4 CombiPK**
category of micro-cogeneration package for providing space and water heating in which domestic hot water (DHW) service is provided wholly from within the package
- 3.5 condensing micro-cogeneration unit (MCG)**
MCG designed to make use of the latent heat released by the condensation of water vapour in the products of combustion and to allow the condensate to leave the package in liquid phase
NOTE Units not so designed, or without the means to remove the condensate in liquid phase, are "non-condensing MCGs".
- 3.6 domestic hot water (DHW) storage tank**
tank used for the storage of domestic (sanitary) hot water
- 3.7 domestic hot water production kit (DHWPK)**
category of micro-generation package for providing only domestic hot water (DHW) service
- 3.8 flow water temperature**
temperature of the water leaving the micro-cogeneration package and entering the test rig
- 3.9 flue loss**
sensible and latent thermal energy lost from a micro-cogeneration package via the flue pipe and the condensate drain
- 3.10 flue pipe**
conduit by which gaseous products of combustion are transported to outside the dwelling
- 3.11 full output**
heat output for space heating as determined by the full output test
- 3.12 gross calorific value (CV)**
(also known as the higher calorific value or higher heating value)
quantity of heat produced by the complete combustion of a unit of weight or volume of a fuel at a constant reference temperature and pressure, with the constituents of the fuel being taken at reference conditions and the products of combustion being brought back to the same conditions
- 3.13 heat output during the heat demand time**
output to space heating produced by the package recorded during the heat demand times
- 3.14 HeatPK**
category of micro-cogeneration package for providing space heating only (no domestic hot water service)
- 3.15 island mode**
operation of a micro-cogeneration package whilst not connected to a public electricity supply network
- 3.16 mean surface temperature**
mean temperature of the surface of the MCG at any location over a prescribed time period

3.17 micro-cogeneration unit (MCG)

(also known as micro-combined heat and power units)

condensing or non-condensing cogeneration unit as a maximum electrical output power below 50 kW_e

NOTE This definition is based on the definition given in Directive 2004/8/EC [2].

3.18 micro-cogeneration package

MCG with associated equipment, excluding any flue pipe over and above the minimum specified by the manufacturer for the safe operation of the micro-cogeneration package

NOTE 1 See 6.2 for a list of associated equipment.

NOTE 2 For the purposes of this PAS, micro-cogeneration packages are referred to as "packages"

3.19 nominal rated heat output (NHRO)

rate of heat output (expressed in kW) of the micro-cogeneration package, declared by the manufacturer that can be maintained indefinitely over successive 24 h periods

3.20 power analyser

meter capable of measuring electrical power and energy that makes true allowance for the voltage, current and power factor (phase angle) as relevant, of an alternating current (AC) or direct current (DC)

3.21 primary circuit

circuit by which hot water flows out of the micro-cogeneration package and cooled water is returned

3.22 proximate

analysis of solid fuel in terms of moisture, ash, volatile matter and (by difference) fixed carbon

3.23 RegPK

category of micro-cogeneration package for providing space and water heating, intended for connection to a separate DHW storage tank

3.24 return water temperature

temperature of the water returning to the micro-cogeneration package from the test rig

3.25 Seasonal Efficiency of Domestic Boilers in the UK (SEDBUK)

method used to determine the average annual installed efficiency of gas and oil boilers in dwellings in the UK, used both for SAP [4] and product endorsement purposes

3.26 synchronous mode

operation of a micro-cogeneration package connected to a public alternating current (AC) electricity distribution network and capable of exporting electrical power to it

3.27 system circulator

circulator of sufficient capacity to pump the central heating (CH) water around the distribution circuit of size proportional to the thermal output of the package

3.28 test laboratory

location where micro-cogeneration packages are tested

3.29 test mode

load pattern applied during test to the micro-cogeneration package

NOTE Test modes include continuous operation, uni-modal operation, bi-modal operation, standby mode and DHW only, which are defined in 6.3.

