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Heating systems in buildings — Inspection of boilers and heating systems

Heizungssysteme in Gebäude — Haupt-Element

Systèmes de chauffage dans les bâtiments — Inspection des chaudières et des installations de chauffage

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Foreword

This document (prEN 15378:2005) has been prepared by Technical Committee CEN/TC 228 “Heating systems in buildings”, the secretariat of which is held by DS.

The subjects covered by CEN/TC 228 are the following:

- design of heating systems (water based, electrical etc.);
- installation of heating systems;
- commissioning of heating systems;
- instructions for operation, maintenance and use of heating systems;
- methods for calculation of the design heat loss and heat loads;
- methods for calculation of the energy performance of heating systems.

Heating systems also include the effect of attached systems such as hot water production systems.

All these standards are systems standards, i.e. they are based on requirements addressed to the system as a whole and not dealing with requirements to the products within the system.

Where possible, reference is made to other European or International Standards, a.o. product standards. However, use of products complying with relevant product standards is no guarantee of compliance with the system requirements.

The requirements are mainly expressed as functional requirements, i.e. requirements dealing with the function of the system and not specifying shape, material, dimensions or the like.

The guidelines describe ways to meet the requirements, but other ways to fulfil the functional requirements might be used if fulfilment can be proved.

Heating systems differ among the member countries due to climate, traditions and national regulations. In some cases requirements are given as classes so national or individual needs may be accommodated.

In cases where the standards contradict with national regulations, the latter should be followed.

STILL TO BE DONE

SYMBOLS, INDICES AND UNITS REVISION

EDITORIAL CORECTIONS (NUMBERING STYLE OF TABLES, ANNEXES ORDER)

FINAL COORDINATION (REFERENCES) WITH OTHER STANDARDS

Introduction

This document specifies procedures and optional measurement methods to be used for the inspection and assessment of energy performance of boilers and heating systems to provide advice to users on the replacement of boilers, other modifications to the heating system and on alternative solutions as required by article 8 of Council Directive 2002-91-EC.

This standard includes, either in the normative text or in the informative annexes:

- inspection procedures;
- measurement procedures;
- calculation formulas;
- sample reports;
- advice criteria.

Procedures and methodologies defined in this standard are not intended to provide a full energy audit of the heating system. They are intended to:

- support identification of areas of possible improvements;
- define criteria to produce reliable advice on possible improvements of the energy performance of boilers and heating systems through replacement of components or other measures.

Any replacement of appliances or modification of the heating system following advice should be designed according to appropriate methodologies. This may require additional input and investigation for detailed design and final check of economical effectiveness.

Clause 5 and 6 describe separately basic inspection procedures related to:

- regular inspection of boilers;
- one-off inspection of the entire heating system.

This standard introduces inspection classes by which different levels of inspection accuracy and detailed inspection requirements can be determined, because:

- the same inspection procedure and level of details cannot reasonably be required for any kind and/or any size of boilers/heating systems;
- there are currently significant differences among member states with respect to:
    - heating systems typologies;
    - legal and/or standard requirements;
    - maintenance and inspection practices.

Alternative and/or optional partial inspection procedures and measurement methods for boilers and heating system parts are described in the relevant annexes.

Inclusion/omission/alternatives of individual inspection items as well as border lines between classes are specified through tables given in national annexes. If no specific national annex is available, default tables and inspection classes are given in annex A. Tables in the national annexes may refer either to methodologies given in the annexes to this standard or to suitable existing national standards.

This standard has been drafted to support inspection required by Council Directive 02/91/CE, that is "*regular inspection of boilers fired by non-renewable gaseous, liquid or solid fuel"* and "*one-off inspection of heating systems with boilers that are more than 15 years old*". This does not exclude the possibility to use this standard for other types of generation devices (e.g. warm air heaters, heat pumps, thermal solar, CHP …) and to domestic hot water systems if appropriate additional classes are defined in the national annexes.

1 Scope

This document specifies inspection procedures and optional measurement methods for the assessment of energy performance of existing boilers and heating systems.

Boiler types covered by this standard are:

- boilers for heating, domestic hot water or both;
- gas, liquid or solid fuel fired boilers.

Parts of heating systems covered by this standard are:

- boilers, including generation control;
- other generation devices;
- domestic hot water production facilities;
- heating distribution network, including associated components and controls;
- heating emitters, including components and controls;
- space heating control system
- storage and associated components
- domestic hot water control system.

2 This standard covers issues related to energy conservation and environmental performance.Normative references

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

ISO 13600:1997

EN 50379-1-2-3, *Measuring instruments for flue gas analysis*

EN 12828, *Heating Systems in buildings - Design of water-based heating systems*

EN 15315, *Energy performance of buildings – Overall energy use and definition of energy ratings*

EN 15316-4-1, *Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies - Part 4-1 Space heating generation systems, combustion systems*

EN 15316-2-1, *Energy performance of buildings — Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies – Part 2-1: Space heating emission systems*

EN 15316-2-3, *Energy performance of buildings — Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies - Part 2-3: Space heating distribution systems*

3 Terms and definitions

3.1 Definitions

For the purposes of this document, the following definitions apply:

3.3.1
energyware
tradable commodity used mainly to produce mechanical work or heat, or to operate chemical or physical processes, and listed in ISO 13600:1997, Annex A

NOTE Energywares form a proper subset of energy carriers. The set of energy carriers is open.

3.3.2
operational rating
rating based on actual energy use.

NOTE: It is a measure of the in-use performance of the building.

NOTE This is particularly relevant to certification of actual performance

3.2 Symbols and units

For the purposes of this document, the following symbols and units (Table 1) and indices (Table 2) apply:

Table 1: Symbols and units

Symbol	Name of quantity	Unit
CO	carbon monoxide contents	ppm
CO_2	carbon dioxide contents	%
DD	degree-days	°C·day
EWA	energyware	J
FC	generator load factor	%
H	combustion specific heat	J/kg or J/Nm³ or J/Stm³
HUM	relative humidity	%
K	ratio of values	-
L	system load	%
M	mass	kg
O_2	oxygen contents	%
P	absolute pressure	Pa
P	losses factor	%
T	thermodynamic (absolute) temperature	K
V	volume	m³ or Nm³ or Stm³
$\dot{V}$	volume flow rate	Nm³/h or Stm³/h
W	electrical auxiliary energy	kWh
k	multiplying factor	-

Symbol	Name of quantity	Unit
t	time	s
α	heat transfer coefficient	W/m²·K
ρ	density	kg/m³
θ	celsius temperature	°C
η	efficiency	-
Φ	thermal or electrical power	W

Table 2: Indices

air	air	fl	flue gas	rd	reading
avg	average	floor	near the floor	ref	reference
ceil	near the ceiling	g	generation	s	sensible
cn	combustion	gn	generator	s	gross (heat value)
cond	condensation	i	net (heat value)	sat	saturation
cons	consumed	ini	initial	st	stoichiometric
corr	corrected	int	internal	v	volumetric
del	delivered	l	loss	w	water
des	design	Meas	measured	x	indices
dry	dry gases	max	maximum	H2O	water
em	emission	mid	at 1,5 m height	θ	temperature
env	envelope	min	minimum	Δ	additional, change
ext	external	pump	circulation pump	0	reference
f	fuel	out	outdoors	0	stand-by
fin	final	r	return		

4 Principle of the method

4.1 Boiler regular inspection

Regular boiler inspection procedures and methods are intended to:

- verify if the boiler is set, operated and maintained correctly with regard to energy efficiency;
- estimate actual boiler energy performance;
- when required, support advice on possible boiler energy performance improvements.

NOTE Council Directive 2002/91/CE does not require advice following boiler regular inspection.

4.2 Heating system one-off inspection

One-off heating system inspection procedures and methods are intended to:

- verify if the heating systems is set, equipped, operated and maintained correctly with regard to energy efficiency;
- estimate actual heating system energy performance;
- support advice on possible heating system energy performance improvements.

Inspection procedures and optional measurement methods (if any) are specified separately for each subsystem of the heating system.

4.3 Inspection classes

Boiler and heating system inspection classes shall be specified according to one or more of the following parameters:

- fuel type;
- nominal boiler power input or output;
- boiler type;
- heated space area or volume;
- type of heat distribution;
- type of emitters;
- other relevant properties.

Optional inspection items and/or measurement methods are applied according to inspection class.

NOTE if intermediate inspection results provide evidence of significant possible improvements, the inspector should recommend more accurate inspection as appropriate and effective to support specific advice.

For each inspection class, required and/or alternative inspection items and/or procedures shall be specified through tables where:

- each row corresponds to a specific inspection item and/or partial inspection procedure and/or methodology;
- each column corresponds to an inspection class;
- each cell specifies whether or not the specific inspection item and/or partial inspection procedure and/or methodology (row) is required for the inspection class (column), according to table A.1.

Two basic types of tables may be used to specify details of inspection classes:

- list of information required about the inspected boiler / heating system /heating system part (typically choice between alternatives, YES/NO, etc.) are specified through tables like Table A.2;
- list of properties to be estimated or measured and required alternative procedures or methods (example: efficiencies may be obtained from measurements, maintenance records or estimation through tables) are specified through tables like Table A.3.

For each inspection item and/or optional procedure, the table shall state whether or not the inspection item is required to comply with the inspection class. If the inspection item is required to comply with the inspection class, the table shall further state:

- whether or not the specific procedure is suitable to comply with the inspection class (there might be more than one possibility with preference, if any, stated in notes to the table);
- whether or not the specific procedure is sufficient to comply with the inspection class;
- whether the specific procedure is more than required to comply with the inspection class.

  NOTE The last option gives the information that the specific inspection item or optional procedure is more detailed than what is required to comply with the inspection class.

- the source of the specific procedure referred (reference to clause or annex of this standard or other relevant document).

If no such table is available in the relevant national annex, default inspection class tables are given in Annex A.

Inspection class tables in the national annexes need not show items which are optional for all classes (i.e. items which are not required for any of the national inspection classes). Inspection class tables in the national annexes should include only such items, which are required by at least one (national) inspection class.

NOTE: A national table can be shorter than the default table in annex A.

An example of national tables is given in informative Annex O.

4.4 Advice

General criteria for advice following boiler inspection, when required, are given in paragraphs 5.10

General criteria for advice following heating system inspection are given in paragraph 6.15

4.5 Inspection report

Following inspection of the boiler or heating system, results shall be recorded in an inspection report for the responsible for operation and maintenance of the boiler or heating system. The report shall include:

- identification of the boiler or heating system;
- identification of the required inspection class;
- description of any activity (adjusting, setting, etc.) which was performed during the inspection;
- data recorded and/or measured as required by the inspection class;
- source of recorded data;
- reference and benchmark values, as required by the inspection class;
- advice, when required..

Benchmark and/or reference values shall be indicated near corresponding actual values.

Inspection report, results and documentation shall be archived and kept available as a reference for follow-up.

5 Boiler inspection procedure

5.1 Boiler inspection class identification

Determine the inspection class of the boiler according to relevant national annex or default annex A.

5.2 Boiler identification

Record information on user, building (i.e. address, location) and boiler identification as specified in the appropriate table of the national annex. If no national annex is available, record information specified in default Table A2.

State in the report the source of information recorded.

5.3 Document collection

Collect and identify available relevant documents to support inspection according to inspection class.

EXAMPLE: Heating system or boiler instructions, previous inspection reports, maintenance reports, fuel bills, commissioning data, system design documentation, schematic diagrams, log-books.

5.4 Boiler visual inspection

Check for visual evidence of:

- fuel, flue gas or heating medium leaks in the boiler installation room;
- boiler insulation damage;
- soot or other dirt in burner, combustion chamber and heat exchanger.

State in the report any such evidence.

5.5 Boiler maintenance status

Determine whether the boiler is regularly and correctly maintained by qualified and/or authorised personnel.

Reference shall be made to:

- system designer's instructions;
- boiler manufacturer's instructions;
- any legal or statutory requirements.

NOTE: consideration may be given to heat medium quality.

5.6 Boiler functionality check

Check whether the boiler is capable of providing the desired and designed services.

State in the report any malfunctioning.

Record in the report any relevant feed-back from user and operation and maintenance personnel, as available and appropriate.

5.7 Boiler controls, sensors and indicators

Identify and provide advice, as appropriate, on:

- location (either external, internal and other);
- function;
- settings

of boiler controls, sensors and indicators which are relevant for energy performance.

5.8 Meter readings

Read available meters and counters such as:

- fuel meter, noting if the same meter takes into account other usages;
- fuel level in the storage, if any;
- operation hour counters;
- any auxiliary energy meter;
- feed water meter;
- domestic hot water meter;
- cycle counters;
- heat meter;

and record values in the report.

If there is no fuel meter, advice should be given on the installation of simple devices (i.e. hour counters) to support reliable tracking of fuel consumption.

5.9 Boiler performance evaluation

Inspection of correct setting and actual performance of the boiler may include:

- boiler combustion power check;
- energyware consumption check;
- boiler basic setting and combustion efficiency check;
- other boiler losses (radiation, total stand-by, etc.) check;
- boiler seasonal efficiency check;
- controls setting check;
- boiler sizing check.

The items which shall be inspected and the required methodologies according to the inspection class are specified in the appropriate table of the national annex or in default Table A3.

Examples of methodologies related to flue gas analysis and boiler basic setting inspection are given in informative annex D.

5.10 Boiler inspection report and advice

5.10.1 Inspection report

Following inspection of the boiler, an inspection report with optional related advice shall be provided.

An example of a boiler inspection report is given in informative Annex M.

5.10.2 Boiler performance advice

Any advice on boiler performance shall be drafted according to the following general requirements and any specific advice criteria related to inspection items required by the inspection class.

