BS EN 304:1992
Incorporating Amendments Nos. 1 and 2

Heating boilers — Test code for heating boilers for atomizing oil burners

The European Standard EN 304:1992, with the incorporation of amendments A1:1998 and A2:2003, has the status of a British Standard

ICS 91.140.10

British Standards

Cooperating organizations

The European Committee for Standardization (CEN), under whose supervision this European Standard was prepared, comprises the national standards organizations of the following countries:

Austria	Oesterreichisches Normungsinstitut
Belgium	Institut belge de normalisation
Denmark	Dansk Standardiseringsraad
Finland	Suomen Standardisoimisliito, r.y.
France	Association française de normalisation
Germany	Deutsches Institut für Normung e.V.
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Sweden	Standardiseringskommissionen i Sverige
Switzerland	Association suisse de normalisation
United Kingdom	British Standards Institution

This British Standard, having been prepared under the direction of the Refrigeration, Heating and Air Conditioning Standards Policy Committee, was published under the authority of the Standards Board and comes into effect on 15 December 1992

The following BSI references relate to the work on this British Standard:

Committee reference RHE/10

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Amendments issued since publication

Amd. No.	Date	Comments
10183	February 1999	See national foreword
16418	30 June 2006	See national foreword

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National foreword

This British Standard has been prepared under the direction of the Refrigeration, heating and air conditioning Standards Policy Committee and is the English language version of EN 304:1992, *Heating boilers — Test code for heating boilers for atomizing oil burners,* including amendments A1:1998 and A2:2003, published by the European Committee for Standardization (CEN).

The start and finish of text introduced or altered by amendment is indicated in the text by tags A1⟩ ⟨A1. Tags indicating changes to CEN text carry the number of the CEN amendment. For example, text altered by CEN amendment A1 is indicated by A1⟩ ⟨A1.

EN 304 was produced as a result of international discussion in which the United Kingdom took an active part.

Please note that the United Kingdom voted against amendment A1 on the grounds that in **5.8.1.1** the indirect method states a mean temperature of (50 ± 1) °C. This does not legally conform to the Boiler Efficiency Directive, which specifies a mean temperature of not less than 50 °C. Therefore boilers tested to this standard may not necessarily conform to the Boiler Equipment Directive.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the EN title page, pages 2 to 37 and a back cover.

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EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 304
September 1992
+A1
June 1998
+A2
September 2003

UDC 697.326:620.1

Descriptors: Central heating, boilers, liquid fuel appliances, tests, thermal tests, measurement

English version

Heating boilers — Test code for heating boilers for atomizing oil burners

Chaudières de chauffage — Règles d'essai pour les chaudières avec brûleurs fioul à pulvérisation

Heizkessel — Prüfregeln für Heizkessel mit Ölzerstäubungsbrennern

This European Standard was approved by CEN on 1992-09-18; amendment A1 was approved by CEN on 1998-06-06. CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

Central Secretariat: rue de Stassart 36, B-1050 Brussels

Ref. No. EN 304:1992

Foreword

This European Standard was drawn up by the Technical Committee CEN/TC 57, Central heating boilers, of which the Secretariat is held by DIN.

The following structure is intended for the standards for heating boilers prepared by CEN/TC 57:

EN 303-1, *Heating boilers — Heating boilers with forced draught burners — Part 1: Terminology, general requirements, testing and marking.*

EN 303-2, *Heating boilers — Heating boilers with forced draught burners — Part 2: Special requirements for boilers with atomizing oil burners.*

EN 303-2, *Heating boilers — Heating boilers with forced draught burners up to a heat output of 70 kW and an operating pressure of max. 3 bar — Terminology, special requirements, testing and marking (standard in preparation).*

EN 304, *Heating boilers — Test code for heating boilers for atomizing oil burners.*

This European Standard shall be given the status of national standard, either by publication of an identical text or by endorsement, at the latest by March 1993, and conflicting national standards shall be withdrawn at the latest by March 1993.

The standard was approved and in accordance with the CEN/CENELEC Internal Regulations, the following countries are bound to implement this European Standard: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom.

Foreword to amendment A1

This amendment EN 304:1992/A1:1998 to EN 304:1992 has been prepared by Technical Committee CEN/TC 57, Central heating boilers, the Secretariat of which is held by DIN.

This amendment to the European Standard EN 304:1992 shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by December 1998, and conflicting national standards shall be withdrawn at the latest by December 1998.

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this standard.

The following structure is intended for the standards for heating boilers:

prEN 303-1, *Heating boilers — Part 1: Heating boilers with forced draught burners — Terminology, general requirements, testing and marking.*

prEN 303-2, *Heating boilers — Part 2: Heating boilers with forced draught burners — Special requirements for boilers with atomizing oil burners.*

prEN 303-3, *Heating boilers — Part 3: Gas-fired central heating boilers — Assembly comprising a boiler body and a forced draught burner.*

prEN 303-4, *Heating boilers — Part 4: Heating boilers with forced draught burners — Special requirements for boilers with forced draught oil burners with outputs up to 70 kW and a maximum operating pressure of 3 bar — Terminology, special requirements, testing and marking.*

prEN 303-5, *Heating boilers — Part 5: Heating boilers for solid fuels, hand and automatically fired, with a nominal heat output of up to 300 kW — Terminology, requirements, testing and marking.*

EN 304, *Heating boilers — Test code for heating boilers for atomizing oil burners.*

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Foreword to amendment A2

This document (EN 304:1992/A2:2003) has been prepared by Technical Committee CEN/TC 57 “Central heatingboilers”, the secretariat of which is held by DIN.

This Amendment to the European Standard EN 304:1992 shall be given the status of a national standard, either bypublication of an identical text or by endorsement, at the latest by March 2004, and conflicting national standardsshall be withdrawn at the latest by March 2004.

This Amendment to the European Standard EN 304:1992 specifies the additionally required heating-related testsand the deviating boundary conditions for low-temperature central-heating boilers. Its purpose is to complete,amend or shorten EN 304:1992. This does not affect the main standard.

WARNING : other requirements and other EU Directives may be applicable to the products falling within the scopeof this European Standard.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the followingcountries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland,France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal,Slovakia, Spain, Sweden, Switzerland and the United Kingdom.

Contents

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1 Scope

The test code applies to the tests of the thermal performance of oil-fired heating boilers (hereafter called "boilers") and combined boilers and water heaters. The requirements are laid down in EN 303-1 and EN 303-2.

This standard includes the requirements and recommendations for carrying out and evaluating the procedure for testing boilers and also the details of the technical conditions under which the tests shall be carried out.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 267:1991, *Atomizing oil burners of monobloc type; testing.*

EN 303-1:1992, *Heating boilers; Heating boilers with forced draught burners — Part 1: Terminology, general requirements, testing and marking.*

EN 303-2:1992, *Heating boilers; Heating boilers with forced draught burners — Part 2: Special requirements for boilers with atomizing oil burners.*

3 Principles of tests

3.1 Choice of boiler to be tested and its accessories

The parts and accessories used should be those supplied as standard by the manufacturer or those recommended by him.

For the rest an atomizing oil burner shall be used which complies with EN 267 and which is suitable for the boiler (dimensions of the combustion chamber, pressure conditions, etc.).

3.2 Condition of the boiler

The condition and the equipment of the boiler to be tested shall conform to the normal supply specification. The use of additional thermal insulation to parts in contact with water, products of combustion and fire is not permitted.