3.30 test regime

set of test modes

3.31 thermal store

any vessel used to store the heat output from the MCG and thus assist the micro-cogeneration package in serving the instantaneous heat demand of the space heating and/or DHW load

NOTE A thermal store could be a purpose designed storage vessel containing water used in the space heating system or it could be the storage vessel conventionally used for DHW, or a combination of the two.

3.32 view factor

fraction of the total energy emitted by one surface that is directly incident on another surface

4 Abbreviations

For the purposes of this PAS, the following abbreviations apply.

Abbreviation	Full term
AC	alternating current
APM	annual performance method
CH	central heating
CV	gross calorific value
DV	direct current
DHW	domestic hot water
DHWPK	domestic hot water production kit
LPG	liquefied petroleum gas
NHRO	nominal-rated heat output
SEDBUK	Seasonal Efficiency of Domestic Boilers in the UK

5 Symbols

For the purposes of this PAS the following symbols apply. All values are based upon the use of the gross calorific value (CV) of the fuel.

Symbol	Unit	Designation
r_{air}	kg/m^3	density of air through grill
Σ	$\text{Wm}^{-2}\text{K}^{-4}$	Stefan-Boltzmann constant (equal to $5.67 \times 10^{-8} \text{Wm}^{-2}\text{K}^{-4}$)
A	m^2	total surface area of the component
C	–	constant for convection
d_i	L/min	flow rate for individual draw-off (tapping)
D	L/min	single specific rate of hot water draw-off (tapping), as specified by the manufacturer

Symbol	Unit	Designation
E_{in}	MJ	total electrical energy input to the package over the 24 h test period, as recorded on the import register of the power analyser
E_{inact}	MJ	actual total electrical energy input to the package during the standby loss test as recorded on the import register of the power analyser <i>NOTE 1 This is likely to be over a period of more than 24 h.</i>
E_{out}	MJ	total electrical energy output from the package over the 24 h test period as recorded on the export register of the power analyser
E_{outact}	MJ	actual total electrical output from the package during the standby loss test period as recorded on the export register of the power analyser <i>NOTE 2 This is likely to be over a period of more than 24 h.</i>
F	–	view factor (see 3.31)
F_{23}	kW	loss due to sensible heat in the dry flue gases (as defined in BS 845-2:1987, 8.2.22)
F_{24}	kW	energy flow rate in flue gas from sensible and latent heat in moisture in fuel (as defined in BS 845-2:1987, 8.2.23)
F_{28}	kW	energy flow rate within any condensate collected from the flue or micro-cogeneration package drain (as defined in BS 845-2:1987, 8.2.27)
F_{53}, F_{54}	kW	energy flow rates within unburnt flue gases (as defined in BS 845-2:1987, 8.2.21)
$J(T)$	kJ/kg	specific enthalpy of water at T °C in the range 10 °C to 240 °C <i>NOTE 3 This is evaluated from: (T) = A + BT + CT² + DT³ + ET⁴ where the following numerical values apply: A = 0.167853; B = 4.18587; C = -1.46789 × 10⁻⁴; D = 9.38153 × 10⁻⁷; E = 8.36764 × 10⁻⁹</i>
$J(T_{spaceflow})$	kJ/kg	specific enthalpy of the central heating water sent out to the system
$J(T_{spacereturn})$	kJ/kg	specific enthalpy of the returning central heating water
$J(T_{thermalstore})$	kJ/kg	specific enthalpy at mean temperature from measurements taken at different locations of a thermal store at a particular time, t
$H_{\mu chp}$	MJ	energy content of the micro-cogeneration package
$H_{thermalstore}$	MJ	energy content of the thermal store
H_s	kJ/m ³	gross (higher) calorific value of the dry test gas at 15 °C, 1013.25 mbar
H_{soil}	kJ/kg	gross (higher) calorific value of the test oil or other liquid fuel
H_{ssolid}	kJ/kg	gross (higher) calorific value of the test solid fuel