Advice shall be based on:

- inspection results:
- availability of better components and appliances, including controls;
- comparison between recorded actual properties, status and values and corresponding references (benchmarks).

Consideration shall be given to the following reference values as appropriate and available:

- applicable legal requirements;
- manufacturer instruction and data;
- average values for similar boilers, given as national tables based on boiler typology;

  NOTE 1 This reference value is meant to support identification of possible problems of the specific boiler or under inspection.

- design specifications;
- best achievable (target) values using cost effective available technologies, given as national tables based on boiler typology.

  NOTE This reference value is meant to support estimation of possible achievable energy and/or economic returns through improvements.

Advice shall take care of cost effectiveness and feasibility of recommended actions.

Advice shall include/suggest both possible immediate actions (replacements) and other actions to be taken in the event of major renovation or replacement due to aging or breakdown of components.

Advice shall take into account interactions between suggested actions.

Advice shall indicate available options and suggestions for cost effective use of renewable energies.

Advice shall include recommendation that regular maintenance by competent personnel is essential to keep a stable good energy performance of the boiler.

Informative Annex L provides a list of possible improvement actions to be recommended. The list is neither exhaustive nor compulsory.

NOTE: Additional advice criteria on specific topics are included in their clauses and related annexes.

6 Heating system inspection procedure

6.1 Heating system inspection class identification

Before the inspection, the responsible for operation and maintenance of the heating system shall be identified. Suitable information has to be available to determine the heating system inspection class according to relevant national annex or default annex A.

NOTE: Heating system inspection class may depend on heated surface, generation system power, date of erection, building type (residential/non residential), etc..

6.2 Heating system inspection preparation

Identify and ask for preparation, collection and availability for inspection of relevant documents and basic information, as appropriate according to the inspection class.

EXAMPLE: Building plans, heated volume, actual use of the building, system design, schematic diagrams, components or heating system instructions, operation or maintenance log-books, previous inspection reports, maintenance reports, fuel bills, commissioning data, energy calculation, energy declaration.

6.3 Heating system identification

Collect and record the information and documentation on owner and heating system identification specified in the appropriate table of the national annex. If no national annex is available, information specified in default Table A4 shall be recorded.

Information and documentation shall at least allow identification of:

- functional diagram of the heating system;
- location of main components of the heating system;
- intended and actual use of the building;
- intended and actual operation of the heating system (heated volume, time schedules, etc);
- type of control subsystem and settings;
- any attached systems and related requirements.

If a satisfactory documentation is not available, a minimum set of information on the heating system shall be assembled by direct inspection.

Correspondence between documentation and actual installed equipment shall be checked. Any difference shall be stated in the report and documentation corrected.

6.4 Heating system functionality check

Check whether the heating system is capable of providing the desired and designed services (i.e. space heating, domestic hot water production and attached systems requirements).

State in the report any malfunctioning.

Record in the report any relevant feed-back from users and operation and maintenance personnel, as available and appropriate.

6.5 Heating system maintenance status

Determine whether the heating system is regularly maintained by qualified and/or authorised personnel.

Reference shall be made to:

- system designer's instructions;
- appliances and component manufacturers' instructions;
- any legal or statutory requirements.

NOTE: consideration may be given to heat medium quality.

6.6 Heating system controls, sensors and indicators

Identify and provide advice, as appropriate, on:

- location (either external, internal and other) ;
- function;
- settings;

of heating system controls, sensors and indicators which are relevant for energy performance.

Check location of such sensors for possible negative interactions with environment, furniture, possible direct insolation, heat emitters and heat distribution sub-system.

6.7 Energyware consumption

6.7.1 Measurement

Energyware consumption (operational rating) shall be assessed according to relevant national standards or Annex C. Fuel and auxiliary energy shall be determined separately.

6.7.2 Reference values

Energyware consumption shall be compared to the following reference (benchmark) values:

- expected energyware consumption of the heating system, which is:
  - if available, energy declaration values;

- if available, design delivered energy;
- otherwise, calculated consumption based on gross volume (or floor area) and specific values specified in national tables. An example of the structure of such table is given in C.6, Table C2;

- target values, calculated consumption based on gross volume (or floor area) and specific values specified in national tables. An example of the structure of such table is given in C.6, Table C3.

6.7.3 Advice criteria on energyware consumption

Advice shall contain a comparison between actual energyware consumption and reference values.

If actual energyware consumption significantly deviates from expected reference values, possible causes shall be investigated and further energy auditing recommended. Possible causes for significant deviations are suggested in C.7.

6.8 Space heating emission subsystem

Collect and record the information on space heating emission subsystem specified in the national annex. If no national annex is available, information specified in default Table A5 shall be recorded.

Identify and provide advice, as appropriate, on:

- type of heat emitters and suitability for the type of room and their intended use;

  EXAMPLE For high ceiling rooms and stratification, see Annex H

- sizing of heat emitters;
- positioning of heat emitters;
- insulation and obstructions around heat emitters;
- auxiliary energy requirements;
- maintenance requirements, if applicable for specific types of heat emitters
- type of hydraulic connection of emitters to distribution;
- type of valves / controls for room-specific supply limitation (hydraulic balancing);

  EXAMPLE Fan coils require periodic filter cleaning.

6.9 Space heating emission control subsystem

Collect and record the information on space heating emission control subsystem specified in the national annex. If no national annex is available, information specified in default Table A6 shall be recorded.

Identify and provide advice, as appropriate, on:

- type of space heating emission control subsystem in relation to its ability to sense indoor temperature and control heat emission according to heat losses and gains;
- method of zone temperature setting and method of control according to occupancy;
- type, location (either external, internal and other), accuracy and maintenance of controls, sensors and indicators;
- settings of controls, including outdoor reset function for supply water temperature

  EXAMPLE Base setting of floor heating, hydraulic balancing.

Information on inspection methodologies and advice criteria are given in informative Annex I

6.10 Space heating distribution subsystem

Collect and record the information on space heating distribution subsystem specified in the national annex. If no national annex is available, information specified in default Table A7 shall be recorded.

Identify and provide advice, as appropriate, on:

- structure and zoning of the distribution network compared to building use;
- type of heat distribution with respect of heating medium, single or multiple circuits, direct or indirect connection to heat generator;
- type of limitation of difference pressure in heat distribution during normal operation;
- type of hydraulic balancing of heat distribution circuits;
- temperatures of the distribution circuits;
- sizing and setting of circulation pumps;
- type and setting of any flow rate control;
- operation and control of individual circuits, including flow temperature control, timing and settings;
- compatibility of distribution circuits with boiler typology and requirements;
- thermal insulation of piping and components;
- open vented / closed vented, including wrong circulation in open vented systems;
- losses of heat medium;
- heat medium quality.

Information on inspection methodologies and advice criteria are given in informative Annex J

6.11 Generation subsystem

6.11.1 Generation subsystem identification

Collect and record the information specified in the appropriate table of the national annex. If no national annex is available, information specified in default Table A.8 shall be recorded.

6.11.2 Boiler(s) inspection

Collect and record, for each boiler, the information specified in the appropriate table of the national annex. If no national annex is available, information specified in default Table A.9 shall be recorded.

For each boiler, inspection of correct setting and actual performance of the boiler may include:

- boiler combustion power check;
- boiler basic setting and combustion efficiency check;
- other boiler losses (radiation, stand-by, etc.) check;
- boiler seasonal efficiency check;
- controls settings check, including running time and effect on cycling (hysteresis).

The items which shall be inspected and the required methodologies according to the inspection class are specified in the appropriate table of the national annex or in default Table A.10.

6.11.3 Storage subsystem for heating systems

Identify and provide advice, as appropriate, on sizing, thermal insulation and temperature control of any hot water storage vessel.

6.11.4 Heat exchangers for heating system

Identify and provide advice, as appropriate, on sizing, performance (including fouling), thermal insulation and temperature control of any heat exchanger;

6.11.5 Other generation sub-systems

Identify and provide advice, as appropriate, on sizing, performance, thermal insulation, temperature control, settings of other generation subsystems connected to the heating system.

6.11.6 Generation subsystem control inspection

Identify and provide advice on flow water temperature control strategy.

If there is more than one heat generator (including non-combustion generators), identify and provide advice on:

- method of total heating system load dispatching among available boilers and other heat generators, including priorities, load splitting and optimisation strategy, running time, proper hydraulic connection, etc.;
- method of hydraulic balance of generators;
- method of hydraulic isolation of stand-by generators from the heating system;
- settings of the generation control devices, if any.

6.12 Generation subsystem sizing

6.12.1 General

Installed power of the generation sub-system shall be compared to the actual heat power requirement of the heating system and any attached systems such as domestic hot water production system.

Boiler (or generation sub-system) sizing shall be determined using the method specified in the appropriate table of the national annex. If no national annex is available, the methodology specified in default Table A.11 shall be used.

6.12.2 Advice

Any statement on the extent to which over-sizing of the boiler affects system efficiency should be qualified by reference to:

- boiler type, taking into account thermal capacity**,** stand-by losses, effect of actual power on efficiency;
- type of burner control (fixed, stepped or modulating), taking into account the modulating range (mainly minimum on power);
- controls settings and mode (interlock with boiler firing, night shut-down of burner, operation timing according to external temperature, etc.);
- generation sub-system controls and hydraulic circuits;

  EXAMPLE: Are stand-by units hydraulically shut-off when off ?

- any specific reason for over-sizing and/or stand-by operation.

EXAMPLE: Instantaneous domestic hot water production or high reliability requirements (spare stand-by units).

6.13 Heating system sub-systems efficiencies

The inspection may include an assessment of the efficiency (or any equivalent parameter, like expenditure factors, relative losses, etc.) of the subsystems of the space heating system.

NOTE: Performance of the generation subsystem is already covered in 6.11.2.

The items which shall be inspected and the required methodologies according to the inspection class are specified in the appropriate table in the national annex or in default Table A.12.

6.14 Domestic hot water systems

Collect and record the information on domestic hot water system specified in the national annex. If no national annex is available, information specified in default Table A13 shall be recorded.

Identify and provide advice, as appropriate, on:

- structure of the domestic hot water system;
- actual domestic hot water consumption pattern compared to design;
- thermal insulation of domestic hot water piping ;
- operation timing, setting and control of circulation system;
- type and size of heat generator used for domestic hot water production;
- sizing, thermal insulation and temperature control of any storage vessel;
- sizing, performance (including fouling and scaling), thermal insulation and temperature control of heat exchanger;
- auxiliary energy requirements (e.g. circulation pump).

Information on inspection methodologies and advice criteria are given in informative Annex K.

6.15 Space heating system and domestic hot water system inspection report and advice

6.15.1 Heating system inspection report

Following inspection of the heating system and domestic hot water system, an inspection report with related advice shall be provided as specified in 4.5 for transfer to the responsible of the heating system.

An example of a heating system inspection report is given in informative Annex N.

6.15.2 Heating system advice

Heating system advice shall be drafted according to the following general requirements and any specific criteria related to inspection items required by the inspection class.

Advice shall be based on:

- results of the inspection, including:
  - original design;
  - changes in the use, structure and/or properties of the building and heating system;
- availability of better components and appliances, including controls;

- comparison between recorded actual properties, status and values and corresponding references (benchmarks).

Consideration shall be given to the following reference values as appropriate and available:

- applicable legal requirements;
- average values for similar boilers or heating systems, given as national tables based on boiler or heating system typology;

  NOTE: This reference value is meant to support identification of possible problems of the specific boiler or heating system under inspection.

- declared values from design specification or energy declaration, as available;
- best achievable (target) values using cost effective available technologies, given as national tables based on boiler, heating system or building typology.

  NOTE This reference value is meant to support estimation of possible achievable energy and/or economic returns through improvements.

Advice shall take care of cost effectiveness and feasibility of recommended actions.

Advice shall include/suggest both possible immediate actions (replacements) and other actions to be taken in the event of major renovation or replacement due to aging or breakdown of components.

Advice shall take into account interactions between suggested actions.

Advice shall indicate available options and suggestions for cost effective use of renewable energies.

Advice shall include recommendation that regular maintenance by competent personnel is essential to keep a stable good energy performance of the boiler and heating system.

Informative Annex L provides a list of possible improvement actions to be recommended. The list is neither exhaustive nor compulsory.

NOTE: Further advice criteria on specific topics are included in clauses and annexes, respectively.

Annex A
(Informative)
Default inspection class tables

A.1 Legend of default inspection class tables

The values in the cells of the tables of annex A have the meaning indicated in Table A1

Table A1 – Legend for default inspection class tables

Optional	the inspection item is not required to comply with the inspection class;
Required	the inspection item is required to comply with the inspection class;
Suitable	the inspection item is required and the specific procedure is suitable to comply with the inspection class (there might be more than one possibility with preference, if any, stated in notes to the table);
NO	the inspection item is required but the specific procedure is not sufficient to comply with the inspection class;
Excellent	the inspection item is required and the specific procedure is more than required to comply with the inspection class;
NOTE	The last option ("Excellent") gives the information that the specific inspection item or optional procedure is more detailed than what is required to comply with the inspection class.

A.2 Boiler inspection

Default boiler inspection classes are based on:

- fuel type;
- maximum boiler rated power input.