When determining the thermal output of a boiler fitted with a water heater (either storage or instantaneous), no sanitary hot water shall be drawn off during the test. The thermal output shall be determined from the heating circuit only.

4 Measuring instruments and methods

Only such measuring instruments shall be used which meet the requirements noted in the following clauses. The use of recording instruments, which show the progress of the test in detail, is recommended, especially for measuring the water temperatures at the flow and return connections to the boiler, the draught at the outlet from the boiler, and the temperature and composition of the products of combustion.

Regarding admissible errors, the measuring instruments shall be chosen in such a way that the efficiency can be determined to an accuracy of ±2 %. The tolerances for test equipment are given in Annex A.

4.1 Fuel

The tests shall be carried out using commercially available heating gas oil or kerosine as selected by the boiler manufacturer.

The viscosity of the gas oil shall be 5,5 ± 0.5 mm^2/s at 20 °C in accordance with EN 267.

The viscosity of kerosene shall be 1,3 mm^2/s to 2,9 mm^2/s at 20 °C.

4.1.1 *Quantities*

The fuel quantitites are either weighed or measured volumetrically (see Figure 1).

4.1.2 ***Determination of the calorific values for oil fuels***

4.1.2.1 *Heating gas oil*

a) If the calorific value is not determined calorimetrically and in the absence of a complete analysis, the value for fuel oil can, with sufficient accuracy, be assumed as follows:

H_U = 42,689 MJ/kg

where

carbon content	c = 0,86 kg/kg;
hydrogen content	h = 0,136 kg/kg;
sulfur content	s = 0,003 kg/kg;
density at 15 °C:	0,85 kg/dm^3.

b) If the density and sulfur content is known (e.g. by analysis) the calorific value can be calculated as follows:

$H_U = 52,92 - (11,93 \cdot \rho_{15}) - (0,3 \cdot s)$ in MJ/kg

where

ρ_{15} = density of the heating gas oil at 15 °C in kg/dm^3;

s = sulfur content in kg/kg.

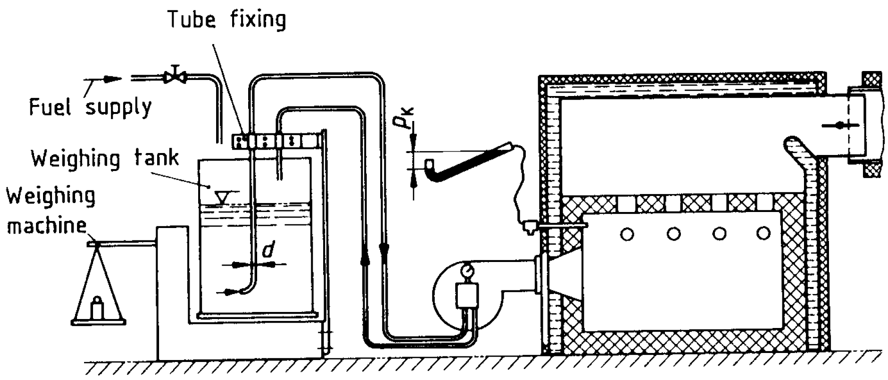


Figure 1 — Measuring installation to determine the amount of fuel

4.1.2.2 *Kerosene*

a) If the calorific value is not determined calorimetrically and in the absence of a complete analysis, the value for kerosene can with sufficient accuracy be assumed as follows:

H_U = 43,300 MJ/kg

where

carbon content	c = 0,85 kg/kg;
hydrogen content	h = 0,141 kg/kg;
sulfur content	s = 0,004 kg/kg;
density at 15 °C:	0,79 kg/dm^3.

b) If the density and sulfur content is known (e.g. by analysis) the calorific value can be calculated in accordance with **4.1.2.1**b).

4.1.3 ***Combustion parameters***

The necessary combustion parameters can be calculated from the analysis of the fuel (see **A.4**).

4.2 Determination of the composition of the products of combustion

In order to minimize the errors of measurement, the instruments shall be installed in a zone of as constant temperature as possible and shall be in operation some time before the commencement of the tests. (See **A.5**.)

5 Tests

5.1 Determination of the heat output and the efficiency of the boiler

5.1.1 ***Method for the measurement of the heat output***

The amount of useful heat transmitted to the heat carrier (water) is measured. It can be determined directly in the boiler circuit or indirectly by means of a heat exchanger.

5.1.1.1 *Measurement of heat output in the boiler circuit*

The useful heat output transmitted to the water is determined either by measuring the mass flow of cold water entering the boiler circuit and the rise of temperature to the outlet temperature, or by measuring the mass flow of the water circulating in the boiler circuit and its temperature rise.

5.1.1.2 *Measurement of heat ouput by means of a heat exchanger*

The heat produced by the boiler is transferred to the cooling water by means of a heat exchanger. The heat received by the latter is calculated from the throughput and the temperature rise of the cooling water. The heat losses from the well-insulated connections between the boiler and the heat exchanger and those of the heat exchanger itself, are determined either by preliminary tests or by calculation.

The heat output of the boiler is the sum of the two amounts of heat.

5.2 Determination of the rated heat output

The tests for the determination of the rated output shall be carried out at a firing rate such that the output is at least 100 %, but does not exceed 105 % of the rated value, and the requirements concerning the rated heat output shall be met. If one of the requirements is not met during the tests, a second test shall be carried out at 95 % to 100 % of the rated output of the boiler. The actual value for the rated heat output shall be determined by linear interpolation between the two test results.

The determination of the rated heat output shall be carried out with a mean flow temperature of between 80 °C and 90 °C, and the mean temperature difference between flow and return shall be between 10 K and 25 K.

A temperature rise of:

$$\frac{t_V + t_R}{2} - t_L \geqslant 50{,}0\ \mathrm{K}$$

shall be maintained.

5.3 Determination of the boiler efficiency (direct method)

The efficiency is determined on the basis of the net calorific value H_U.

The direct method is to be used. The indirect method allows an additional check of test accuracy of the test rig to be made by means of a heat balance. From this the values of other losses will also be determined.

5.4 Test operation

5.4.1 *Basic details*

The boiler and the burner shall be operated in accordance with the manufacturer's instructions throughout the tests.

The minimum ambient temperature shall be ⩾15 °C.

The settings of the combustion equipment shall not be manually adjusted during the test, and no change shall be made to the water flow.

The temperature, pressure and composition of the products of combustion shall be measured at intervals of not more than once per minute or continuously and shall be recorded simultaneously on recording instruments. The time intervals shall be selected so that any variations of measured values are detected with sufficient accuracy.

The temperatures t_V and t_R shall not differ by more than 0,5 (K/h) × test period (h) at the beginning and the end of the test.

During the test for efficiency determination the burner heat input shall remain constant and shall not be interrupted by the thermostat or the safety temperature limiter.

5.4.2 *Draught adjustment*

5.4.2.1 *Boilers operating under negative pressure*

For boilers operating under negative pressure the draught at the boiler outlet shall be adjusted so that there is a negative pressure in the combustion chamber. The draught shall be measured.

5.4.2.2 *Boilers operating under positive pressure*

In positive pressure boilers the pressure shall be set at the boiler outlet to approximately 0 mbar. The pressure difference between combustion chamber and boiler outlet shall be measured.

5.4.3 *Establishment of steady state conditions*

It is recommended that the boiler be operated for about 1 h before the commencement of the performance and efficiency test at the output intended for the test.

The steady state condition is regarded as reached when the water temperature does not vary by more than ±0,5 K/h.