Symbol	Unit	Designation
L_{1gr}	%	loss due to sensible heat in the dry flue gases (as defined in BS 845-1:1987, 6.3.1)
L_{2gr}	%	loss due to enthalpy in the water vapour in the flue gases (as defined in BS 845-1:1987, 6.3.2)
L_{3gr}	%	loss due to unburnt flue gases (as defined in BS 845-1:1987, 6.3.3)
M_{oil}	Kg	measured mass of oil or other liquid fuel over the 24 h test period
M_{solid}	Kg	measured mass of solid fuel over the 24 h test period
$M_{thermalstore}$	Kg	mass of water contained within thermal store
$m_{spacewater}$	kg/sec	flow rate of central heating water through the micro-cogeneration package
N	–	constant for convection
N	–	number of tapings
p_a	mbar	atmospheric pressure at time of test
p_g	mbar	gas pressure at the meter
p_s	mbar	saturated vapour pressure of water
$Q_{balance}$	MJ	total measured energy input minus total measured energy output of micro-cogeneration package
Q_{case}	MJ	total energy loss from the case (estimated)
q_{com}	W	rate of energy released at time, t , from the component
Q_{DHW}	MJ	total energy to DHW
$Q_{DHWpump}$	kJ	total power demand as indicated by the pump power meter over 1 h
$Q_{DHWrigloss}$	kJ	total energy supplied to/lost from RegPK DHW test circuit over 1 h during assessment of standing loss
$Q_{DHWtankloss}$	kJ	total power demand as indicated by the heater power meter over 1 h
$q_{DHWpipelossinst}$	W	average instantaneous rate of energy “supplied to/lost from” RegPK DHW pipework test circuit during assessment of standing loss
$q_{DHWriglossinst}$	W	average instantaneous rate of energy “supplied to/lost from” RegPK DHW storage tank and pipework test circuit during assessment of standing loss
q_{fan}	kW	rate of energy loss from the case by forced convection (usually a fan)
Q_{fuel}	MJ	total energy of fuel consumed
$Q_{fuelact}$	MJ	actual total energy of fuel consumed during the standby mode test
		<i>NOTE 4 This is likely to be over a period of more than 24 h.</i>
Q_{flue}	MJ	total energy loss from flue (estimated)

Symbol	Unit	Designation
Q_{flueuf}	MJ	energy loss from flue under fire
$q_{\text{flueppsingle}}$	MJ	energy loss associated with single pre-purge or post-purge from flue
$Q_{\text{fluepptotal}}$	MJ	total energy loss associated with pre-purge and post-purge from flue equals $\sum_0^{24} q_{\text{flueppsingle}}$
Q_{fuelfull}	MJ	total energy of fuel consumed during the 24 h full output test
Q_{space}	MJ	total energy to space heating
Q_{spacedt}	MJ	energy output to space heating recorded as produced by the package during the heat demand times
$spht_{\text{air}}$	kJ/(kg×K)	mean specific heat of air through grill (default value 1.05)
$spht_{\text{water}}$	kJ/(kg ×K)	specific heat of water <i>NOTE 5 Used when evaluating the energy content of water under DHW tests (12.7). This is defined in BS EN 13203-2, 5.2.2.2 as 4.1868 kJ/(kg×K)</i>
$T_{\text{coldwater}}$	°C	temperature of the water at the inlet to DHW production
$T_{\text{ContentDHW}}$	°C	weighted mean instantaneous temperature of DHW tank
T_{DHW}	°C	instantaneous temperature of DHW
T_{g}	°C	gas temperature at the meter
t_{dur}	s	test period of the test for standby mode
t_{i}	min	tapping duration of the useful water
T_{r}	°C	ambient temperature
T_{pwater}	°C	temperature of the water returning to the pump
T_{pair}	°C	mean temperature of the air measured 35 mm above and below the pump
$T_{\text{primflowDHW}}$	°C	temperature 75 mm (±25 mm) from the point where the primary flow pipework is connected to the MCG unit
$T_{\text{primretDHW}}$	°C	temperature 75 mm (±25 mm) from the point where the primary return pipework is connected to the MCG unit
T_{xyzDHW}	°C	temperature at any point, xyz, measured during a DHW test
T_{s}	°C	mean surface temperature of any component at time, t
$T_{\text{spaceflow}}$	°C	temperature of the central heating water sent out to the system
$T_{\text{spacereturn}}$	°C	temperature of the central heating water returning from the system
$T_{\text{thermalstore(at t=0h)}}$	°C	average of the representative temperatures of defined locations of a thermal store at the beginning of the 24 h period