Table A2 – User, building and boiler identification information for use in 5.2

Fuel type	Gaseous and liquid		Solid	
Power	< 100 kW	> 100 kW	< 100 kW	> 100 kW
Owner, user or administrator name	Required	Required	Required	Required
Address	Required	Required	Required	Required
Fuel	Required	Required	Required	Required
Fuel feed typology (1)	Optional	Optional	Required	Required
Boiler duty (heating/domestic hot water/both)	Required	Required	Required	Required
Boiler manufacturer	Required	Required	Required	Required
Boiler model	Required	Required	Required	Required

Table A2 – User, building and boiler identification information for use in 5.2

Fuel type	Gaseous and liquid		Solid	
Power	< 100 kW	> 100 kW	< 100 kW	> 100 kW
Boiler serial number	Optional	Required	Optional	Required
Boiler manufacture date or year	Required	Required	Required	Required
Maximum power rated input (2)	Required	Required	Required	Required
Maximum power rated output (3)	Optional	Optional	Optional	Optional
Minimum power rated input	Required	Required	Required	Required
Minimum power rated output	Optional	Optional	Optional	Optional
Boiler classification (4)	Optional	Optional	Optional	Optional
Condensing/non condensing	Required	Required	Required	Required
CE labelling efficiency stars (if available)	Required	Required	Required	Required
Burner manufacturer (5)	Required	Required	Required	Required
Burner model (5)	Required	Required	Required	Required
Power modulation type (6)	Required	Required	Required	Required
Heating medium quality reports	Optional	Required	Optional	Required

NOTES

(1) Automatic or manual

(2) Combustion power. Specify if referred to net or gross calorific value

(3) Net power to heating system

(4) Bxx or Cyyy : typology of air flue gas circuit, fan position, etc.

(5) If a separate burner is fit to the boiler

(6) Fixed, stepped (multistage), continuous modulation.

Table A3 – Procedures and methodologies required for boiler inspection for use in 5.9

Fuel type			Gaseous and liquid		Solid	
Power			< 100 kW	> 100 kW	< 100 kW	> 100 kW
Combustion power	Measurement	B.1	Excellent	suitable	Excellent	suitable
	Maintenance data	B.2	suitable	NO	suitable	NO
Energyware consumption evaluation		Annex C	optional	suitable	optional	suitable
Boiler basic setting and combustion efficiency	Measurement	D.1	suitable	suitable	suitable	suitable
	Maintenance data	D.2	suitable	NO	suitable	NO

Table A3 – Procedures and methodologies required for boiler inspection for use in 5.9

Fuel type			Gaseous and liquid		Solid	
Power			< 100 kW	> 100 kW	< 100 kW	> 100 kW
Losses through the envelope (radiation losses)	Tabulated values	E.5.1.1	optional	optional	optional	optional
	Surface temperature	E.5.1.2	optional	optional	optional	optional
Losses through the chimney with burner off	Tabulated values	E.5.2	optional	optional	optional	optional
Total stand-by losses test	Tabulated values	E.5.3.1	optional	optional	optional	optional
	Stand-by operation	E.5.3.2	optional	optional	optional	optional
	Auxiliary heater	E.5.3.3	optional	optional	optional	optional
Boiler seasonal efficiency (1)	Database reference	E.1.1	optional	optional	optional	optional
	Default tables	E.1.2	optional	optional	optional	optional
	Boiler directive data	E.1.3	optional	optional	optional	optional
	Boiler cycling method	E.1.4	optional	optional	optional	optional
	Total stand-by losses	E.1.5	optional	optional	optional	optional
Controls settings verification		Annex F	suitable	suitable	suitable	suitable
Boiler sizing check		G.1.3	optional	optional	optional	optional

NOTES

(1) Specify required methodologies for necessary individual losses factors in the rows before

A.3 Heating system inspection

Default heating system inspection classes are based on:

- heated surface;
- type of building;
- heat generation power.

Table A4 – User and heating system identification information for use in 6.3

Heated surface	All			
Type of building	Residential		Non residential	
Nominal heat generation power	< 100 kW	> 100 kW	< 100 kW	> 100 kW
Owner/administrator name	Required	Required	Required	Required
Address	Required	Required	Required	Required
Total floor area or volume	Required	Required	Required	Required
Heated floor area or volume	Required	Required	Required	Required
Age of the building (1)	Required	Required	Required	Required
Height above sea level	Required	Required	Required	Required
Design outside temperature	Required	Required	Required	Required
Building category and use (2)	Required	Required	Required	Required
Building height	Required	Required	Required	Required
Type of building thermal insulation (3)	Required	Required	Required	Required
Conservation of building insulation (4)	Required	Required	Required	Required
Building plans / sketch	Optional	Required	Optional	Required
List of heated zones	Required	Required	Required	Required
Occupancy patterns and timing	Required	Required	Required	Required
Date of installation of the heating system	Required	Required	Required	Required
Heating system design	Required	Required	Required	Required
Commissioning reports	Optional	Required	Optional	Required
Energy declaration (5)	Required	Required	Required	Required
Functional diagram	Required	Required	Required	Required
Control system identification	Required	Required	Required	Required
Location of main components	Required	Required	Required	Required
Attached systems data	Required	Required	Required	Required
Heating medium quality reports	Optional	Required	Optional	Required

NOTES

(1) 0-20 Years / 20-50 Years / More than 50 years

(2) House / Apartment / Office/ etc as defined in EPBD Annex

(3) Non insulated / External insulation / Internal insulation

(4) Original / Improved / Damaged

(5) Depending on installation date

Table A5 – Space heating emission subsystem identification information for use in 6.8

Heated surface	All			
Type of building	Residential		Non residential	
Nominal heat generation power	< 100 kW	> 100 kW	< 100 kW	> 100 kW
Type of emitters (1)	Required	Required	Required	Required
Emitter hydraulic connection type (2)	Required	Required	Required	Required
Number of emitters	Optional	Required	Optional	Required

NOTES

(1) For each zone

(2) Direct / By-pass or Two pipes / Single pipe

Table A6 – Space heating emission control subsystem identification information for use in 6.9

Heated surface	All			
Type of building	Residential		Non residential	
Nominal heat generation power	< 100 kW	> 100 kW	< 100 kW	> 100 kW
Type of local control (1)	Required	Required	Required	Required
Type of central control (2)	Required	Required	Required	Required
Setting of outdoor reset function for supply water temperature	Required	Required	Required	Required
Time control type (3)	Required	Required	Required	Required
List of controls available to users	Required	Required	Required	Required
User instruction available	Required	Required	Required	Required

NOTES

(1) Manual / Zone / Room

(2) None / External temperature compensation

(3) None / Fixed time schedule / Occupancy based

Table A7 – Space heating distribution subsystem identification information for use in 6.10

Heated surface	All			
Type of building	Residential		Non residential	
Nominal heat generation power	< 100 kW	> 100 kW	< 100 kW	> 100 kW
Network typology (1)	Required	Required	Required	Required
Expansion system type	Required	Required	Required	Required
List of zones	Required	Required	Required	Required
Circulation type (2)	Required	Required	Required	Required
Status of space heating distribution system piping insulation	Required	Required	Required	Required
Circulation pump(s) maximum rated power	Required	Required	Required	Required
Circulation pump(s) set power	Required	Required	Required	Required
Circulation pump(s) type (4)	Required	Required	Required	Required
Circulation pump(s) working point (5)	Optional	Required	Optional	Required
Unbalancing symptoms (6)	Required	Required	Required	Required

NOTES

(1) zones/vertical columns,

(2) open vented / closed

(3) gravity/forced

(4) Fixed speed / adjustable speed / constant differential pressure / variable/proportional differential pressure

(5) Head and flow rate

(6) example: unequal room temperatures, time delay, different $\Delta\theta$s on emitters

Table A8 –Generation sub-system identification information for use in 6.11.1

Heated surface	All			
Type of building	Residential		Non residential	
Nominal heat generation power	< 100 kW	> 100 kW	< 100 kW	> 100 kW
Number of boilers installed	Required	Required	Required	Required
Total installed nominal power	Required	Required	Required	Required
Fuel(s)	Required	Required	Required	Required
Type of generation control	Required	Required	Required	Required
Hydraulic circuit functional diagram	Required	Required	Required	Required
Spare units	Required	Required	Required	Required

Table A8 –Generation sub-system identification information for use in 6.11.1

Heated surface	All			
Type of building	Residential		Non residential	
Nominal heat generation power	< 100 kW	> 100 kW	< 100 kW	> 100 kW
Other generation sub-systems type	Required	Required	Required	Required
NOTES				

Table A9 – Heating system boiler identification information for use in 6.11.2

Fuel type	Gaseous and liquid		Solid	
Nominal heat generation power	< 100 kW	> 100 kW	< 100 kW	> 100 kW
Boiler duty (heat/dhw)	Required	Required	Required	Required
Fuel(s)	Required	Required	Required	Required
Fuel feed typology (1)	Optional	Optional	Required	Required
Boiler manufacturer	Required	Required	Required	Required
Boiler model	Required	Required	Required	Required
Boiler serial number	Optional	Optional	Optional	Optional
Maximum power rated input (2)	Required	Required	Required	Required
Maximum power rated output (3)	Optional	Optional	Optional	Optional
Minimum power rated input (2)	Required	Required	Required	Required
Minimum power rated output (3)	Optional	Optional	Optional	Optional
Boiler manufacture date or year	Required	Required	Required	Required
Boiler classification (4)	Optional	Optional	Optional	Optional
Condensing/non condensing	Required	Required	Required	Required
CE labelling efficiency stars (if available)	Required	Required	Required	Required
Burner manufacturer and model (5)	Required	Required	Required	Required
Burner power range (5)	Required	Required	Required	Required
Power modulation type (6)	Required	Required	Required	Required

NOTES

(1) Automatic or manual

(2) Combustion power

(3) Net power to heating system

(4) Bxx or Cyyy : typology of air flue gas circuit, fan position, etc.

(5) If a separate burner is fit to the boiler

(6) Fixed, stepped (multistage), continuous modulation.

Table A10 – Procedures and methodologies required for heating system boiler inspection for use in 6.11.2

Fuel type			Gaseous and liquid		Solid fuel	
Nominal heat generation power			< 100 kW	> 100 kW	< 100 kW	> 100 kW
Combustion power	Measurement	B.1	suitable	suitable	suitable	suitable
	Maintenance data	B.2	suitable	NO	suitable	NO
Boiler basic setting and combustion efficiency	Measurement	D.1	suitable	suitable	suitable	suitable
	Maintenance data	D.2	NO	NO	NO	NO
Losses through the envelope (radiation losses) (1)	Tabulated values	E.5.1.1	suitable	suitable	suitable	suitable
	Surface temperature	E.5.1.2	suitable	suitable	suitable	suitable
Losses through the chimney with burner off (1)	Tabulated values	E.5.2	suitable	suitable	suitable	suitable
Total stand-by losses test (1)	Tabulated values	E.5.3.1	suitable	suitable	suitable	suitable
	Stand-by operation	E.5.3.2	suitable	suitable	suitable	suitable
	Auxiliary heater	E.5.3.3	suitable	suitable	suitable	suitable
Boiler annual efficiency	Database reference	E.1.1	suitable	suitable	suitable	suitable
	Default tables	E.1.2	suitable	suitable	suitable	suitable
	Boiler directive data	E.1.3	suitable	suitable	suitable	suitable
	Boiler cycling method	E.1.4	suitable	suitable	suitable	suitable
	Total stand-by losses	E.1.5	suitable	suitable	suitable	suitable
Settings verification		Annex F	suitable	suitable	suitable	suitable

NOTES

(1) As required by the selected methodology for boiler annual efficiency

Table A11 – Procedures and methodologies required for generation subsystem sizing for use in 6.12.1

Fuel type		Gaseous and liquid		Solid	
Nominal heat generation power		< 100 kW	> 100 kW	< 100 kW	> 100 kW
Heat load calculation	G.1.1	suitable	suitable	suitable	suitable
Existing heat load calculation	G.1.2	suitable	suitable	suitable	suitable
Energy signature	G.1.3	suitable	suitable	suitable	suitable
Fuel consumption	G.1.4	suitable	suitable	suitable	suitable
Emitters installed	G.1.5	suitable	suitable	suitable	suitable
NOTES Preferred methodology: energy signature					

Table A12 – Procedures and methodologies required for heating system subsystems performance determination, for use in 6.13

Building type			Residential		Non residential	
Nominal heat generation power			< 100 kW	> 100 kW	< 100 kW	> 100 kW
Emission	Tabulated calculation method–	prEN 15316-2-1	suitable	suitable	suitable	suitable
Emission control	Tabulated calculation method	prEN 15316-2-1	suitable	suitable	suitable	suitable
Distribution	Tabulated calculation method	prEN 15316-2-3	suitable	suitable	suitable	suitable

Table A13 – Domestic hot water sub-system identification information for use in 6.14

Type of building	Residential		Non residential	
Nominal heat generation power	< 100 kW	> 100 kW	< 100 kW	> 100 kW
Type of domestic hot water production (1)	Required	Required	Required	Required
Heat source type and duty (2)	Required	Required	Required	Required
Boiler nominal power	Required	Required	Required	Required
Heat exchanger capacity	Required	Required	Required	Required
Storage volume	Required	Required	Required	Required
Type of domestic hot water production control	Required	Required	Required	Required
Type of recirculation (3)	Required	Required	Required	Required
Circulation pump(s) maximum rated power	Required	Required	Required	Required
Circulation pump(s) set power	Required	Required	Required	Required
Circulation pump(s) type (4)	Required	Required	Required	Required
Recirculation timing	Required	Required	Required	Required
Status of domestic hot water piping insulation	Required	Required	Required	Required

NOTES

(1) Instantaneous / Storage

(2) Specific generator / Heating system generator

(3) gravity/forced

(4) Fixed speed / adjustable speed / constant differential pressure / variable/proportional differential pressure

Wrong order: A reference to annex B first appears in annex E, a reference to annex C in annex G, and references to annexes D, E, G and K are only partly existent or not existent at all. This is not in accordance to CEN/CENELEC – Internal Regulations – Part 3, 5.2.6

Annex B
(informative)
Boiler combustion power

B.1 Measurement methodologies

B.1.1 Gaseous fuel with meter

B.1.1.1 Measurement procedure

Measure volumetric flow rate $\dot{V}_f$ according to the following procedure:

- verify that there are no other appliances drawing gas from the same meter during measurement;
- check gas pressure;
- stabilise burner operation at power to be measured;
- measure volumetric flow rate;

  EXAMPLE: Measure time interval between readings.