5.4.4 *Test period*

For the rated heat minimum output test, the test period shall be at least 60 min. Intermediate results shall be taken every 30 min. If the efficiency results deviate by more than 0,5 % points, the test shall be extended by periods of 30 min until this requirement is met.

5.4.5 *Setting up the test rig*

The test rig shall be set up in such a way that the test conditions laid down in **A.6** are met, and the efficiency can be determined within a tolerance of ±2 % points.

Other equivalent arrangements of rigs may be used.

5.5 Calculation

The calculations are to be based on the mean values of the individual readings recorded during the test period.

5.5.1 *Boiler heat output*

The necessary formulae relevant to the individual test methods are given in **A.7**.

5.5.2 *The heat input*

For these calculations, formulae in **A.8** are to be used.

5.5.3 ***Boiler efficiency***

5.5.3.1 *Direct method*

In the direct method the boiler efficiency is determined by:

$$\eta_K = \frac{Q}{Q_B} \tag{1}$$

5.5.3.2 *Indirect method* (only to be used for checking purposes, see **A.9**)

In the indirect method the boiler efficiency is given by:

$$\eta_K = 1 - q_A - q_U - q_S \tag{2}$$

where

q_A is the loss through sensible heat of the products of combustion (values relative to the heat input);

q_U is the loss through incomplete combustion (values relative to the heat input);

q_S is the loss through radiation, convection and conduction (values relative to the heat input).

5.6 Determination of the waterside resistance

The waterside resistance (measured in mbar) shall be determined for the flow which is equivalent to the rated output of the boiler at a temperature difference at Δt = 10 K and 20 K between the flow and return.

5.7 Determination of the standby loss

5.7.1 ***General***

No useful heat shall be extracted for heating or hot water.

5.7.2 ***Test arrangement and measurement*** (see **A.11**)

The boiler shall remain as set up for the determination of Q and η_K. The short-circuit section remains connected. For boilers producing hot water, the hot and cold water feed pipes remain connected, the cylinder is kept full.

The circulation in the short-circuit section is interrupted during the "off" period of the burner.

5.7.3 ***Standby heat loss***

The thermostat shall be set in such a way that the mean temperature at the sensor exceeds the ambient temperature by 50 ± 3 K during the operation of the burner when no transmission of useful heat takes place. If the mean temperature difference deviates from the prescribed temperature by more than 3 K the test shall be repeated after the thermostat has been adjusted.

The boiler temperature and the air temperature at mid-height of the boiler shall be measured by automatic instruments.

A negative pressure of between –0,05 mbar and –0,07 mbar shall be maintained at the measuring section when the burner is not firing during the whole test period.

The electrical energy used during the test shall be measured and included in the test report.

5.7.3.1 *Calculation*

The calculation is in accordance with **A.11.2**.

5.7.3.2 *Standby heat loss from boilers with and without water heaters*

After heating the boiler up, the test begins at a burner start. The test ends at a subsequent burner start (a period commences at a burner start and ends at the next burner start).

The standby heat loss shall be calculated from the measured fuel consumption during the test periods, always using complete periods.

The standby loss shall be calculated from the beginning of the test at the end of each test period.

The test can be terminated when two consecutive results vary from one another by not more than 5 %. The smaller value of these two results will be used as the basis for the calculation of q_B at the reference temperature. (See **A.11**.)

5.7.3.3 *Standby heat loss from boilers with temperature controlled water heaters where switching times of the burner and feed pump overlap*

The equipment shall be pre-heated to the specified temperature above ambient temperature as follows:

— boiler without modulating control: 50 ±3 K

— water heater: 40^{+5}_{-0} K

During the test it is to be noted that the hot water heating period can be longer than that of the boiler (see Figure 5). In this case the period for the heating of the hot water is to be used for the determination of the standby loss and is calculated in accordance with **5.7.3.2**.

After heating the boiler and water heater the test begins with the first burner start caused by the heating of the water storage tank.

The same procedure is applicable to other combinations of equipment with overlapping periods.

[A1⟩ 5.8 Useful efficiency at part load

To determine the useful efficiency at a load corresponding to 30 % of the nominal heat input, or the arithmetic mean of the maximum and minimum heat input for range-rated boilers, the manufacturer has the choice between either the direct method or the indirect method.

[A2⟩ It shall be checked whether the requirements of EN 303-2 and EN 303-2/A1:2003 have been met.

NOTE The boiler supply temperature is held constant with a maximum variation in this temperature of ±1 K (for direct method) during the measurement period at the appropriate temperature levels as follows, where the mean temperature in all cases should be not less than those given in the Efficiency Directive 92/42/EC. ⟨A2]

5.8.1 *Direct method*

The boiler is operated as for the determination of the useful efficiency at nominal heat input or at the arithmetic mean of the maximum and minimum heat input in the case of range-rated boilers.

Throughout the test, the water volume rate is maintained constant within ±1 % taking into account the temperature variations, and the pump operates continuously.

5.8.1.1 *Operating mode no. 1*

The boiler is installed as described in **A.6**, fitted to the thermally insulated test rig shown schematically in Figure 6 or Figure 7 (or any other test rig giving at least comparable results and equivalent measurement accuracies).

The boiler return temperature is held constant at 47 ± 1 °C, with a maximum variation in this temperature during the measurement period of ±1 K. [A2⟩ Diverging from the normal condition the test on low-temperature boilers is carried out at (37 ± 1) °C and the test on condensing boilers is carried out at (27 ± 1)°C. ⟨A2]

If the boiler control does not permit operation at a return temperature as low as 47 °C, the test is made with the lowest return temperature compatible with the operation of the boiler.

A timer is connected to the terminals of the room thermostat so as to obtain a complete operating cycle of 10 min.

The shutdown and operating times are calculated as indicated in Table 2.

The temperatures are measured continuously directly on the flow and return of the boiler.

The boiler is considered to be in thermal equilibrium when the efficiency measurement of three consecutive cycles, combining any two results from three, does not vary by more than 0,5 percentage points. In this case, the result is equal to the average value of at least three consecutive measurement cycles. For any other case, the average value shall be calculated from at least ten consecutive cycles.

The respective fuel and water consumptions over complete cycles are measured. ⟨A1]

[A1› Temperatures t_1 and t_2 are measured continuously.

The useful efficiency is calculated using the following formula:

$$\eta_K = \frac{W(t_2 - t_1) \times 4,186 + Q}{V\ H_i \times 10^3}$$

where

- W total mass of water collected during the test in kg;
- t_1 temperature of the cold water or of the cooling water in the secondary exchanger in °C;
- t_2 temperature of the collected water in °C;
- Q heat losses of the test rig corresponding to the maximum water flow temperature (taking into account the thermal input due to the pump) in kJ;
- V total fuel consumption in kg;
- H_i calorific value of the fuel used for the test in MJ/kg.

A variation of ±2 percentage points, with respect to the 30 % of the nominal heat input is permitted. For variations up to ±4 percentage points, it is necessary to carry out two measurements, one above and one below 30 % of the nominal heat input. The efficiency corresponding to 30 % is determined by linear interpolation.

5.8.1.2 *Operating mode no. 2*

The boiler is installed as described in **A.6**, fitted to the thermally insulated test rig shown schematically in Figure 6 or Figure 7 (or any other test rig giving at least comparable results and equivalent measurement accuracies).