Symbol	Unit	Designation
$T_{\text{thermalstore(at } t=24\text{h})}$	°C	average of the representative temperatures of defined locations of a thermal store at the end of the 24 h period
T_{ventin}	°C	temperature of the ambient air into MCG case through the grill
T_{ventout}	°C	average temperature of the warmed air exiting from the discharge vents
U_{grill}	m/s	mean velocity of air through grill
V	m ³	measured volume of the test gas over the 24 h test period

6 Micro-cogeneration packages, test modes and test regimes

6.1 Category of micro-cogeneration package

For testing purposes, the manufacturer shall categorize the package as one of the following:

- HeatPK – micro-cogeneration package for the provision of space heating only, no DHW service, i.e. a system for meeting the space heating demand only;
- CombiPK – micro-cogeneration package for the provision of space and water heating, in which the DHW service is provided wholly from within the package, i.e. a system acting as an alternative for a combination boiler providing both space heating and DHW;

NOTE 1 The performance of the package in winter mode (i.e. the simultaneous provision of both central heating and DHW) may be evaluated by the separate measurement of performance in central heating mode and DHW mode followed by use of a higher level programme (for example the APM) to combine these values.

NOTE 2 Provision of the DHW may utilize either a DHW storage tank or heat exchange coils within the package.

NOTE 3 The DHW test conditions described in this PAS for CombiPK require either that the thermal state of the MCG package be determined at the beginning or end of the 24 h test periods or that the package can demonstrate equilibrium by repeated 24 h testing.

- RegPK – micro-cogeneration package for the provision of space and water heating, in which the DHW storage tank is outside the package but connected to it, i.e. a system acting as an alternative for a regular boiler.

The manufacturer shall specify and supply the DHW storage tank thermostat to be used in testing which shall be recorded in 8.1.

NOTE 4 Any MCG in which any DHW storage tank, internal or external to the package, is expected to operate also as a thermal store, should be tested under category CombiPK.

- DHWPK micro-cogeneration package for the provision of water heating alone.

6.2 Composition of the micro-cogeneration package to be tested

The micro-cogeneration package shall consist of the following items. Each item shall be provided by the manufacturer except where otherwise indicated:

- a) a MCG;
- b) declaration in accordance with Results Table 1 (Clause 13);
- c) thermal store(s), as specified by the manufacturer (if required);
- d) a full set of installation, commissioning and operating instructions, as provided for the normal installation in dwellings;
- e) items according to category declared in 6.2b):

NOTE Figure A.1 shows the arrangement for space heating tests for HeatPK, CombiPK and RegPK package categories.

- 1) for a HeatPK:

If a thermal store is to be used it shall be included within the package tested. The manufacturer shall define the control strategy so as to maintain the temperature of water at temperature measurement device, T2 [see 6.2f) and Figure A.1].

- 2) for a CombiPK:

The manufacturer shall define the control strategy so as to maintain the temperature of water at T2 [see 6.2f)] and Figure A.1 and temperature measurement device, T4 [see 6.2f)] and Figure A.2).

- 3) for a RegPK:

The manufacturer shall define the control strategy so as to maintain the temperature of water at temperature measurement device, T2 [see 6.2f) and Figure A.1].

The DHW storage tank, obtained from the test laboratory, shall have a nominal volume of 117 L, and shall conform to the minimum standard defined within BS 1566 (Ref 7, type G). The manufacturer shall provide instructions on how to fit and operate the thermostat to the DHW storage tank such that the set point of the DHW draw-off is $60\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$.

NOTE 1 A temperature of DHW draw-off of $60\text{ }^{\circ}\text{C}$ might require a bespoke setting on the DHW tank thermostat, which might or might not correspond to $60\text{ }^{\circ}\text{C}$.

NOTE 2 Figure A.1 shows the arrangement for space heating tests for all package categories.