- if required, apply correction to volume reading as specified in B.1.1.2;

Calculate combustion power Φ_{cn} in kW according to:

$$\Phi_{cn} = \dot{V}_f \cdot H_x \qquad \text{[kW] [B1]}$$

where

- $\dot{V}_f$ fuel volumetric flow rate in Nm³/h or Stm³/h;
- H_x fuel combustion heat in kWh/Nm³ or kWh/Stm^3 (either net or gross) given in prEN 15315 – annex D or in a national annex.

Record fuel flow rate and calculated power in the report.

Record if net or gross calorific value is used.

Reset burner or boiler controls.

B.1.1.2 Correction of gas volume readings

If the gas pressure is higher than 20 mbar or the temperature of the gas differs by more than 10°C from the reference condition, pressure and/or temperature at the flow rate measuring point shall be measured and readings from volumetric measurement devices shall be corrected according to applicable national standards or to the following formulas.

The volumetric correction factor k_v is given by:

$$k_v = \frac{P_{meas}}{P_0} \cdot \frac{T_0}{T_{meas}} \qquad \text{[B2]}$$

where:

- T_{meas} absolute temperature of gas at the measuring point;
- P_{meas} absolute pressure of gas at the measuring point;
- T_0 reference absolute temperature of gas;
- P_0 reference absolute pressure of gas.

NOTE normal cubic meters (Nm³/h) are referred to 0°C / 1 bar abs, standard cubic meters are referred to 15°C / 1 bar abs

The normalised volume volumetric flow rate $\dot{V}_f$ is given by:

$$\dot{V}_f = \dot{V}_{meas} \cdot k_v \qquad \text{[B3]}$$

where:

- $\dot{V}_m$ actual measured gas volume;

B.1.2 Gaseous fuel with no meter available

If no gas meter is available, fuel flow rate can be calculated according to:

- pressure measured before nozzle;
- size of nozzle;
- suitable information on pressure/flow relationship (example: tables supplied by the manufacturer).

B.1.3 Liquid fuel with meter available

Measure volumetric flow rate $\dot{V}_f$ according to the following procedure:

- verify that there are no other appliances drawing fuel from the same meter during measurement;
- stabilise burner operation at power to be measured;
- measure volumetric flow rate $\dot{V}_f$;

  EXAMPLE: Measure time interval between readings.

- calculate combustion power Φ_{cn} in kW according to

$$\Phi_{cn} = \dot{V}_f \cdot \rho_f \cdot H_x \qquad \text{[B4]}$$

where

- $\dot{V}_f$ fuel volumetric flow rate in l/h;
- H_x fuel combustion heat in kWh/kg (either net or gross) given in prEN 15315 – annex D or in a national annex.;
- ρ_f fuel density in kg/l;

Record fuel flow rate and calculated power in the report.

Record if net or gross calorific value is used.

Reset burner or boiler controls.

If two separate meters are used for flow and return pipes, accuracy of the measurement of the net fuel flow shall be estimated.

B.1.4 Liquid fuel with no meter available

Fuel flow rate can be determined according to:

- pressure measured before nozzle;
- type and size of nozzle;
- suitable information on pressure/flow relationship (example: tables supplied by nozzle manufacturer).

If there is a return (modulating) nozzle:

- both flow and return pressure shall be measured;
- a suitable table supplied by nozzle manufacturer shall be used.

Information on pressure/flow rate relationship shall be appropriate to actual fuel viscosity.

NOTE: For single pipe systems, fuel flow rate can be determined by installation of a provisional meter and applying the method given in B.1.3.

B.1.5 Fuel weighting

Measure time to feed a known weight of solid or liquid fuel.

NOTE: For a liquid fuel burner, the flow rate can be determined by feeding the burner from a provisional tank on a weight measuring device.

B.2 Maintenance data

Combustion power can be obtained from maintenance records, if available.

Maintenance records shall be checked for reliability.

The source of information shall be recorded.

B.3 Advice criteria on combustion power

Advice on combustion power setting shall be based on the following criteria.

Actual set maximum combustion power and minimum combustion power (for multistage or modulating boilers) should be reduced to the lowest possible value sufficient for correct operation conditions because this:

- increases combustion efficiency;
- reduces stand-by losses relative to net energy supplied to the distribution sub-system (because of increase of burner-on efficiency and reduction of stand-by time);

taking into account the following limitations:

- any setting shall be within the range specified and allowed by the boiler and/or burner manufacturer;

- boilers without combustion air setting (only fuel setting) may not benefit from a reduced combustion power (i.e. fuel flow rate);
- actual (set) maximum combustion power shall not exceed nominal combustion power for safety reasons
- actual (set) maximum combustion power shall be sufficient to provide power required for designed operation (i.e. instantaneous domestic hot water, coldest days for space heating, any attached systems or requirements of the distribution sub-system);
- actual (set) minimum (maximum for single stage burners) combustion power shall be sufficient to avoid condensation in boiler or chimney if they are not designed and suitable for this operation condition. Flue gas temperature has to be checked therefore, taking into account possible boiler water temperature reductions;
- actual (set) minimum combustion power shall be sufficient to:
  - guarantee flame stability;
  - provide acceptable ignition conditions;
  - provide satisfactory emission levels;
  - avoid combustion efficiency decay because of high excess air.

Annex C
(informative)
Space heating and domestic hot water energyware consumption evaluation

C.1 General

Energyware consumption evaluation for the space heating system and domestic hot water production system shall be performed according to general criteria defined in EN 15315 chapter 7 " 7 Measured energy use ". Information about specific issues is given in the following.

Energyware consumption evaluation for a heating system shall take into account separately, as far as reasonably possible:

- fuel and auxiliary energy;
- heating, domestic hot water production and other usages consumption.

Energyware consumption for space heating shall be referred to a heating season base. Further reference to specific climatic data (i.e. corresponding year) might be appropriate.

Energyware consumption for domestic hot water production shall be referred to:

- an annual base;
- the corresponding volume of domestic hot water supplied, if available.

Winter and summer operation should be considered separately, as appropriate and possible.

C.2 Energyware measurement methodologies

C.2.1 Fuel with meter

Identify any other usage (cooking, domestic hot water dedicated appliances, attached systems, etc.) that is fed by the same meter for successive separation.

The volume of fuel consumed V_{cons} shall be determined as:

$$V_{cons} = V_{rd,fin} - V_{rd,ini} \qquad \text{(C1)}$$

where

- $V_{rd,fin}$ final reading
- $V_{rd,ini}$ initial reading

Readings may be obtained from:

- maintenance reports, previous inspection reports (see 5.8) or heating system log-books;
- invoices or delivery notes of the energyware supplier.

The date of each reading shall be checked carefully.

If the source is an invoice or delivery note, one shall verify:

- the date of the reading or delivery, which may be different from the invoice date;
- that the invoice is based on an actual reading.

NOTE Energyware suppliers may send periodic invoices based on an estimated reading.

C.2.2 Fuel with tank

The volume of fuel consumed V_{cons} shall be determined as:

$$V_{cons} = V_{meas,ini} + \Sigma V_{del} - V_{meas,fin} \quad \text{(C2)}$$

- $V_{meas,fin}$ final volume of fuel in the storage;
- $V_{meas,ini}$ initial volume of fuel in the storage;
- ΣV_{del} sum of the deliveries in the considered period.

If the initial volume of the fuel in the storage $V_{m,ini}$ is not known, an estimate has to be provided based on known delivery dates and expected consumption in the intervals between deliveries. This shall be clearly stated in the report.

An estimation based over several years is recommended to reduce the effect of the uncertainties (storage volume readings and others).

C.2.3 Fuel with hour counter

If no meter or delivery note is available, fuel consumption evaluation can be based on hour counters readings, either directly installed on the appliances or on a building management system.

The volume of fuel consumed V_{cons} shall be determined as:

$$V_{cons} = \sum_i \left[\left(t_{rd,fin,i} - t_{rd,ini,i} \right) \cdot \dot{V}_i \right] \quad \text{(C3)}$$

where

- $t_{rd,fin,i}$ final reading of the hour counter;
- $t_{rd,ini,i}$ initial reading of the hour counter;
- $\dot{V}_i$ fuel volume flow rate associated with the hour counter.

Proportionality of fuel consumption to hour counter readings has to be checked.

EXAMPLE Proportionality might not be true for modulating or multistage burners.

C.2.4 Electrical energy measurement

C.2.4.1 Electrical energy, meter available

If a dedicated electrical energy metering device is available, the methodology specified in C.2.1 shall be used.

It has to checked which devices are supplied through the meter. Significant corrections may be provided, according to methodologies suggested in C.2.4.2 below as far as reasonably possible, for:

- energy to be added because of heating system devices not connected through the meter;

- energy to be subtracted because of devices connected through the meter which are not part of the heating system.

C.2.4.2 Electrical energy, no meter available

If no meter is available, electrical energy W should be estimated as:

$$W = \sum_i t_i \cdot \Phi_{W,i} \qquad \text{(C4)}$$

where

- t_i actual (either estimated or measured) operation time of the device (or group of devices);
- $\Phi_{W,i}$ actual (either measured or estimated) absorbed electrical power.

NOTE Do not use nominal (rated) electrical power as this is different from actually used (absorbed) power.

For the purpose of estimating the operation time of devices, they should be divided into the following main groups:

- devices running continuously;
- devices running when the heating system is on (boiler on);
- devices running in proportion to energy delivered (burner on).

NOTE 1 Time periods with heating system on are usually determined by time switches

NOTE 2 Time periods with burner on can be estimated according to the load factor of the heating system.

C.3 Measurement period

C.3.1 General

Energyware consumption shall be assessed on a clearly defined reference period, which should be one year or one heating season.

The actual measurement or observation period may be different (either shorter or longer) than the reference period.

NOTE 1 Shorter periods are typical for on site tests with system running

NOTE 2 Longer periods should be used for estimations based on recorded data, thus allowing to reduce the influence of climatic data or uncertainties of initial stored fuel level.

The actual measurement period shall be clearly identified and recorded as well as the methodology used to calculate the equivalent consumption in the reference period.

C.3.2 Extrapolation criteria

Extrapolation may be performed according to the following methodologies, as appropriate.

For energywares used at constant average power, the energyware in the reference period EWA_{ref} is given by (linear extrapolation):

$$EWA_{ref} = EWA_{meas} \cdot \frac{t_{ref}}{t_{meas}} \qquad \text{(C5)}$$

where

- t_{meas} measurement period;
- t_{ref} reference period;
- EWA_{meas} energyware amount measured during t_{meas};

For energywares used for heating, the extrapolation can be performed either by using the energy signature signature (see prEN 15315, Annex B) or by weighting according to degree-days (DD) or other appropriate data.

$$EWA_{ref} = EWA_{meas} \cdot \frac{DD_{ref}}{DD_{meas}} \qquad \text{(C6)}$$

where

- DD_{meas} degree-days (or other appropriate data) in the measurement period;
- DD_{ref} degree-days (or other appropriate data) in the reference period;
- EWA_{meas} measured energyware amount;

EXAMPLE Other appropriate data may be occupancy.

If the assessment is done by energy signature, the assessment period should encompass a wide range of values of the average external temperature.

NOTE: Different extrapolation criteria may be appropriate for winter and summer operation.

C.4 Usage separation

Usage of metered energyware shall be clearly identified (cooking, domestic hot water dedicated appliances, attached systems, etc.)

Other usage of fuel may be evaluated and separated based on:

- recorded readings when no heating is supplied;

  EXAMPLE Summer data typically provides the sum of cooking usage and domestic hot water.

- default values from national tables. An example of such tables is given in Table C1.

NOTE: Other usage is typical of gas.

Table C1 – Sample values for cooking (natural gas)

Residential unit surface [m²]	Energy for cooking [MJ/day]
Up to 50 m²	15 MJ/day
From 50 to 120 m²	20 MJ/day
Over 120 m²	30 MJ/day
NOTE: Data from Italian CTI recommendation	

C.5 Climatic data and domestic hot water production

The following data should be supplied for the same reference period as energyware measurement, as appropriate and available, to support comparison with reference values:

- climatic data;
- building internal temperature setting and/or actual value;
- domestic hot water consumed.

C.6 Reference values

Reference specific values for the fuel and auxiliary energy consumption shall be given in national tables according to building typology. An example of such tables is given in Table C2 and TableC3.

Table C.2 – Sample table of reference values for expected energyware consumption for heating

Description	Fuel		Auxiliary energy
	$\frac{kJ}{m^3 \cdot °C \cdot day}$	$\frac{Wh}{m^2 \cdot °C \cdot day}$	$\frac{Wh}{m^3 \cdot °C \cdot day}$
Single family dwellings	80	66,7	0,3
…	…	…	…
Multifamily dwellings	60	41,7	0,2
NOTE 1 two possibilities for fuel units are shown in this table as an example NOTE 2 units for electrical energy may be others, too (i.e. referred to m² instead of m³, MJ instead of kWh, expressed as a percentage of fuel energy etc.).			

Table C.3 – Sample table of target reference values for energyware consumption for heating

External gross surface over gross volume ratio $[m]^{-1}$	Fuel		Auxiliary energy
	$\frac{kJ}{m^3 \cdot °C \cdot day}$	$\frac{Wh}{m^2 \cdot °C \cdot day}$	$\frac{Wh}{m^3 \cdot °C \cdot day}$
0,3	18	15	0,05
0,5	29	24,2	0,09
0,7	41	34,2	0,14
0,9	50	41,6	0,2
NOTE: Values shown for fuel are proposed in Italy as primary energy limit –for 2200 °C·day (northern Italy).			