The boiler flow and return temperatures and the operating on and off cycles are given by the boiler control when a heat input leading to a burner working at (30 ± 2) % of the nominal heat input (or the arithmetic mean of the maximum and minimum output for range-rated boilers) is drawn through the heat exchanger. The temperatures are measured continuously at the flow and at the return of the boiler.

The average water temperature shall be no less than 50 °C.

[A2› If the boiler control does not permit operation at a return temperature as low as 50 °C for standard boilers and 40 °C for low-temperature boilers, the test is carried out at the lowest return temperature compatible with the operation of the boiler. For condensing boilers a return temperature of 30 °C has to be set. ‹A2]

The boiler is considered to be in thermal equilibrium when the efficiency measurement of three consecutive cycles, combining any two results from three, does not vary by more than 0,5 %. In this case, the result is equal to the average value of at least three consecutive measurement cycles. For any other case, the average value shall be calculated from at least ten consecutive cycles.

The respective fuel and water consumptions over complete cycles are measured.

The efficiency is determined using the formula in **5.8.1.1**.

A variation of ±2 percentage points with respect to the 30 % of the nominal heat input is permitted. For variations up to ±4 percentage points, it is necessary to carry out two measurements, one above and one below 30 % of the nominal heat input. The efficiency corresponding to 30 % is determined by linear interpolation.

5.8.2 ***Indirect method***

5.8.2.1 *Measurements*

5.8.2.1.1 *Useful efficiency at the nominal heat input at 50 °C*

[A2› The test of **5.5.3**, at the nominal heat input (or the arithmetic mean of the maximum and minimum heat input for range-rated boilers), is repeated with a water flow temperature of (60 ± 2) °C for standard boilers, (50 ± 2) °C for low-temperature boilers and (40 ± 1) °C for condensing boilers and a return temperature of (40 ±1) °C for standard boilers and (30 ± 1) °C for low-temperature and condensing boilers so that the average water temperature shall be (50 ± 1) °C for standard boilers, (40 ± 1) °C for low-temperature boilers and (35 ± 1) °C for condensing boilers. ‹A2]

The measured value η_1 is noted. ‹A1]

A1 **5.8.2.1.2** *Efficiency at the minimum controlled rate*

A2 If the boiler is fitted with a control system incorporating a main burner reduced rate, a test is carried out at the minimum heat input allowed by the control for a water flow temperature of (55 ± 2) °C for standard boilers, (45 ± 2) °C for low-temperature boilers and (40 ± 1) °C for condensing boilers and a return temperature of (45 ± 1) °C for standard boilers, (35 ± 1) °C for low-temperature boilers and (20 ± 1) °C for condensing boilers so that the average temperature shall be (50 ± 1) °C for standard boilers, (40 ± 1) °C for low-temperature boilers and (30 ± 1) °C for condensing boilers. A2

The measured value is designated η_2.

5.8.2.1.3 *Standby losses*

The test installation is described in Figure 8.

The circuits joining the different parts of the installation shall be insulated and as short as possible. The inherent losses of the test installation and the thermal contribution of the pump for the different flow rates shall be determined at the beginning to be able to take account of them (see Annex B).

The boiler is fitted with the largest diameter test flue stated by the manufacturer in the technical instructions.

A2 The boiler water temperature is brought to a mean temperature of (30 ± 5) °C for standard boilers, (20 ± 5) °C for low-temperature boilers boilers and (10 ± 1) °C for condensing boilers above ambient temperature. The fuel supply is then shut off, the pump (11) and the boiler pump, if any, are stopped, the exchanger circuit (12) is shut off. A2

With the water circulating continuously by means of the pump (5) of the test rig, the thermal contribution of the electric boiler is adjusted so as to obtain, in the steady state condition, a difference of (30 ± 5) °C for standard boilers, (20 ± 5) °C for low-temperature boilers and (10 ± 1) °C for condensing boilers between the mean water temperature and the ambient temperature.

Throughout the test the variation in room temperature shall not exceed 2 °C/h.

The following information shall be noted:

— P_m in kW, the electrical power consumed by the auxiliary electric boiler, corrected for the losses of the test rig and the thermal contribution of the pump (5);

— T in °C, the mean water temperature equal to the mean of the temperature indicated by the two probes (2) at the return and the flow of the boiler during the test;

— T_A in °C, the mean ambient temperature during the test.

A2 The standby losses, expressed for a mean water temperature of 50 °C for standard boilers, 40 °C for low-temperature boilers and 30 °C for condensing boilers and an ambient temperature of 20 °C are given, in kW, by:

$$P_s = P_m \left[\frac{30}{T - T_A}\right]^{1,25}$$

for standard boilers (see *formula* 2.1)

$$P_s = P_m \left[\frac{20}{T - T_A}\right]^{1,25}$$

for low-temperature boilers (see *formula* 2.2) and

$$P_s = P_m \left[\frac{10}{T - T_A}\right]^{1,25}$$

for condensing boilers (see *formula* 2.3). A2

NOTE Determination of the heat losses from the test rig and the heat contributions of the circulating pump of the test rig see Annex F.

5.8.2.2 *Calculations*

A2 The useful efficiency for a load of 30 % of the nominal heat input (or the arithmetic mean of the maximum and minimum heat input for range-rated boilers) and at an average water temperature of 50 °C for standard boilers, 40 °C for low-temperature boilers and 30 °C for condensing boilers is calculated for a control cycle. A2

The symbols of Table 1 are used. A1

A1⟩ Table 1 — Symbols and quantities needed to calculate the efficiency at part load

Operational phases of the main burner	Heat input kW	Operation time s	Measured values at 50 °C
			Efficiencies
Full rate	Q_1	t_1	η_1
Reduced rate	Q_2	t_2	η_2
			Standby losses
Controlled off	—	t_3	P_3

The efficiency is calculated from the ratio between the useful energy to the energy supplied by the fuel during a 10 min cycle.

Depending on the means of control, the following operating cycles can be identified, which correspond to the formulae in Table 2:

1) permanent operation with $Q_2 = 0{,}3Q_1$ (fixed reduced rate or modulating);

2) full rate/controlled off (one fixed rate);

3) reduced rate/controlled off operation (reduced rate or modulation where the minimum heat input $Q_2 > 0{,}3\ Q_1$) (see cycle 5 if, by design, the ignition is carried out at full rate);

4) full rate/reduced rate operation (reduced rate where the minimum heat input $Q_2 < 0{,}3\ Q_1$);

5) full rate/reduced rate/controlled off operation (by design, ignition is carried out at Q_1, for a time t_1, with reduced rate or modulation such that the cycle comprises a controlled shut down ($t_3 > 0$); otherwise cycle 4 above applies).

The efficiency is calculated as indicated in Table 2. ⟨A1

5.9 Surface temperature

The mean surface temperature for the determination of q_s shall be measured under nominal output conditions. For this a minimum of five points on each boiler surface shall be measured. Under the same conditions the critical temperatures (e.g. boiler doors, operating levers) shall be measured.

5.10 Floor temperatures

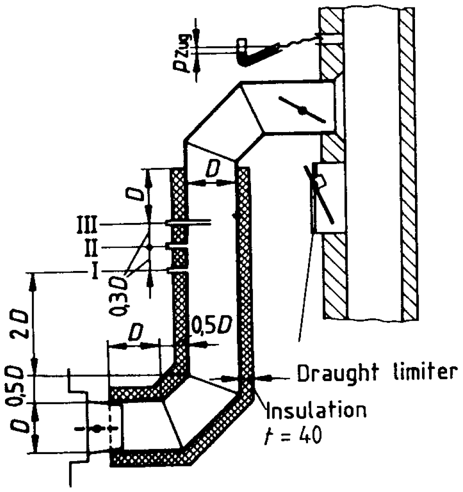
In order to determine the floor temperature below the boiler, the boiler is installed on a test base as for example in Figure 3. The surface temperatures of this test base shall be measured in at least five points under maximum nominal output conditions.