- 4) DHWPK:

The manufacturer shall define the control strategy so as to maintain the temperature of water at temperature measurement device, T2 [see 6.2f)] and Figure A.1 or a corresponding location in Figure A.3;

- f) an internal control system identical to that of production models of the package intended to be placed on the market under the declared unique package identifier, (see manufacturer's declaration, Results Table 1) and information to enable the test laboratory to control the package in such a way as to deliver the heat output required for the various tests or follow the electrical demand. If electrically led, the package shall contain such devices to limit system operation in the event of their being no demand for heat energy either externally to the micro-generation package or internally to the package for storage for future use. No device being tested according to PAS 67 shall by design discard heat to its surroundings. If the package is designed to receive functional instructions from a remote computer via the internet, this shall

be permitted but a record of these instructions shall be provided to the test laboratory. This information shall include values and timing of signals (from genuine or artificial origin) that would be received from a typical installation;

NOTE 1 For example, signals from a room thermostat, DHW tank thermostat, external thermostat, programmer or any other devices that communicate heat demand from the dwelling. These signals will represent the call for heat within the dwelling and control the heat output from the package.

NOTE 2 The performance of micro-cogeneration packages is dependent on the functionality of the internal control system and these requirements are intended to ensure that the performance of the installation in the laboratory replicates that likely to occur in a real installation.

- g) the minimum effective length of flue pipe specified in the installation instructions;
- h) in the case of equipment to be tested in synchronous mode, any power conversion and conditioning equipment to enable compliance with the electrical conditions specified in **10.5**;
- i) a detailed description of how the thermal energy content of the package can be determined at the beginning and end of any 24 h test period, to allow compliance with **10.8**;
- j) flow and return connections and valves, as specified by the test laboratory, that will enable the package to be connected to the test rigs specified in Annex A;
- k) details of the recommended values for $T_{\text{spacereturn}}$ and $T_{\text{spaceflow}}$ and space heating and DHW flow rates that would allow the test laboratory to comply with the minimum temperatures defined within Clause **12**;
- l) apparatus to simulate the electrical current that will control any modulation of the package, where called upon the design of the package.

6.3 Test modes and test regimes

6.3.1 The test modes shall be as follows:

- a) *Continuous operation* – requires compliance with continuous operational criteria (see Table 1 for the relevant output test subclauses). The heat produced by the package shall be relatively uniform and, as a minimum, conform to the minimum hot period defined in Table 8 and Table 9, as appropriate, delivered over the 24 h period.
- b) *Uni-modal operation* – requires compliance with certain operational criteria during the heating period 07:00 to 23:00 (see Table 1 for the relevant output test subclauses). The heat produced by the package shall be relatively uniform and as a minimum conform to the minimum hot period defined in Table 8 and Table 10 as appropriate, delivered over the 16 h period.
- c) *Bi-modal operation* – requires compliance with certain operational criteria during the heating periods 06:00 to 09:00 and 15:00 to 23:00 (see Table 1 for the relevant output test subclauses). The heat produced by the package shall be relatively uniform and, as a minimum, conform to the minimum hot period defined in Table 8 and Table 11 as appropriate, delivered during the morning and evening on periods.
- d) *Domestic hot water only* – hot water shall be produced in accordance with **12.7**.
- e) *Standby mode* – the package shall be tested in standby mode (see **12.6**).

Table 1 Relevant subclause for each test mode

Test mode	Subclause		
	Full (100%) Output test	30% Output test	10% Output test
Continuous operation	12.2	12.3.2	12.4.2
Uni-modal operation	12.2	12.3.3	12.4.3
Bi-modal operation	12.2	12.3.4	12.4.4
Standby mode		12.6	
DHW only		12.7	

6.3.2 Manufacturers shall choose a test regime from Table 2. The manufacturer's operating instructions supplied to customers with the package shall be appropriate to assess how the package will perform after installation in accordance with the manufacturer's design and installation instructions.

NOTE 1 The manufacturer should give careful consideration as to how the results may be treated in any higher level procedures before choosing which test mode and test regime to follow. Different test regimes might lead to different performance results, and further calculations are necessary to determine the overall annual energy performance and carbon emissions in any particular dwelling.