Reference for auxiliary energy may be given in a national table also as a percentage of (or relative value to) fuel consumption.

C.7 Advice criteria on energyware consumption

Advice shall take into account that possible reasons for deviations in energy consumption might be:

- use of the building (occupancy);
- users behaviour;
- wrong room ventilation rates;
- high building envelope losses (missing or degraded insulation layer);
- actual climatic conditions, including degree days and solar radiation;
- heating system inefficiencies (e.g. poor balancing) ;
- oversizing of boilers;
- wrong settings of heating system controls;
- losses of heating medium from concealed piping;
- losses of fuel.

To ease tracking of energyware consumption, the following actions should be recommended:

- organise collection of data on fuel supply and periodic reading of available meters and fuel level in tanks;
- organise collection of actual climatic data;
- if missing, provide a counter for total domestic hot water supplied;
- if missing, provide an hour counter in parallel with burner fuel valve(s);
- if missing, provide independent electrical energy meters for high consuming appliances (example: heat pump, oil heaters, distribution pumps, boiler room, etc.).

Annex D
(informative)
Flue gas analysis and boiler basic setting check

D.1 Measuring procedure

D.1.1 General procedure

Sample flue gas near boiler discharge, at least within 3 diameters.

Sampling hole shall be tight.

Flue gas shall be sampled in the middle of the stream. The hottest point or the point with lowest measured O_2 are also suitable.

Combustion air temperature shall be measured at burner intake. Simultaneous measurement of flue gas and intake air temperature is recommended.

If there is a combustion air preheater, flue gas temperature and combustion air temperature shall be measured between boiler and heat recovery device.

The following flue gas properties shall be measured in the same point, preferably with a multifunction device (combined probe), using an instrument complying with EN 50379:

- θ_{fl} flue gas temperature (°C)
- $O_{2\ fl,dry}$ oxygen dry flue gas contents (%)
- CO flue gas contents (ppm)
- θ_{air} combustion air temperature (°C) shall be measured at the burner intake.

Adequate measuring ports shall be provided either by the installer or by the manufacturer of boilers.

Before reading and recording values, operator shall wait for the response time of the instrument.

Water temperature may be read on boiler or flow pipe thermometer as available.

D.1.2 Combustion efficiency

Sensible heat flue gas losses $P_{ch,on,s}$ (sensible heat losses through the chimney with burner on) shall be calculated from properties measured according to D.1.1 and relevant national standards or methods specified in EN 50379. A typical formula is:

$$P_{ch,on,s} = \left(\theta_{fl} - \theta_{air}\right) \cdot \left(\frac{A}{21 - O_{2,\,fl,dry}} + B \right) \qquad [\%] \qquad (D1)$$

where A and B are constants given in national annexes, depending on the fuel.

Combustion efficiency η_{cn} is given by

$$\eta_{cn} = 100 - P_{ch,on,s} \qquad [\%] \qquad (D2)$$

$P_{ch,on,s}$ may be corrected to take into account a different running temperature as specified in prEN 15316-4-1, paragraph 5.4.3.2.

D.1.3 Condensation latent heat recovery

D.1.3.1 General

For low flue gas temperature, a correction (additive term) shall be applied to take into account latent heat recovery as specified in EN 50379.

$$\eta_{cn,corr} = \eta_{cn} + \Delta\eta_{cn,cond} \quad [Nm^3/Nm^3] \text{ or } [Nm^3/kg] \quad (D3)$$

If no national standard is available, the correction factor for condensation $\Delta\eta_{cn,cond}$ can be calculated according to the methodologies given in D.1.3.2.

D.1.3.2 Calculation of condensation latent heat recovery

Default data on fuel for condensation heat recovery calculation is given in Table D1. If other fuels are used, data should be given in a national annex.

Table D1 – Data for condensation heat recovery calculation

Property	Symbol	Unit	Fuel				
			Methane	Natural gas (Groningen)	Propane	Butane	Fuel oil EL
Gross calorific value	H_s	J/kg or J/Nm³	$39,851 \cdot 10^6$ [J/Nm³]	$35,169 \cdot 10^6$ [J/Nm³]	$101,804 \cdot 10^6$ [J/Nm³]	$131,985 \cdot 10^6$ [J/Nm³]	$45,336 \cdot 10^6$ [J/kg]
Net calorific value	H_i	J/kg or J/Nm³	$35,790 \cdot 10^6$ [J/Nm³]	$31,652 \cdot 10^6$ [J/Nm³]	$93,557 \cdot 10^6$ [J/Nm³]	$121,603 \cdot 10^6$ [J/Nm³]	$45,270 \cdot 10^6$ [J/kg]
Stoichiometric dry air	$V_{air,st}$	Nm³/kg or Nm³/Nm	9,52 [Nm³/Nm³]	8,4 [Nm³/Nm³]	23,8 [Nm³/Nm³]	30,94 [Nm³/Nm³]	11,23 [Nm³/kg]
Stoichiometric dry flue gas	$V_{fl,st,dry}$	Nm³/kg or Nm³/Nm	8,52 [Nm³/Nm³]	7,7 [Nm³/Nm³]	21,8 [Nm³/Nm³]	28,44 [Nm³/Nm³]	10,49 [Nm³/kg]
Stoichiometric water production	$M_{H2O,st}$	kg/kg or kg/Nm³	1,61 [kg/Nm³]	1,405 [kg/Nm³]	3,3 [kg/Nm³]	4,03 [kg/Nm³]	1,18 [kg/kg]

The following properties of flue gas shall be measured:

- θ_{fl} flue gas temperature [°C]
- $O_{2\ fl,dry}$ oxygen flue gas contents [%]

The following properties of flue gas shall be measured or estimated:

- θ_{air} combustion air temperature [°C]. If not measured assume external temperature from climatic data
- HUM_{air} combustion air relative humidity . Assume 50% if not measured
- HUM_{fl} flue gas relative humidity. Assume 100% if not measured

If flue gas CO_2 contents $CO_{2\,fl,dry}$ is measured instead of $O_{2\,fl,dry}$, get $O_{2\,fl,dry}$ from:

$$O_{2\,fl,dry} = 20{,}94 \cdot \frac{CO_{2\,st} - CO_{2\,fl,dry}}{CO_{2\,st}} \quad [\%] \quad (D4)$$

where $CO_{2\,st}$ is the CO_2 contents of stoichiometric flue gas, given in national tables according to the fuel.

The actual amount of dry flue gas $V_{fl,dry}$ is given by:

$$V_{fl,dry} = V_{fl,st,dry} \cdot \frac{20{,}94}{20{,}94 - O_{2\,fl,dry}} \quad [Nm^3/Nm^3] \text{ or } [Nm^3/kg] \quad (D5)$$

The actual amount of dry combustion air $V_{air,dry}$ is given by:

$$V_{air,dry} = V_{air,dry} + V_{fl,dry} - V_{fl,st,dry} \quad [Nm^3/Nm^3] \text{ or } [Nm^3/kg] \quad (D6)$$

NOTE $V_{fl,dry} - V_{fl,st,dry}$ is excess air

Saturation humidity of air $M_{H2O,air,sat}$ and flue gas $M_{H2O,fl,sat}$ shall be calculated according to θ_{air} (combustion air temperature) and θ_{fl} (flue gas temperature) respectively and expressed as kg of humidity per Nm³ of dry air or flue gas. Data can be found in the following Table D2. Interpolation or polynomial approximations may be used for intermediate temperatures.

Table D2 – Saturation humidity as a function of temperature

Temperature	°C	0	10	20	30	40	50	60	70
Saturation humidity	kg/Nm³	0,00493	0,00986	0,01912	0,03521	0,06331	0,1112	0,1975	0,3596
NOTE: Saturation humidity expressed as kg of water vapour per Nm³ of dry gas									

Total humidity of combustion air $M_{H2O,air}$ is given by

$$M_{H2O,air} = M_{H2O,air,sat} \cdot V_{air,dry} \cdot \frac{HUM_{air}}{100} \quad [kg/Nm^3] \text{ or } [kg/kg] \quad (D7)$$

Total humidity of flue gas $M_{H2O,fl}$ is given by

$$M_{H2O,fl} = M_{H2O,fl,sat} \cdot V_{fl,dry} \cdot \frac{HUM_{fl}}{100} \quad [kg/Nm^3] \text{ or } [kg/kg] \quad (D8)$$

The amount of condensing water $M_{H2O,cond}$ is given by:

$$M_{H2O,cond} = M_{H2O,st} + M_{H2O,air} - M_{H2O,fl} \quad [kg/Nm^3] \text{ or } [kg/kg] \quad (D9)$$

If $M_{H2O,cond}$ is negative there is no condensation. Then $M_{H2O,cond} = 0$ and $\Delta\eta_{cn,cond} = 0$.

The condensation specific latent heat $H_{cond,fl}$ is given by:

$$H_{cond,fl} = 2500600 - \theta_{fl} \cdot 2435 \quad [J/kg] \quad (D10)$$

The condensation heat Q_{cond} is given by:

$$Q_{cond} = M_{H2O,cond} \cdot H_{cond.fl} \quad [J/Nm^3] \text{ or } [J/kg] \quad (D11)$$

The correction factor for condensation $\Delta\eta_{cn,cond}$ is given by

$$\Delta\eta_{cn,cond} = \frac{100 \cdot Q_{cond}}{H_s} \text{ or } \Delta\eta_{cn,cond} = \frac{100 \cdot Q_{cond}}{H_i} \quad [\%] \quad (D12)$$

depending on whether combustion efficiency η_{cn} was calculated relative to H_s or H_i.

For natural gas and fuel oil EL, correction factor for combustion efficiency referred to H_i is given in table D.3, based on dry flue gas oxygen contents and temperature, assuming:

- θ_{air} = 10 °C
- HUM_{air} = 80%
- HUM_{fl} = 100%.

Table D3 - Condensation correction factor for natural gas and fuel oil EL

Flue gas temperature		[°C]	10	15	20	25	30	35	40	45	50	55	58	60	62	64
Natural gas	$\Delta\eta_{cn,cond}$ with $O_{2,fl,dry}$ = 0%	[%]	11,1	10,8	10,4	10,0	9,5	8,8	8,0	6,9	5,6	4,1	3,0	2,2	0,2	0,1
	$\Delta\eta_{cn,cond}$ with $O_{2,fl,dry}$ = 3%	[%]	11,1	10,7	10,3	9,8	9,2	8,4	7,5	6,3	4,8	3,0	1,7	0,8		
	$\Delta\eta_{cn,cond}$ with $O_{2,fl,dry}$ = 6%	[%]	11,0	10,7	10,2	9,6	8,9	7,9	6,8	5,3	3,6	1,4				
	$\Delta\eta_{cn,cond}$ with $O_{2,fl,dry}$ = 9%	[%]	11,0	10,5	10,0	9,2	8,3	7,2	5,8	4,0	1,8					
Fuel oil EL	$\Delta\eta_{cn,cond}$ with $O_{2,fl,dry}$ = 0%	[%]	6,0	5,7	5,3	4,9	4,4	3,7	2,9	1,8	0,5					
	$\Delta\eta_{cn,cond}$ with $O_{2,fl,dry}$ = 3%	[%]	6,0	5,6	5,2	4,7	4,1	3,3	2,4	1,2						
	$\Delta\eta_{cn,cond}$ with $O_{2,fl,dry}$ = 6%	[%]	5,9	5,6	5,1	4,5	3,8	2,8	1,7	0,2						

D.1.4 Bacharach test

Force a known volume of flue gas through a paper filter.

Compare color of dot on paper filter with an appropriate reference scale.

D.2 Maintenance data

Flue gas analysis data can be obtained from maintenance records, if available.

The source of information shall be recorded and reliability of such information checked.

D.3 Reference values for flue gas analysis

Reference values for flue gas properties shall take into account:

- instructions and specifications by appliance manufacturer or system designer;
- values given in national tables.

If no such reference is available, the following values are considered good practice

Table D4 - Reference values for flue gas properties

Fuel	$[O_2]$ [%]	Temperature [°C]	CO [ppm]	Bacharach [-]	Combustion efficiency [%]
Natural gas non condensing	2-4 (1)	120-160	<100		>92
Natural gas condensing	2-4	$\theta_{gn,w,r}$ + 5-20 °C (2)	<100		(2)
Light oil non condensing	3-5	140-180	<50	< 1	>90
Fuel oil EL condensing	2-5	$O_{gn,w,r}$ + 5-20 °C (2)	< 50	< 1	(2)

NOTES

(1) Value referred to flue gases before any mixing with tertiary or dilution air

(2) Depending on return water temperature $\theta_{gn,w,r}$ and combustion power (modulating step)

D.4 Advice on boiler basic setting

Advice should include recommendation to set the burner within the limits defined in previous D.3, taking into account the following criteria:

- minimum oxygen contents shall guarantee against drift towards defect air, which would result in high pollution, energy waste and explosion danger

  NOTE approximately 1% higher oxygen is required if setting in summer conventional burners (drift according to combustion air temperature)

- maximum oxygen contents shall guarantee against drift towards high excess air, which would result in pollution and energy waste. High excess air inhibits condensation.
- Minimum flue gas temperature is required to prevent conventional boiler or chimney corrosion.
- CO contents shall be reduced to a minimum anyway.

Recommendation shall be given to check burner excess air setting stability (compare with previous setting before maintenance or test after power stepping).