It is recommended that the surface temperatures of the test base are measured using thermocouples in accordance with, for example, Figure 4 or with commercial surface thermometers.

A1⟩ Table 2 — Calculation of part-load efficiency

Conditions of operation		Heat input	Cycle times	Measurements	Useful efficiency
1	30 % reduced rate	$Q_2 = 0{,}3\ Q_n$	$t_2 = 600$ s	η_2	$\eta_u = \eta_2$
2	Full rate	$Q_1 = Q_n$	$t_1 = 180$ s	η_1	$\eta_u = \frac{(\eta_1 Q_1 t_1) - (P_s t_3)}{Q_1 t_1}$
	Controlled shutdown		$t_3 = 420$ s	P_s	
3	Reduced rate	$Q_2 > 0{,}3\ Q_n$	$t_2 = \frac{180\ Q_1}{Q_2}$	η_2	$\eta_u = \frac{(\eta_2 Q_2 t_2) - (P_s t_3)}{Q_2 t_2}$
	Controlled shutdown		$t_3 = 600 - t_2$	P_s	
4	Full rate	$Q_1 = Q_n$	$t_1 = \frac{180\ Q_1 - 600\ Q_2}{Q_1 - Q_2}$	η_3	$\eta_u = \frac{(\eta_1 Q_1 t_1) + (\eta_2 Q_2 t_2)}{Q_1 t_1 + Q_2 t_2}$
	Reduced rate	$Q_2 < 0{,}3\ Q_n$	$t_2 = 600 - t_1$	η_2	
5	Full rate	$Q_1 = Q_n$	t_1 = measured value (see annex G)	η_1	$\eta_u = \frac{\eta_1 Q_1 t_1 + \eta_2 Q_2 t_2 - P_s t_3}{Q_1 t_1 + Q_2 t_2}$
	Reduced rate	Q_2	$t_2 = \frac{(180 - t_1)\ Q_1}{Q_2}$	η_2	
	Controlled shutdown		$t_3 = 600 - (t_3 + t_2) \geq 0$	P_s	

⟨A1

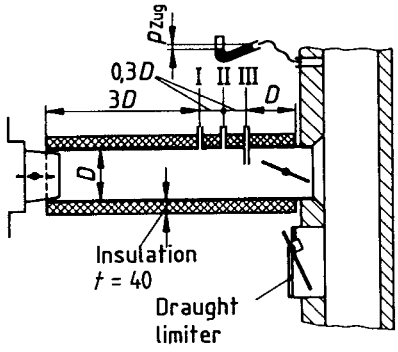


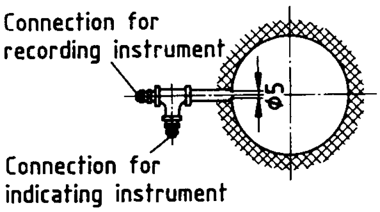
I Section for draught measuring

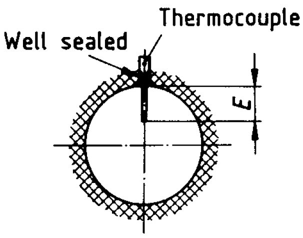
II Section for temperature measuring

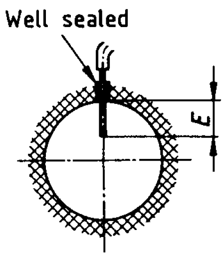
Measuring device for flue gas analysis (sampling cross)

III Section for measuring the smoke contents in the flue gas









I Connection for draught measurement (flush with internal wall of flue gas pipe. Internal welding point deburred)

II Flue gas temperature measurement immersion depth E

a) with horizontal measuring section = D/3

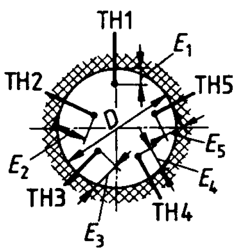
b) with vertical measuring section = D/2

III Probe for immersion depth E

a) with horizontal measuring, section = D/3

b) with vertical measuring, section immersion depth = D/2

for measurements in built-in installations only



Immersion depth of the thermocouples

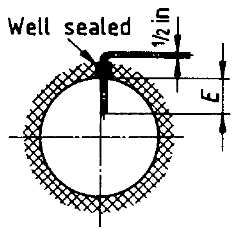
E_1 = 0.10 D

E_2 = 0.17 D

E_3 = 0.24 D

E_4 = 0.30 D

E_5 = 0.37 D



IIa A flue gas temperature measurement by means of 5 thermocouples (recommended in cases where unequal temperature distribution is expected)

IIIa Connection for smoke test immersion depth

a) with horizontal measuring section = D/3

b) with vertical measuring section = D/2

Figure 2 — Flue gas section

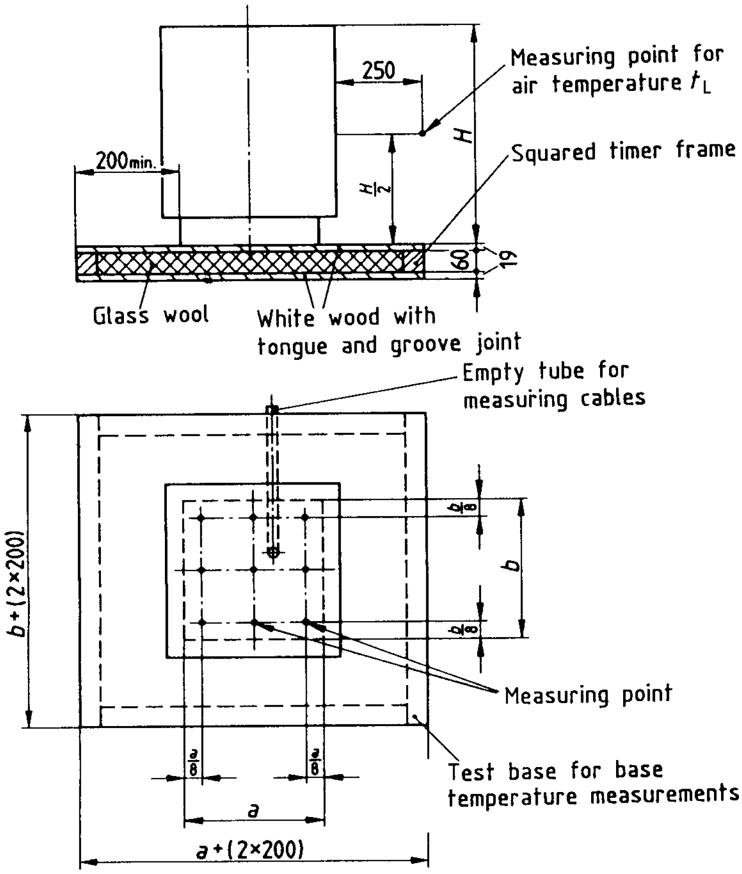


Figure 3 — Test configuration for the determination of base temperatures

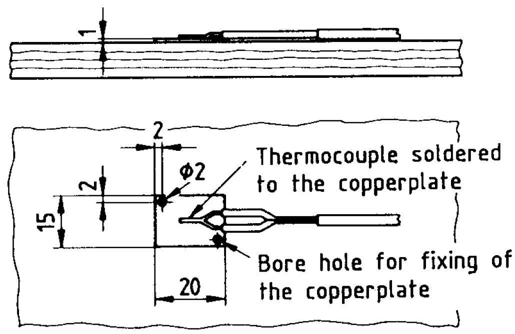


Figure 4 — Configuration of a thermocouple for measuring the surface temperatures of the test base