Table 2 Definitions of test regimes for output tests

Test regime	Output test		
	Full (100%) (see 12.2)	30 % (see 12.3)	10 % (see 12.4)
1	Continuous	Continuous	Continuous
2	Continuous	Uni-modal	Uni-modal
3	Continuous	Bi-modal	Bi-modal
4	Continuous	Uni-modal	Bi-modal
5 ^{A)}	DHW only		

^{A)} This test regime is included as it is the principal test required for packages producing DHW alone. Packages submitted under this test regime should be tested in accordance with at least two EU tapping cycles, one of which should be Table 12.

6.3.3 Manufacturers shall choose whether the package is to be tested at any of the supplementary operational conditions (see 6.4 and 12.5).

6.4 Supplementary partial output tests

As well as the full output, 30% output, and 10% output tests, supplementary partial-output tests might be carried out at 90%, 80%, 70%, 60%, 50%, 40%, 30% and 20% under the conditions specified in 12.5. Supplementary tests are optional, but might be included and reported as part of the same group of tests.

Where supplementary tests are to be carried out, the test mode for each package shall be in accordance with Table 3. The test regime shall be selected on the basis of the test regime selected in Table 2, whereby the test regime numbers are the same.

NOTE 1 If test regime 1 has been chosen from Table 2, then the test mode is chosen from the row labelled test regime 1 in Table 3.

NOTE 2 Supplementary test results enable a more reliable curve of performance (a graph of thermal efficiency and net electrical output versus partial output) to be produced. The performance curve is required in order to calculate annual performance.

data and the additional points that are established through supplementary partial output tests reduces the errors of interpolation. For example, it might be beneficial to carry out a test close to the partial output at which the highest ratio of electrical power generation to heat is obtained.

Table 3 Definitions of test regimes for supplementary partial output tests

Test regime	Supplementary partial output tests						
	90%	80%	70%	60%	50%	40%	20%
1	Cont	Cont	Cont	Cont	Cont	Cont	Cont
2	N/A	N/A	N/A	Uni-modal	Uni-modal	Uni-modal	Uni-modal
3	N/A	N/A	N/A	N/A	N/A	Bi-modal	Bi-modal
4	Cont	Cont	Cont	Uni-modal	Uni-modal	N/A	N/A

NOTE Cont = Continuous, N/A = Not allowed

6.5 Range-rated appliances

NOTE Some manufacturers may wish to test range-rated packages where the total nominal-rated heat output (NRHO) is adjusted to meet the maximum heat demand of the dwelling in which it is to be installed.

The manufacturers shall provide within the installation instructions precise details on how the maximum heat demand of the dwelling is to be evaluated and how the MCG is to be adjusted to meet this. The method by which this adjustment can be made shall be made available to installers and not to the householder. In principle each adjustment within the range shall be considered to produce a separate package requiring completion of a full set of PAS 67 test work.

Packages where the ratio of NRHO is two or less can be linearly interpolated to obtain intermediate values.

EXAMPLE The conditions under which a package comprising a MCG unit of 1.5 kW_e and 6 kW fixed output main burner, plus a supplementary burner that can be either permanently off or adjusted (range-rated) to give maximum outputs of between 6 kW to 18 kW is tested are shown in Table 4.

Table 4 Example of test conditions of package with adjustable heat output

NRHO	Test Output	Heat output in 24 h
kW	%	MJ
6	100	518.4
	30	155.5
	10	51.8
12	100	1036.8
	30	311.0
	10	103.7
24	100	2073.6
	30	622.1
	10	207.4

The installer shall be provided with instructions on how to adjust the package for dwellings of maximum heat demand of 6 kW, 12 kW or 24 kW. As the NRHO varies by a factor of four, all three packages shall be tested. If the manufacturer

permitted intermediate settings (by way of the example 15 kW) the performance of the package at this output might be determined by interpolation.