Annex E
(informative)
Boiler seasonal efficiency

E.1 Measurement and estimation methodologies

E.1.1 Database reference

Use the boiler identity data to find, from a reliable source, the seasonal efficiency of the boiler when new and installed in comparable conditions. Record the method used to calculate the seasonal efficiency.

E.1.2 Default tables

Use the boiler identity data to find the seasonal efficiency of the boiler in a table supplied in a national annex.

An example is given in Table P1 and Table P2.

E.1.3 Boiler directive data

Use the boiler identity data to find the 30% part-load boiler efficiency, and multiply by a tabulated factor given in a national table to get approximate seasonal efficiency. Record whether the efficiency has been calculated from net or gross calorific value of the fuel.

An example of such table is given in Table E1.

Table E1: Sample boiler conversion factor - multiplication factor on part load efficiency to determine seasonal efficiency

Floor-mounted				Wall-mounted			
Natural draught		Forced draught		Natural draught		Forced draught	
Permanent pilot flame	Electronic ignition	Permanent pilot flame	Electronic ignition	Permanent pilot flame	Electronic ignition	Permanent pilot flame	Electronic ignition
0,85	0,9	0,91	0,94	0,91	0,94	0,92	0,96

If 30% part-load efficiency is not available, use the boiler identity data to find the full-load efficiency, and multiply by a tabulated factor given in a national table to get approximate seasonal efficiency. Record whether the efficiency has been calculated from net or gross calorific value of the fuel.

An example of such table is given in Table E2.

Table E2: Sample boiler conversion factor - multiplication factor on full-load efficiency to determine seasonal efficiency

Floor-mounted				Wall-mounted			
Natural draught		Forced draught		Natural draught		Forced draught	
Permanent pilot flame	Electronic ignition	Permanent pilot flame	Electronic ignition	Permanent pilot flame	Electronic ignition	Permanent pilot flame	Electronic ignition
0,80	0,85	0,87	0,92	0,87	0,92	0,89	0,94

E.1.4 Boiler cycling method

Measure combustion efficiency η_{cn} [%] as described in D.1.

Determine loss factor $P_{gn,env}$ according to E.5.1.

Determine loss factor $P_{ch,off}$ according to E.5.2.

Estimate FC as specified in E.4.

If data on running temperatures are available (either estimated or measured), correct the loss factors according to prEN 15316-4-1, § 5.3.3.

NOTE Losses through the envelope and stand-by losses through the chimney are considered to be proportional to the difference between average boiler temperature and boiler room temperature.

Estimate seasonal generation efficiency η_{gn} by:

$$\eta_{gn} = \eta_{cn} - \left(\frac{1}{FC} - 1\right) \cdot P_{CH,off} - \frac{1}{FC} \cdot P_{gn,env} \quad [\%] \quad (E1)$$

E.1.5 Total stand-by losses method

Measure combustion efficiency η_{cn} [%] as described in D.1.

Determine loss factor $P_{gn,env}$ according to E.5.1.

Determine total stand-by losses P_0 according to E.5.3.

Estimate FC as specified in E.4.

Calculate seasonal generation efficiency η_{gen} by:

$$\eta_{gen} = \left(\eta_{cn} - P_{gn,env}\right) \cdot \frac{100 - \frac{P_0}{FC}}{100 - P_0} \quad (\%) \quad (E2)$$

E.2 Reference values

Reference values for seasonal efficiency may be obtained from:

- design specification;

- energy declaration data;
- national tables specifying seasonal efficiency according to boiler and heating system typology. An example is given in Table P1 and Table P2.

E.3 Advice

Compare efficiency of inspected generation subsystem or boiler with appropriate reference values, which are:

- expected efficiency (design specification or similar system average value);
- best achievable value (average efficiency of best available systems).

Recommend actions on factors affecting seasonal efficiency, as appropriate:

- improve combustion efficiency;
- reduce combustion power;
- increase boiler envelope insulation;
- limit air flow to the stack with burner off (air intake closure during stand-by);
- avoid high frequency intermittency (boiler thermostatic settings)
- modify system operation parameters or timing or upgrade the distribution and emission control system to reduce average and return water temperature to the boiler.

E.4 Boiler FC (average load) determination

E.4.1 Introduction

In this standard, FC is used as an intermediate input for the estimation of average efficiency of a boiler.

E.4.2 Fuel consumption method

Determine actual fuel consumption V_f as described in C.1 .

Determine actual set maximum combustion power Φ_{cn} as described in Annex B

Calculate the operation time t_{gn} of the generator from

t_{gn} = days of operation x operation hours per day x 3600 [s] [E3]

or read it from a dedicated hour counter, if available.

NOTE 1: This hour counter shall be connected to the boiler on signal, not the burner on signal.

NOTE2: Eq. E3 can be applied only if operation time is a known schedule.

Determine the actual average load FC of the generator by:

$$FC = \frac{V_f \cdot H_x}{\Phi_{cn} \cdot t_{op}} \cdot units\ factor \qquad [-] \qquad [E4]$$

where H_x is either H_s or H_i according to which has been used to determine Φ_{cn}.

E.4.3 Operation hour counter method

If an hour counter is fit on the fuel valve, read fuel valve open time t_{on}.

Determine hours of operation of the boiler t_{gn} as specified in E.4.2.

Determine FC by:

$$FC = \frac{t_{on}}{t_{gn}} \quad [-] \quad [E5]$$

E.5 Estimation of loss factors

E.5.1 Losses through the envelope (radiation losses)

E.5.1.1 Boiler surface temperature method

Losses through the boiler envelope, factor $P_{gn,env}$ (%), can be estimated on site with the following procedure.

Divide the envelope of the boiler into a number of elementary surfaces. The number of elementary surfaces shall be at least:

- 2 for non insulated parts;
- 8 for insulated parts.

For each elementary surface i:

- determine the area A_i;
- measure the surface temperature θ_i.

For each elementary surface i, determine the heat transfer coefficient α_i according to the following Table E3:

Table E3 – Heat transfer coefficient for use in equation E6

Surface temperature	[°C]	30	80	150
Heat transfer coefficient α_i	[W/m²·K]	9	12	15

Calculate the absolute value of losses through the envelope $\Phi_{gn,env}$ by:

$$\Phi_{gn,env} = \sum_i A_i \cdot \alpha_i \cdot \left(\theta_i - \theta_{\text{int}}\right) \quad (E6)$$

where θ_{int} is the boiler room temperature.

Calculate relative losses through the envelope $P_{gn,env}$ by:

$$P_{gn,env} = \frac{100 \cdot \Phi_{gn,env}}{\Phi_{cn}} \quad (E7)$$

The test should be performed with an average water temperature of the boiler of 70 °C.

If the average water temperature $\theta_{gn,w,av}$ is not 70 °C or the boiler room temperature θ_{int} during the test is not 20 °C, the value $P_{gn,env}$ shall be obtained from the measured value $P_{ge,env,meas}$ by:

$$P_{gn,env} = P_{gn,env,meas} \frac{50}{\theta_{gn,w,av} - \theta_{\text{int}}} \qquad \text{(E8)}$$

NOTE This equation can be combined with eq. E7 to get immediately the standard value of $P_{gn,env}$ at ΔT=50°C.

E.5.1.2 Tabulated values

Losses through the boiler envelope, factor $P_{gn,env}$ (%), can be found either in a table in a national annex or calculated according to:

$$P_{gn,env} = A - B \cdot \text{Log}\Phi_{cn} \qquad [\%] \qquad \text{(E9)}$$

where

A,B parameters given in a national annex. Default values are given in Table E4

Φ_{cn} generator nominal combustion power in kW

Table E4 – A and B coefficients for $P_{gn,env}$ calculation

Generator insulation type	A	B
Well insulated, high efficiency generator	1,72	0,44
Well insulated and maintained	3,45	0,88
Old generator with average insulation	6,90	1,76
Old generator, poor insulation	8,36	2,2
No insulation	10,35	2,64

E.5.2 Losses through the chimney with burner off

Identify stand-by losses through the chimney factor $P_{ch,off}$ in a national annex or in the default Table E5

Table E5 – Default values for $P_{ch,off}$ factor

Description	$P_{ch,off}$ [%]
Liquid fuel or gas fired boiler with the blower before the combustion chamber and automatic closure of air intake with burner off Premixed burners	0,2
Wall mounted, gas fired boiler with blower and wall flue gas exhaust	0,4
Liquid fuel or gas fired boiler with the blower before the combustion chamber and no closure of air intake with burner off	
Chimney height < 10 m	1,0
Chimney height > 10 m	1,2
Atmospheric gas fired boiled	

Table E5 – Default values for $P_{ch,off}$ factor

Description	$P_{ch,off}$ [%]
Chimney height < 10 m	1,2
Chimney height > 10 m	1,6
NOTE: Copied from draft prEN 15316 – 2.2.1	

E.5.3 Total stand-by losses

E.5.3.1 Tabulated values

Identify the total stand by losses P_0 either from:

- manufacturer declared data;
- tabulated values from a national annex.

E.5.3.2 Stand-by operation

Stand-by losses can be measured as a relative value according to the following procedure:

- measure combustion efficiency η_{cn} [%] as described in D.1;
- close any secondary circuit;
- install an hour counter on the burner fuel valve or read the fuel meter;
- run the boiler (stand-by operation) for a known time t_{test} (recommended one day or more);
- read t_{ON} (time with flame on) on the hour counter or calculate it according to the ratio of fuel used and combustion power;
- calculate relative stand-by losses P_0 as the ratio between test time t_{test} and flame on time t_{ON} by:

$$P_0 = \eta_{cn} \cdot \frac{t_{ON}}{t_{test}} \quad [\%] \qquad \text{(E10)}$$

If the burner is of the multistage or modulating type, the test shall be performed with the burner power locked to the set minimum power $\Phi_{cn,min}$. Then relative losses are given by:

$$P_0 = \eta_{cn} \cdot \frac{t_{ON}}{t_{test}} \cdot \frac{\Phi_{cn}}{\Phi_{cn,\min}} \quad [\%] \qquad \text{(E11)}$$

NOTE1 This method may be applied only if the heating system can be run with all distribution (secondary) circuits closed.

NOTE2 If there is circulation in the generator (primary) circuit, the value will not be the same as the generator data since it includes losses outside the boiler. This is indeed not a problem because primary circuit losses are continuous run-time losses as well as boiler stand-by losses.

E.5.3.3 Auxiliary heater method

Stand-by losses can be estimated as a relative value according to the following procedure:

- close any secondary circuit;

- install a secondary heat source, like an electrical heater, equipped with an energy meter;
- keep the circulation of water within the boiler and install an electrical energy meter on the pump;
- stabilize the temperature at running level for a defined time t_{test}, using the secondary heat source;
- read Q_{auxh}, energy supplied to the water by the auxiliary heater and $Q_{l,auxh}$ losses of the auxiliary heater during test time t_{test};
- read W_{pump}, electrical energy used by the pump;
- determine pump efficiency h_{pump} at working point;
- calculate stand-by losses $Q_{l,o}$ by:

$$Q_{l,0} = Q_{auxh} - Q_{l,auxh} + \eta_{pump} \cdot W_{pump} \quad \text{(J)} \quad \text{(E12)}$$

- calculate relative stand-by losses P_0 by:

$$P_0 = \frac{Q_{l,0} \cdot 100}{\Phi_n \cdot t_{test}} \quad \text{(\%)} \quad \text{(E13)}$$

where Φ_n is the nominal power of the generator.

Annex F
(Informative)
Boiler settings verification

The setting of the following devices, if existing, shall be recorded and verified against available design (system instructions) or previously recorded values:

- boiler thermostatic control, including effect of hysteresis on boiler on-off cycling frequency;
- outdoor temperature compensation setting;
- temperature setting of zone control;
- temperature control for domestic hot water production operation.

System design specification should be considered as a reference.

Advice to user shall include information on appropriate settings of available controls.

Annex G
(informative)
Boiler or generation subsystem sizing

G.1 Methodologies

G.1.1 Heat load calculation

The installed boiler power shall be compared to the required heat supply capacity calculated according to EN 12828.

G.1.2 Existing heat load calculation data

The installed boiler power shall be compared to the original design heat supply capacity calculated according to EN 12828 or previous national standards or codes of practice.

The inspector shall verify the correspondence between calculation data and actual building.

Example: Check whether the insulation of the building (floor, walls, roof, glazing) has been improved since the installation has been designed.

G.1.3 Energy signature method

Use the energy signature method defined in EN 15315 – annex B and determine the power Φ_{des} required in design conditions with equation G1 in prEN assuming $\theta = \theta_{ext,des}$ = design external temperature.

Compare the power of the actual installed generation system to Φ_{des}.

In determining the correct sizing of the new boiler, the expected improvement in generation seasonal efficiency (as determined according to annex E) may be taken into account.

For the purpose of generation system sizing, the energy signature line may be calculated in a simplified way based on the following two points:

- $\Phi = 0$ for external temperature $\theta_{ext} = 17$ °C (true on most existing building);
- Φ = seasonal average power for external temperature θ_{ext} = seasonal average external temperature.

External temperature for 0 load may be supplied in a table in a national annex, according to building typology.

G.1.4 Fuel consumption

Fuel energy consumed Q_f in a defined time interval t_{meas} (i.e. average power) shall be compared to installed combustion power P_n.

NOTE auxiliary energy is not significant for this purpose.

Fuel consumed shall be determined according to any methodology specified in Annex C. The ratio L_{av} of average power to maximum power is given by:

$$L_{av} = \frac{V_f \cdot H_x}{\Phi_{cn} \cdot t_{meas}} \quad [-] \qquad (G1)$$

Note 1 Φ_{cn} shall be the actual set maximum combustion power, as defined in Annex B.

Note 2 L_{av} shall not be confused with FC which is referred to generator on time.