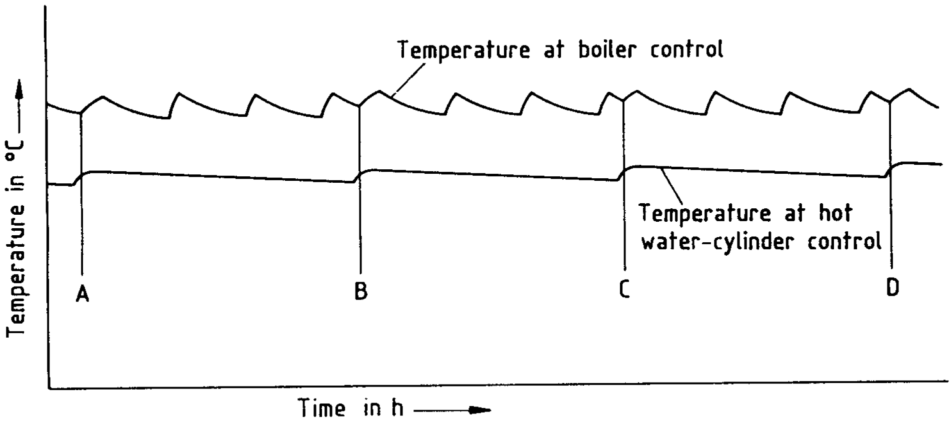


Figure 5 — Relation of temperature to time for a boiler equipped with a pumped hot water cylinder

5.11 Emission values of NO_x and CO

The emission values of NO_x and CO are determined by means of methods and instruments specified in EN 267.

6 Test report and other documents

The following documents shall be attached to the test report:

a) drawings (e.g. blue prints) showing clearly the type of construction of the boiler and boiler range, and all components;

b) photograph of the boiler (13 cm × 18 cm);

c) publications concerning the boiler, in particular the installation and operating instructions;

d) an exact description of the boiler including the data given on the boiler data plate;

e) information regarding the atomizing oil burner to EN 267 used in the tests.

The test report shall be signed by the head of the test station or test engineer, responsible for carrying out the test.

The test report shall not be published in abbreviated form.

A1

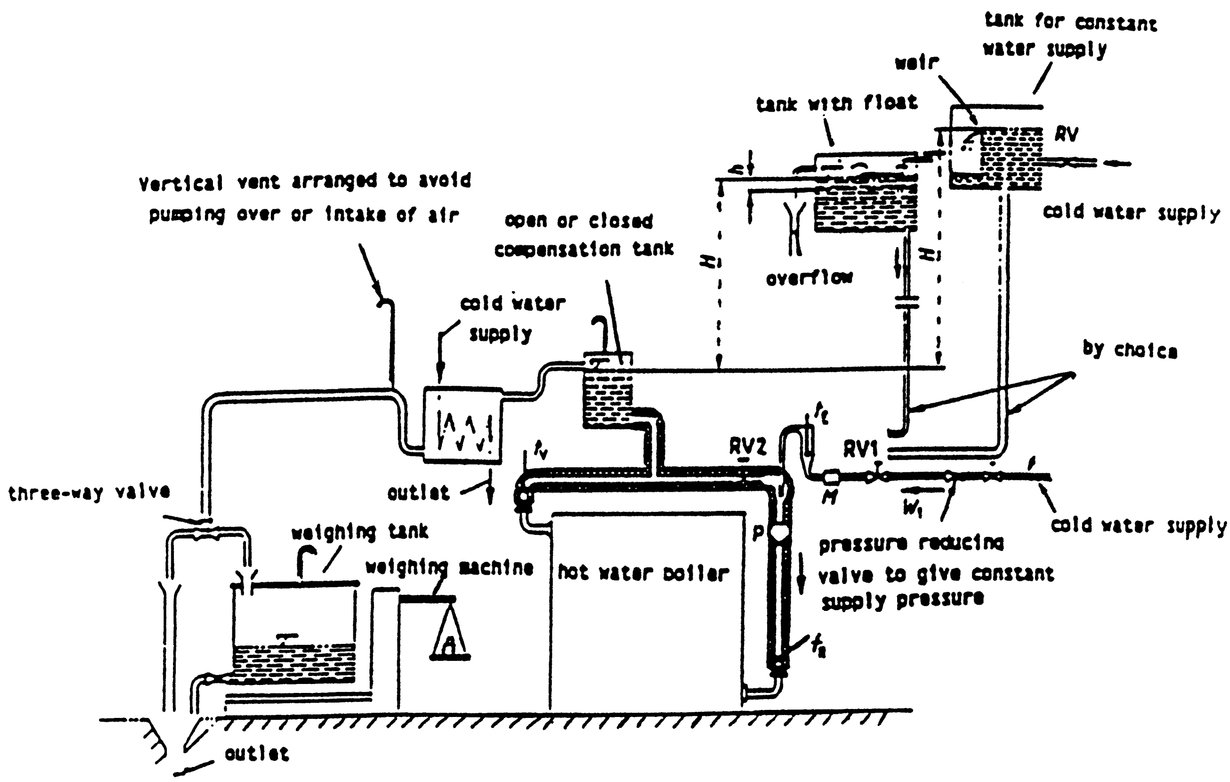


Figure 6 — Test rig with short-circuit section and three possible arrangements for cold water supply