7 Test laboratory conditions adjacent to the MCG

The ambient air temperature in the test laboratory shall be $20\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$. The maximum air velocity adjacent to the package shall be 0.5 m/s, except where the air velocity is inherently generated by the package. The package shall at all times be shaded from sunlight. The laboratory temperature, humidity and pressure shall be recorded hourly during the test at a height of 1.5 m and between 1 m and 3 m horizontally away from the MCG. The thermometer shall be protected from direct radiation from the MCG. The averages of each condition shall be reported in Results Table 2 (Clause 13).

NOTE Wherever possible, relative humidity should be controlled between 50% and 70%.

8 Records for future package surveillance

8.1 General

The manufacturer shall compile a technical file, in conjunction with the test laboratory, that accurately defines the package and the conditions under which the package was tested in accordance with 8.2 to 8.4.

8.2 Manufacturer

The manufacturer shall provide to the test laboratory:

- a) the manufacturer's declaration (see Results Table 1 in Clause 13);
- b) a set of functional drawings that accurately define all the physical attributes of the package;
- c) a set of functional data, including information as specified in 6.2f), that accurately and completely defines any control system used within the package. If the manufacturer operates a transparent system in accordance with an approved quality scheme this shall be the manufacturer's own code number (e.g. the ABC Ltd. micro-cogeneration control program Version 7.16). This code number might in turn call up a number of further references detailing the commercial software with which such a control program might have been written. In the absence of such a scheme, the manufacturer shall provide the appropriate logic trees, ladder diagrams or electronic programs and shall include all time constants for proportional, integral and differential controls (where applicable).

NOTE 1 The information is not to be analysed by the test laboratory but can act as a permanent record of the control strategy used by the package at the time of test.

NOTE 2 Users of this PAS are advised to consider the desirability of quality system assessment and registration against the appropriate standard in the BS EN ISO 9000 series by an accredited third-party certification body.

8.3 Manufacturer and test laboratory

The manufacturer shall provide the following in conjunction with the test laboratory:

- a) the test declaration (see Results Table 7 in Clause 13);
- b) a set of functional data, including information as specified in 6.2f), that defines how the package and the control system were set up for all laboratory tests.

NOTE 1 This data would be similar to that required for compliance with the Gas Appliances Directive 90/396/EEC [6] at the time of publication and certainly greater than generally recorded for the testing of boilers to the Boiler Efficiency Directive [3]. This is particularly important with respect to the setting or unusual adjustment of controls, for example pressure switches.

NOTE 2 This functional data should be set at a sufficient level of detail to allow reliable and unambiguous replication of the test procedure in another test laboratory.

8.4 Test laboratory

The manufacturer shall obtain the following from the test laboratory:

- a) the test results (see Results Tables 2, 3, 4, 5 and 6 in Clause 13);
- b) the details and conditions under which the package was tested, including any additional equipment used by the test laboratory, with particular reference to 6.2e) and 6.2f);
- c) any additional comments relating to the tests that could allow reproducible surveillance testing.

9 Actions of the test laboratory upon acceptance of micro-cogeneration package

The manufacturer shall request that the test laboratory assesses the package to ensure that all components of the micro-cogeneration package are accurately specified. Details of the equipment shall be recorded in the technical file (see Clause 8).

10 Testing principles

10.1 General

The total measured energy flowing into the micro-cogeneration package during any 24 h period shall be compared with the measured energy flowing out of the package. All timed events (for example the beginning or end of a measurement period) shall be carried out within ± 15 s of the specified time.

NOTE This is required due to the relative complexity of micro-cogeneration packages when compared with boilers. The techniques to be used to determine this are specified in 10.2 to 10.10.

The expression of measurement uncertainties shall be in accordance with UKAS M3003, 2007 [N1].

10.2 Test fuels

10.2.1 General

All the calculations shall be determined using gross CVs.

Test fuels and their input rates shall be determined by the techniques specified in 10.2.2 to 10.2.7.

10.2.2 Second and third family gas

For second and third family gas, this shall be the reference test gas listed in BS EN 437.

NOTE 1 Second and third family gases are usually natural gas or LPG.

NOTE 2 The test gas should be selected taking into account the eventual geographical destination of the package.