Average load should be determined:

- on a heating season basis (t_{meas} = entire heating season);
- on a shorter period, preferably in the coldest months.

If it is determined on a shorter period, a correction factor shall be applied to convert it to equivalent seasonal or design external outdoor conditions.

Example: Correction of measured L_{av} according to climatic data during measurement (external temperature, solar radiation, etc.).

G.1.5 Emitters installed

Total power of emitters installed shall be compared to boiler maximum output.

G.2 Reference value

Reference values for L_{av} are given in national tables according to building type, use, climate and reference period. If no such table is given, default values are given in Table G1.

Reference should be given for average seasonal or design external temperature reference.

Table G1 – Reference L_{av} range

Building type	Reference L_{av} value	
	Seasonal outdoor temperature	Design outdoor temperature
Individual house	0,15-0,3	0,5-0,7
Block building	0,2-0,3	0,6-0,8

Annex H
(informative)
Stratification in high ceiling rooms

Stratification in high ceiling rooms (more than 5 m) can be estimated by measuring the following temperatures in the middle of the room:

- temperature near the floor θ_{floor} (within 0,1 m elevation);
- temperature at 1,5 m elevation θ_{mid}
- temperature at ceiling minus 0,1 m θ_{ceil}
- external temperature θ_{out}.

The relative temperature spread is given by:

$$k_s = \frac{\theta_{ceil} - \theta_{floor}}{\theta_{mid} - \theta_{out}} \qquad \text{[H1]}$$

If the relative temperature spread k_s is higher than 0,2, destratification or a change of type of emitters and/or installation should be recommended.

NOTE This check can be done only during the heating season and should be done preferably in the coldest month.

Annex I
(Informative)
Heat emission control

I.1 Identification of the heat emission control level

Heat emission control subsystem may be classified according to its level of indoor temperature control:

- no indoor temperature measurement (heating system is driven manually or only by external temperature);
- one indoor temperature sensor (is it installed in a representative location ?);
- one sensor and actuator per zone (are zones made of homogeneous heated spaces ? Are zone sensors installed in representative locations ?);
- one sensor and actuator per emitter with local set
- room specific, time depending temperature set point.

I.2 Indoor temperature check

Indoor temperature measurement can give evidence of poor control efficiency. Temperature should be measured in an adequate number of sample rooms like:

- corner rooms, lowest and highest floor;
- rooms in the center of facades.

The relative temperature spread is given by:

$$k_\theta = \frac{\theta_{\text{int,max}} - \theta_{\text{int,min}}}{\theta_{\text{int,}av} - \theta_{out}} \qquad \text{[I1]}$$

where

- $\theta_{\text{int,max}}$ maximum measured internal temperature;
- $\theta_{\text{int,min}}$ minimum measured internal temperature;
- $\theta_{\text{int,av}}$ average of measured internal temperature;
- θ_{out} outdoor temperature.

If the relative temperature spread k_θ is higher than 0,2, advice should be given to introduce zone or room by room control.

NOTE This check can be done only during the heating season and should be done preferably in the coldest month.

I.3 Advice

If there is a high temperature spread with cold or overheated areas, balancing of the distribution system or upgrading the level of indoor temperature control should be recommended.

Better location of sensors should be recommended, as appropriate and feasible.

If there are different use of the building or different temperature requirements, the addition of separate temperature and timing control should be recommended.

Improve the setting of the outdoor reset function for supply water temperature.

Annex J
(informative)
Distribution subsystem

J.1 Flow rate

Measurement of actual flow and return temperatures, average power and outdoor temperature allows estimating the flow rate and ΔT (flow-return) under design conditions.

Low ΔT values (example: less than 10 °C) in design conditions shows that flow rate is excessive, causing high auxiliary energy consumption.

Higher ΔT should be recommended, taking into account that reducing the flow rate may require balancing of the distribution system or installing automatic balancing devices (example: thermostatic valves),

J.2 Type and setting of circulation pumps

If variable flow rate circuits are used, consideration should be given to variable speed pumps.

Proper setting of variable speed pumps shall be checked (i.e. fixed speed step, constant head control, proportional head control, maximum head setting, etc.)

J.3 Distribution circuit typology

Recommendation should be given to replace by-pass type circuits with variable flow circuits, using variable speed pumps.

J.4 Compatibility of distribution circuits with boiler typology

If the generation includes condensing boilers, the system should be designed and operated to minimise return temperature to the generator. Any emitter or zone by-pass should be avoided.

J.5 Insulation

Insulation may be checked by visual inspection on accessible parts, termography for concealed parts.

Effectiveness of accessible thermal insulation may be checked by comparing water (conveyed fluid), surface and room temperatures.

Annex K
(informative)
Domestic hot water

K.1 Recirculation losses

Inspection should determine which parts of the system are kept continuously hot to provide ready domestic hot water and their insulation level.

Advice should include recommendation to reduce, as appropriate and possible:

- temperature of constantly hot parts (any storage vessel, recirculation circuits);
- losses of constantly hot parts (increase insulation efficiency and thickness, reduce or eliminate thermal bridges e.g. by using insulated pipe hangers);
- operation time and control of recirculation.

Gravity recirculation systems should be reconstructed into forced recirculation systems with insulated pipes or a shut valve should be added to prevent unnecessary recirculation.

Annex L
(informative)
List of possible improvement actions

L.1 Introduction

This list includes suggestions on possible improvement of boilers and heating systems efficiency.

This list is neither exhaustive (other improvements may be possible) nor compulsory (any suggestion may not be suitable for the specific system under consideration).

Any advice should take into account cost effectiveness of suggested actions.

Advice shall include/suggest both possible immediate actions (replacement) and other actions to be taken in the event of major renovation or replacement due to aging or breakdown of components.

L.2 Boiler

Possible improvement actions:

- Seasonal maintenance of burners, furnaces, boilers, chimneys
- Check fuel-air mixture for optimal efficiency
- Reduce the set-point temperature of the water in the boiler as much as possible. The lowest possible temperature depends on the heating demand and on the materials used for the boiler and flue gas exhaust (corrosion risk).
- Shut down the boiler when not in use (e.g. in summer if not used for domestic hot water production). Use a timing control to reduce operation time (e.g. during night time).
- Check flue gas temperature. It should be as low as possible but sufficiently high to avoid corrosion. The lowest possible temperature depends on the materials used for boiler and chimney.
- Check if the burner is adapted to the boiler. If not, change as appropriate.
- Compare the power of the burner-boiler with actual needs at design outdoor temperature. If this power is too large, reduce it by changing the power of the burner (new jet) or the whole burner-furnace unit.
- Add thermal insulation to the boiler envelope.

L.3 Heating system generation

Possible improvement actions:

- When more than boiler is available, check that only necessary boilers are in operation as required by varying load.
- Check that cascade control of boilers shuts down the hydraulic circuit as well
- Check that the cascade strategy is appropriate according to the type of boiler. Condensing boiler may benefit from continuous operation of multiple boilers at minimum power output.
- Check that cascade control gives priority to higher efficiency generation appliances and/or subsystems.

L.4 Space heating distribution system

Possible improvement actions:

- Shut down circulation pumps when heat is not demanded.
- Check if circulation pumps are correctly sized. If oversized, change them for a proper size.
- Add thermal insulation around heat distribution ducts, eliminate insulation gaps (e.g. caused by shrinkage of insulation tubes), reduce thermal bridges e.g. by using insulated pipe hangers
- Check the balance of the heat distribution network.
- Use variable-speed pumps where a varying flow rate is expected
- Prefer low flow rate and high ΔT operation rather than high flow rate and low ΔT operation.
- Check for heat medium losses
- Check if the circulation pumps are correctly sized and set. If a pump is oversized, choose a lower setting or replace it with a suitable smaller one. Recommend differential pressure controlled pumps.
- Check quality of the heat transfer medium to maintain the energetical quality
- Check if the circulation pumps energy consumption is high in relation to modern pumps. If yes, replace the pumps with more efficient ones (EU Energy Label)
- Add automatic pressure controller per circuit in plants with more than three circles and pressure loss higher than 160 mbar.

L.5 Space heating emission system

Possible improvement actions:

- Replace undersized radiators, thus allowing a lower heating water temperature. Adjust controls accordingly.
- Improve the efficiency of radiators; avoid curtains or boxes around them. Purge periodically air and mud.
- Avoid stratification. Pay attention to high ceiling rooms

L.6 Heating system control

Possible improvement actions:

- Check set point temperatures; set to the lowest possible values and adapt set point temperatures to each room.
- Implement night temperature set back or set down (NOTE: not always appropriate for condensing systems)
- Shut down heating (or cooling) in spaces that should not be heated (or cooled)
- Improve control system; add thermostatic valves or thermostats, especially in spaces heated by other sources than the heating system.
- Hydraulic balancing of each radiator by presetting THV`s
- Improvement of control system by hydraulic balancing with automatic balancing valves, THV`s with presetting of each emitter, e g. including time control
- Control optimisation by creation of heating-up schedules and reduced power operation
- Add thermostatic valves in connection with condensing boilers to control return temperature.

- Divide the building into zones for heating and cooling, separating rooms having different needs and putting together rooms having similar needs (e.g. parts of the building exposed to sun and parts of the building not exposed to sun).

L.7 Domestic hot water

Possible improvement actions:

- Save water: repair leaky taps, install economy shower heads, etc.
- Check hot water temperature. It should not be more than 60°C. 50°C is sufficient for most uses, but it is not legionella-safe.
- Control optimisation by creation of heating-up schedules
- Shut down hot water circulation when hot water is not necessary. Use temperature control.
- Check if the circulation pumps are correctly sized and set. If a pump is oversized, choose a lower setting or replace it with a suitable smaller one. Recommend temperature or differential temperature controlled pumps..
- Check if the circulation pumps power consumption is high in relation to modern pumps. If yes, replace the pumps with efficient ones.
- Disconnect unused hot water taps and pipes leading to them
- Add thermal insulation to hot water pipes, especially those that are always hot, eliminate insulation gaps (e.g. caused by shrinkage of insulation tubes), reduce thermal bridges e.g. by using insulated pipe hangers
- Detect and seal all leaks, including leaky taps.
- Scale regularly hot water boiler, or install a water softener where the water is hard.
- In summer, don't use the space-heating boiler to heat the water.
- Install a solar water heater
- Replace separate cold and hot water taps by mixing valves
- Replace or renew old mixing valves
- Install individual hot water metering in multi-family housing.

L.8 Other

Possible improvement actions:

- For condensing systems: try to minimise water return temperature to the boiler. Avoid any mixing of hot water with return water to the boiler.
- Clean heating plant room regularly
- Respect the maintenance schedules for burners, boilers, HVAC units, etc.
- Record regularly (weekly interval is recommended) the energy use for all fuels. Drawing the weekly average heating power versus average outdoor temperature helps in detecting dysfunctions.
- Inform tenants regularly on energy use and possible energy saving measures.
- Use renewable energy. In many European climates, solar water heaters are cost-efficient.
- Replace flue gas system if this enables to reduce flue gas temperature (flue gas system not suitable for wet operation require a high flue gas temperature and therefore lower combustion efficiency)

Annex M
(Informative)
Sample boiler inspection report

Address and responsible person: *Mr John Smith Central Street Littletown*

Fuel: *natural gas* Duty: *heating and domestic hot water with integrated storage*

Boiler: *Newmake*, model *30* Serial *000001* Year *2000*

Maximum power input: *30 kW* Minimum power input *8 kW* *Non condensing boiler*

CE efficiency labelling : **

Burner *integrated in the boiler*

Power modulation: *modulating gas and air*

Available documentation: *boiler instruction, maintenance reports, fuel invoices*

Visual inspection: *OK*

Maintenance status: *OK from maintenance reports according to law xxxx requirements*

Boiler functionality test: *OK*

Boiler controls check: OK

Meter readings			
Fuel meter	6850 Nm³	Fuel level	N.A.
Burner hour counter	5200 h	Boiler hour counter	N.A.
Burner cycle counter	--	Heat meter	N.A.
Feed water meter	--.	DOMESTIC HOT WATER	110 m³
NOTE: N.A. = Not Available			

Actual power setting: *minimum 9,2 kW maximum 28 kW source: maintenance report*

Boiler basic setting						
Oxygen	CO	Flue gas temperature	Air temperature	Boiler temperature	Combustion efficiency	Conditions
%	ppm	°C	°C	°C	%	
5,2	20	162	12	64	91,8	Measured at full load
8,4	52	142	12	58	91,3	Measured at minimum load
2-4	<100	120-160			>92	Reference value *Table D4: Gas, non condensing*

Boiler settings		
Control name	Actual setting	Suggested setting
Boiler temperature setting	65 °C	OK
Domestic hot water storage temperature setting	60 °C	50 °C

Advice

Improve basic setting (reduce excess air)

Add a timer for domestic hot water production

Regular maintenance by competent personnel is essential to keep a stable good energy performance of boiler and heating system

Inspection date: *30 February 2005*

Inspector: _____

Owner: _____

Annex N
(Informative)
Sample heating system inspection report

Heating system identification	
Owner/administrator name	*Mr John Smith*
Address	*Central Street Littletown*
Total floor area or volume	*120 m² gross*
Heated floor area or volume	*120 m², 360 m³ gross*
Age of the building	*16 years*
Height above sea level	*100 m*
Design outside temperature	*-5 °C*
Building category and use	*Residential*
Building height	*6,5 m*
Type of building thermal insulation	*External insulation*
Conservation of building insulation	*Original*
List of heated zones	*3 zones: night, day and bathrooms*
Occupancy patterns and timing	*Continuous occupation*
Date of installation of the heating system	*1990*
Heating system design	*Available*
Energy declaration	*Not required: installed before 2006*
Functional diagram	*Direct domestic hot water circuit – 3 way valve mixing circuit for heating, no primary pump – 3 zones with on-off valve*
Control system type	*Zone thermostats acting on valves.* *Outdoor temperature compensation acting on mixing valve*
Location of main components	*Verified*
Attached systems data	*No attached system*