A1

A1

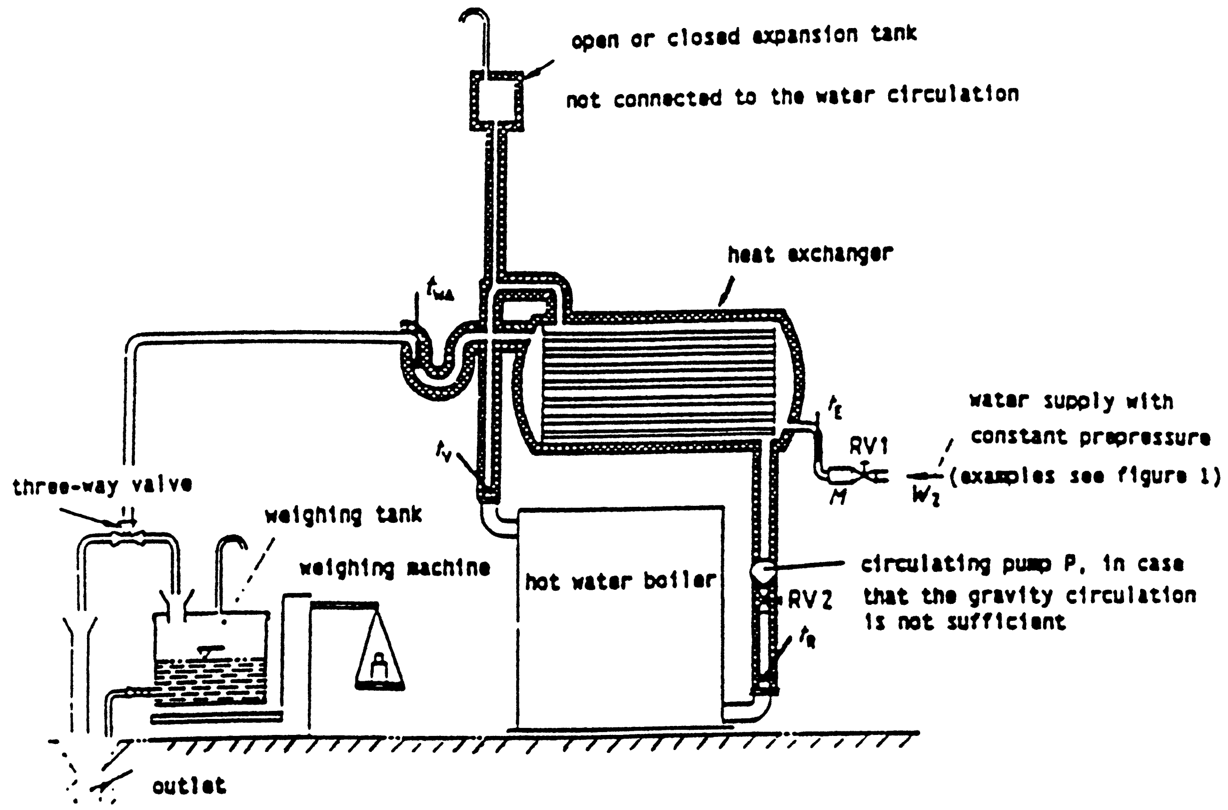


Figure 7 — Test rig with heat exchanger

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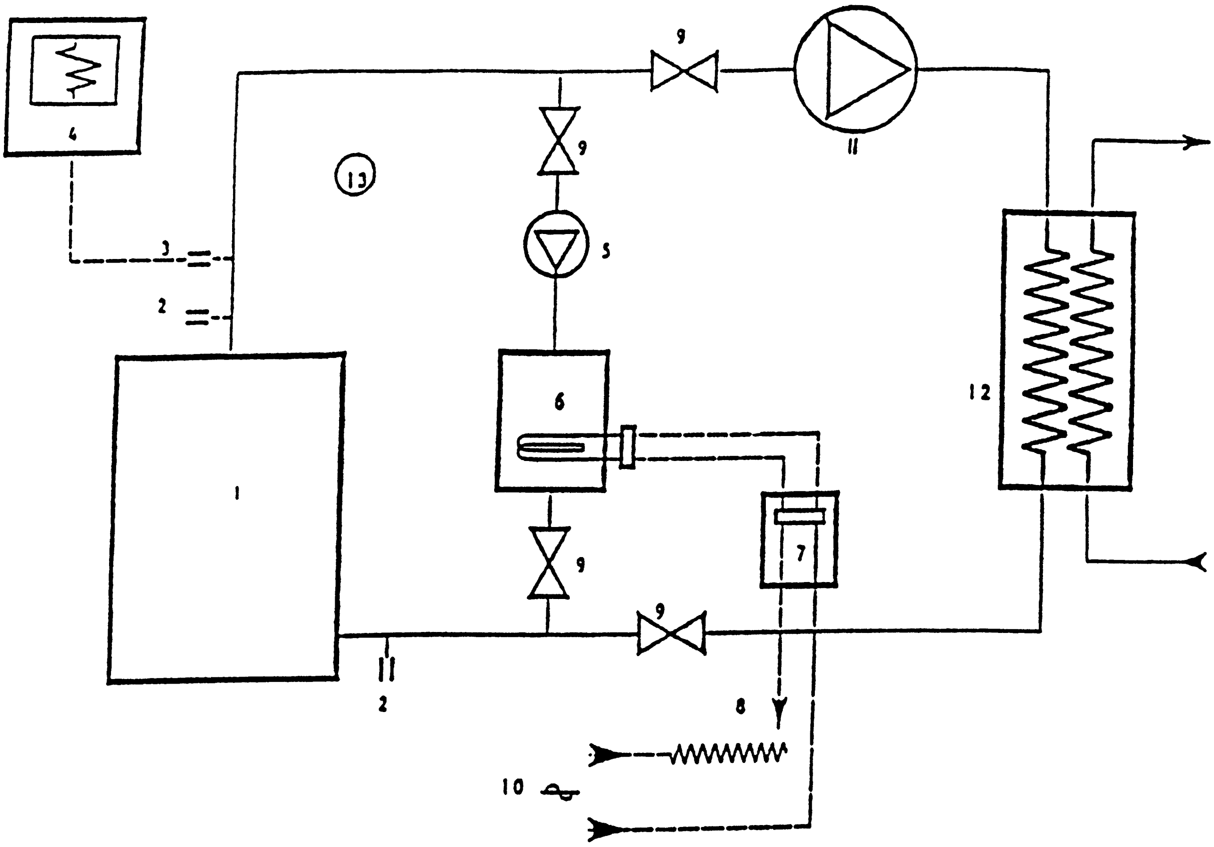


1 Boiler under test
2 Temperature probes
3 Low inertia thermocouple
4 Recorder
5 Pump with a rate such that the temperature difference between the two probes is between 2 °C and 4 °C at the maximum test temperature
6 Auxiliary electric boiler
7 Device for measuring the electric power
8 Voltage regulator
9 1/4 turn valves
10 Electrical supply
11 Additional pump (if necessary)
12 Heat exchanger

Figure 8 — Test installation to determine the heat emissions of the boiler when the burner is off and the thermal capacity of the boiler

A1

Annex A (normative) Measurements

A.1 Pressure measurement

For measured values up to 0,6 mbar, the admissible error is 0,01 mbar, for higher values it is equal to 2 % of the measured value.

A.2 Volume measurement

The instruments for measuring volume flow shall be checked before the tests by weighing the mass flowing. The error in the appropriate measurement range shall not exceed 0,5 % of the volume flowing.

A stopwatch calibrated in 0,01 min shall be used for the time element in flow measurement.

A.3 Fuel quantity measurement

Volumetric measurement shall give an accuracy of ±0,5 % of the flow measured by the measuring vessel.

A.4 Calculation of combustion parameters

The values of the components to be used in the following equations appear in Table A.1. An example is given in [ ]:

Oxygen requirement

$$O_{min} = \Sigma\, 3 \qquad \text{in } m^3/kg \qquad (1)$$

Air requirement

$$L_{min} = \frac{O_{min}}{0,21} \qquad \text{in } m^3/kg \qquad (2)$$

Dry flue gas volume for stoichiometric combustion

$$V_{Atr\,min} = \Sigma\, 5 + \Sigma\, 7 + \Sigma\, 11 + O_{min} \cdot \frac{0,79}{0,21} \qquad \text{in } m^3/kg \qquad (3)$$

Max. carbon dioxide content

$$CO_{2max} = \frac{\Sigma\, 5}{V_{Atr\,min}} \qquad \text{in } m^3/m^3 \qquad (4)$$

Max. sulfur dioxide content

$$SO_{2max} = \frac{\Sigma\, 7}{V_{Atr\,min}} \qquad \text{in } m^3/m^3 \qquad (5)$$

Actual dry flue gas volume

$$V_{Atr} = \frac{V_{CO_2} + V_{SO_2}}{(CO_2 + SO_2)_{measured} + CO_{measured}} = \frac{\Sigma\, 5 + \Sigma\, 7}{(CO_2 + SO_2)_{measured} + CO_{measured}} \qquad \text{in } m^3/Kg \qquad (6)$$

Water vapour content

$$V_W = C(9) \qquad \text{in } m^3/kg \qquad (7)$$

Using V_{Atr} and V_W the flue gas loss q_A is calculated from equation (15) or (16).