Functionality check: *System works correctly*

Maintenance: *Documentation of maintenance according to law xxxx requirements.*

Fuel consumption	
Total fuel consumption	2200 Nm³/year, estimated from bills of the last 4 years
Cooking and domestic hot water fuel consumption	270 Nm³/year, estimated from summer bills
Cooking fuel consumption	214 Nm³/year

Fuel consumption	
domestic hot water fuel consumption	250 Nm³/year (during summer operation)
Heating fuel consumption	1930 Nm³/year (total – other usage)
Reference average fuel consumption for similar houses (haeting function)	2100 Nm³/year (Table C2, 2500 °C days, single family)
Reference target fuel consumption (heating function)	1200 Nm³/year (Table C3, 2500 °C days S/V=0,8)

Space heating emission subsystem identification	
Type of emitters	*Radiators*
Emitter hydraulic connection type	*Two pipe system, all radiators in parallel*

Space heating emission control subsystem identification	
Type of local control	*Zone thermostat*
Type of central control	*Outdoor temperature compensation, mixing valve*
Timing control type	*Zone thermostats include daily timer*
List of controls available to users	*Time and temperature setting for zones*
User instruction available	*NO*

Space heating distribution subsystem identification	
Network typology	*Two pipes, three zones, closed circuit*
Open /closed circuit	*Closed circuit*
List of zones	*3 zones: night, day and bathrooms*
Status of space heating distribution system piping insulation	*Regular*
Circulation type	*Forced*
Circulation pump(s) power	*120 W*
Circulation pump(s) type	*Adjustable speed – Setting 3 of 3 (maximum)*
Unbalancing symptoms	*One cold room*

Generation subsystem identification	
Number of boilers installed	*1*
Total installed nominal power	*30 kW*
Fuel(s)	*Natural gas*
Type of generation control	*Running at constant temperature – Timing control set at 16 hours/day in winter and 4 hours/day in summer.*

Generation subsystem identification	
Hydraulic circuit functional diagram	*Direct connection to domestic hot water boiler, three way mixing valve to heating circuits*
Spare units	*None*
Other generation sub-systems type	*None*

Boiler identification	
Boiler duty	*Heating and domestic hot water*
Fuel(s)	*Natural gas*
Boiler manufacturer	*Newmake*
Boiler model	*Combi 30*
Maximum power rated input	*30 kW*
Minimum power rated input	*Not available*
Boiler manufacture date or year	*1990*
Condensing/non condensing	*Non condensing*
CE labelling efficiency stars (if available)	*Not available*
Burner manufacturer and model	*Oldmake – Size 4*
Burner power range	*20-40 kW*
Power modulation type	*Single stage*

Power input	*measured, 27 kW*

Boiler basic setting						
Oxygen	CO	Flue gas temperature	Air temperature	Boiler temperature	Combustion efficiency	Conditions
%	ppm	°C	°C	°C	%	
7,0	20	165	12	65	91,3	Measured at full load
2,0-4,0	<100	120-160			>92,0	Reference value

Generation efficiency	
$P_{ch,off}$	*1,0 % - Table E3, no closure of air intake, <10m*
$P_{gn,env}$	*1,07 % - Table E2, well insulated high efficiency*
FC, heating season	*0,26 - Formulas E3-E4, 16 hours/day x 185 day operation fuel consumed 1930 + 125 = 2055 Nm³*
Generation efficiency, heating season	*84,2 % - Formula E1*
Reference value	*75% Table P1 - Gas fired boiler for a single dwelling outside the heated space, full load net efficiency >= 88,5 %*

Generation efficiency	
FC, summer	*0,06 - Formulas E3-E4, 4 hours/day x 180 day operation fuel consumed 125 Nm³*
Generation efficiency, summer	*59 % - Formula E1*
Reference value	*30 % - Table P3 – Gas fired hot water heater or combi-boiler*

Boiler settings		
Control name	Actual setting	Suggested setting
Boiler temperature setting	65 °C	OK
Domestic hot water storage temperature setting	60 °C	50 °C

Generation subsystem sizing (energy signature)	
Actual average power for heating	*4,33 kW – 1930 Nm³ on 180 days at burner input*
Average building losses	*3,65 kW – 4.33 kW x 0.85 (generation efficiency)*
Mean outdoor temperature	*6,1 °C (from 2500 °C days on 180 days)*
Design outdoor temperature	*-7 °C*
Outdoor temperature with no heat load	*17 °C*
Building losses at design outdoor temperature	$3{,}65 \cdot \frac{17+7}{17-6.1}$ = *11,4 kW*
Efficiency of new boiler	*90 %*
Minimum sizing of new boiler	*12,7 kW (for continuous operation)*

Heating system efficiencies	
Distribution	*94,7 % - from tabulated values*
Emission	*96 % - from tabulated values*
Control	*97 % - from tabulated values*

Domestic hot water sub-system identification	
Type of domestic hot water production	*Storage*
Heat source type and duty	*Heating system generator*
Boiler nominal power	*30 kW*
Heat exchanger capacity	*10 kW*
Storage volume	*120 l*
Type of domestic hot water production control	*On-off on storage*

Domestic hot water sub-system identification	
Type of recirculation	*None*
Recirculation timing	*None*
Status of domestic hot water piping insulation	*Regular*

Advice

Energy consumption and efficiencies are in line with average buildings.

The effects of the oversizing of the installed boiler and its stand-by losses are mitigated by the timing control of the generation subsystem.

Generation seasonal efficiency can be improved by:

- reducing the set combustion power;
- reducing the excess air;
- adding an interlock that turns the boiler on only when at least one zone or the domestic hot water storage is requiring heat.

Distribution and control efficiency can be improved by reducing the heating system pump speed after re-balancing the system or installing thermostatic valves (cold room).

When the boiler will be replaced, consider the following integrated solution to optimise the energy performance of the heating system:

- install a condensing boiler allowing a low flow rate and a high $\Delta\theta$ (connection with radiators);
- install a burner with total closure of combustion air inlet at stand-by;
- install a burner that allows modulating both air and gas;
- remove the three-way mixing valve and connect directly the heating circuit to the boiler. Use the boiler control to get required flow temperature;
- install thermostatic valves on the radiators to set individually room temperatures;
- install a variable speed circulation pump on the heating system circuit
- use zones only for timing purposes (night or day shut-off);
- use a high flow temperature to reduce return temperature;
- limit the burner power in heating mode;
- reduce the flow rate in the domestic hot water primary circuit to lower water return temperature to the boiler

Should the storage be replaced consider using an external heat exchanger and a loading pump dimensioned to get a low return temperature to the boiler.

Installation of a variable speed pump and thermostatic valves can be anticipated to improve heating system balancing.

Regular maintenance by competent personnel is essential to keep a stable good energy performance of boiler and heating system

Inspection date: *30 February 2005*

Inspector: _____

Owner: _____

Annex O
(Informative)
Example of national table

O.1 Classes definition

The same inspection class (procedure) applies to any boiler or heating system

O.2 Boiler inspection

Table O1 – User and boiler identification data required for use in 5.2 (national table A1)

Fuel type	All
Power	All
User name	Required
Address	Required
Fuel	Required
Boiler make	Required
Boiler model name	Required
Boiler model qualifier	Required
Boiler serial number	Required
Boiler manufacture date or year	Required
Boiler type (regular / combi)	Required
Maximum power rated output	Required
Burner type (fixed/stepped/modulating)	Required
Rated power output range	Required
Current setting of power output (1)	Required
NOTES (1) If range rated	

Table O2 –Procedures and methodologies required for boiler inspection for use in 5.9

Fuel type	All fuels
Power	All powers
Optional auxiliary classification property	All

Table O2 –Procedures and methodologies required for boiler inspection for use in 5.9

Boiler annual efficiency	Database reference	E.1.1	Suitable (1)
	Default tables	E.1.2	Suitable (1)
	Boiler directive data	E.1.3	Suitable (1)
	Boiler cycling method	E.1.4	Excellent
	Total stand-by losses	E.1.5	Excellent
NOTES (1) Preferred order: database reference then boiler directive data then default tables.			

Table O3: Default seasonal efficiency based on fuel, boiler age and type for use in 5.9

Fuel, boiler age and type	**Default seasonal efficiency**
Gas, pre-1979, balanced or open-flue, floor mounted	55%
Gas, 1979-1997, balanced or open-flue, floor mounted	65%
Gas, pre-1998, balanced or open-flue, wall mounted	65%
Gas, pre-1998, fan assisted flue, high thermal capacity	68%
Gas, pre-1998, fan assisted flue, low thermal capacity	72%
Gas, pre-1998, condensing	85%
Gas, 1998 onward, non-condensing, with permanent pilot light	69%
Gas, 1998 onward, non-condensing, with automatic ignition	73%
Gas, 1998 onward, condensing, with permanent pilot light	79%
Gas, 1998 onward, condensing, with automatic ignition	83%
Oil, pre-1985	65%
Oil, 1985-1997	70%
Oil, 1998 onward, non-condensing	79%
Oil, condensing	83%
Solid fuel, manual feed, installed in unheated space	55%
Solid fuel, manual feed, installed in heated space	60%
Solid fuel, auto feed, installed in unheated space	60%
Solid fuel, auto feed, installed in heated space	65%

Annex P
(Informative)
Examples of national data

Table P1: Gross boiler seasonal efficiency for single boiler for heating
Source: NL

Boiler type (efficiencies at net values)	Gross seasonal boiler efficiency	
Local gas or oil heater (incl. pilot flame)	65 %	
Gas fired air heater (excl. pilot flame)		
– no test data	75 %	
– full load net efficiency >= 88,5 %	80 %	
– Gaskeur HR 100 label (part load net efficiency >= 101 %)	90 %	
– Gaskeur HR 104 label (part load net efficiency >= 105 %)	92,5 %	
– Gaskeur HR 107 label (part load net efficiency >= 108 %)	95 %	
Oil fired boiler for a single dwelling, within the heated space or Oil fired boiler for a non residential building with a “user surface” <= 500 m^2, within the heated space. Efficiency excl. pilot flame.	75 %	
Oil fired boiler for a single dwelling outside the heated space or Oil fired boiler boiler in a collective heating installation for more dwellings or Oil fired boiler for a non residential building with a “user surface” > 500 m^2 or with the boiler outside the heated space. All efficiencies excl. pilot flame.	70 %	
Gas fired boiler for a single dwelling, within the heated space or Gas fired boiler for a non residential building with a “user surface” <= 500 m^2, within the heated space. All efficiencies excl. pilot flame.	$\theta_{flow,design}$ <= 55°C	$\theta_{flow,design}$ > 55°C
– no test data	75 %	75 %
– full load net efficiency >= 88,5 %	80 %	80 %
– Gaskeur HR 100 label (part load net efficiency >= 100 %)	92,5 %	90 %
– Gaskeur HR 104 label	95 %	92,5 %

Table P1: Gross boiler seasonal efficiency for single boiler for heating
Source: NL

Boiler type (efficiencies at net values)	Gross seasonal boiler efficiency	
(part load net efficiency >= 104 %) – Gaskeur HR 107 label (part load net efficiency >= 107 %)	97,5 %	95 %
Gas fired boiler for a single dwelling outside the heated space or Gas fired boiler boiler in a collective heating installation for more dwellings or Gas fired boiler for a non residential building with a “user surface” > 500 m^2 or with the boiler outside the heated space. All efficiencies excl. pilot flame.		
– no test data	70 %	70 %
– full load net efficiency >= 88,5 %	75 %	75 %
– Gaskeur HR 100 label (part load net efficiency >= 100 %)	87,5 %	85 %
– Gaskeur HR 104 label (part load net efficiency >= 104 %)	90 %	87,5 %
– Gaskeur HR 107 label (part load net efficiency >= 107 %)	92,5 %	90 %

Table P2 - Gross boiler seasonal efficiency for domestic hot water
Source: NL

Boiler type (efficiencies at net values)	Gross seasonal boiler efficiency
Individual boilers	
Gas fired hot water heater or combi-boiler	**30 %**
Gas fired hot water heater Gaskeur CW label	**40 %**
Gas fired combi-boiler Gaskeur CW label	**50 %**
Gas fired combi-boiler Gaskeur HR/CW label	**60 %**
Collective systems	
Gas fired hot water storage heater (> 70 kW)	**50 %**

Table P3: Default seasonal efficiency based on fuel, boiler age and type. Source UK

Fuel, boiler age and type	Default seasonal efficiency
Gas, pre-1979, balanced or open-flue, floor mounted	55%
Gas, 1979-1997, balanced or open-flue, floor mounted	65%
Gas, pre-1998, balanced or open-flue, wall mounted	65%
Gas, pre-1998, fan assisted flue, high thermal capacity	68%
Gas, pre-1998, fan assisted flue, low thermal capacity	72%
Gas, pre-1998, condensing	85%
Gas, 1998 onward, non-condensing, with permanent pilot light	69%
Gas, 1998 onward, non-condensing, with automatic ignition	73%
Gas, 1998 onward, condensing, with permanent pilot light	79%
Gas, 1998 onward, condensing, with automatic ignition	83%
Oil, pre-1985	65%
Oil, 1985-1997	70%
Oil, 1998 onward, non-condensing	79%
Oil, condensing	83%
Solid fuel, manual feed, installed in unheated space	55%
Solid fuel, manual feed, installed in heated space	60%
Solid fuel, auto feed, installed in unheated space	60%
Solid fuel, auto feed, installed in heated space	65%