The following combustion parameters result from **A.4**:

Oxygen requirement: $O_{min} = \Sigma\ 3 = [2{,}346\ m^3/kg]$

Air requirement: $L_{min} = \dfrac{O_{min}}{0{,}21} = [11{,}17\ m^3/kg]$

Quantity of dry flue gases at stoichiometric combustion:

$$V_{Atr\ min} = \Sigma\ 5 + \Sigma\ 7 + \Sigma\ 11 + O_{min}\frac{0{,}79}{0{,}21}\ \text{in } m^3/kg$$

$$= [1{,}60] + [0{,}0016] + [0] + [2{,}346] \cdot \frac{0{,}79}{0{,}21}$$

$$= [10{,}427\ m^3/kg]$$

Table A.1

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Constituents in fuel	**Material content kg/kg**	**O_2 requirement in m^3/kg of fuel**	**Flue gas constituents resulting from fuel in m_3/kg of fuel**								
				CO_2		SO_2			H_2O		N_2
a			Material × O_2 requirement		Material × CO_2 content		Material × SO_2 content		Material × H_2O content		Material × N_2 content
c	[0,865]	1,86	[1,6089]	1,85	[1,6003]	—	—	—	—	—	—
s	[0,0024]	0,70	[0,0017]	—	—	0,68	[0,0016]	—	—	—	—
h	[0,1325]	5,55	[0,7354]	—	—	—	—	11,1	[1,4708]	—	—
n	[0,0001]	—	—	—	—	—	—	—	0,8	[0,0001]	
o	[0]	– 0,7	[0]	—	—	—	—	—	—	—	—
w (water)	[0]	—	—	—	—	—	—	1,24	[0]	—	—
Σ (total)	[1,0]	O_{min} =	[2,346]	V_{CO_2} =	[1,600]	V_{SO_2} =	[0,0016]	V_W =	[1,471]	V_{N_2} =	[0]

a In accordance with fuel analysis, calculation example in [ ].

Maximum carbon dioxide content:

$$CO_{2max} = \frac{\Sigma\ 5}{V_{Atr\ min}} = \frac{[1{,}6000]}{[10{,}427]} = [0{,}1534]$$

$$= [15{,}34]\ \%\ \text{by volume}$$

Maximum sulfur dioxide content:

$$SO_{2max} = \frac{\Sigma\ 7}{V_{Atr\ min}} = \frac{[1{,}0016]}{[10{,}427]} = [0{,}0001534]$$

$$= [0{,}0153]\ \%\ \text{by volume}$$

Quantity of water vapour:

$V_W = \Sigma\ \ 9 = [1{,}471\ m^3/kg]$

True quantity of dry flue gases:

$$V_{Atr} = \frac{V_{CO_2} + V_{SO_2}}{(CO_2 + SO_2)_{measured} + CO_{measured}}$$

$$= \frac{\Sigma\ 5 + \Sigma\ 7}{(CO_2 + SO_2)_{measured} + CO_{measured}}$$

Assuming that the measured $(CO_2 + SO_2)$ = [14,2] % by volume
and the measured CO = [1,02] % by volume
the example shows:

$$V_{Atr} = \frac{[1,6] + [0,0016]}{[0,142] + [0,0002]} = \frac{[1,6016]}{[0,1422]} = [11,26 \text{ m}^3/\text{kg}]$$

A.5 Combustion

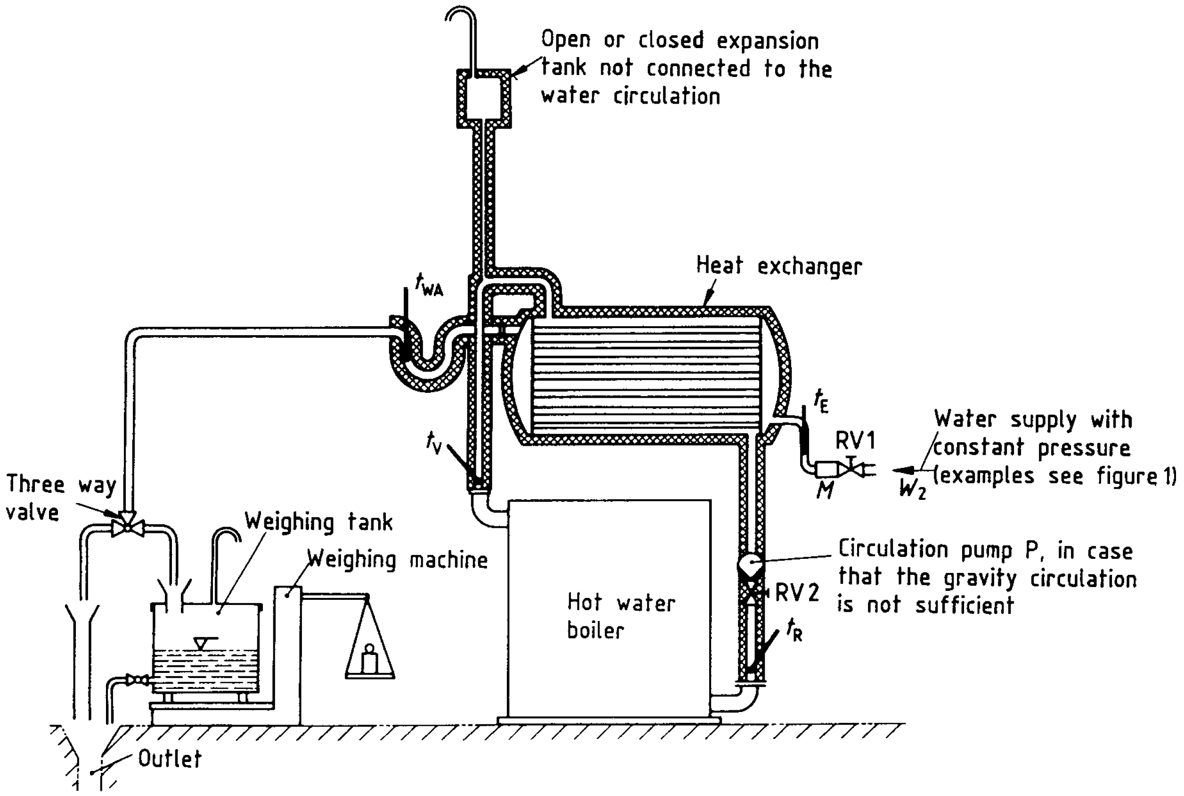
The tests shall only be carried out using calibrated instruments.

The CO content shall be measured to an accuracy of ±0,001 % by volume.

The air number shall be adjusted within a ±4 % tolerance.

A.6 Test rigs

A.6.1 ***Test rig with heat exchanger***



NOTE Because of the bigger water volume and the longer pipe runs the reaction of the test rig is relatively slow. This makes it more difficult for the steady state to be established. A correction is also necessary if the outlet and return temperatures are not exactly the same at the end of the test as at the beginning. Unless the relatively high heat losses are determined exactly, the test accuracy is impaired.

Figure A.1 — Test rig with heat exchanger

A.6.2 *Test rig with short-circuit section*

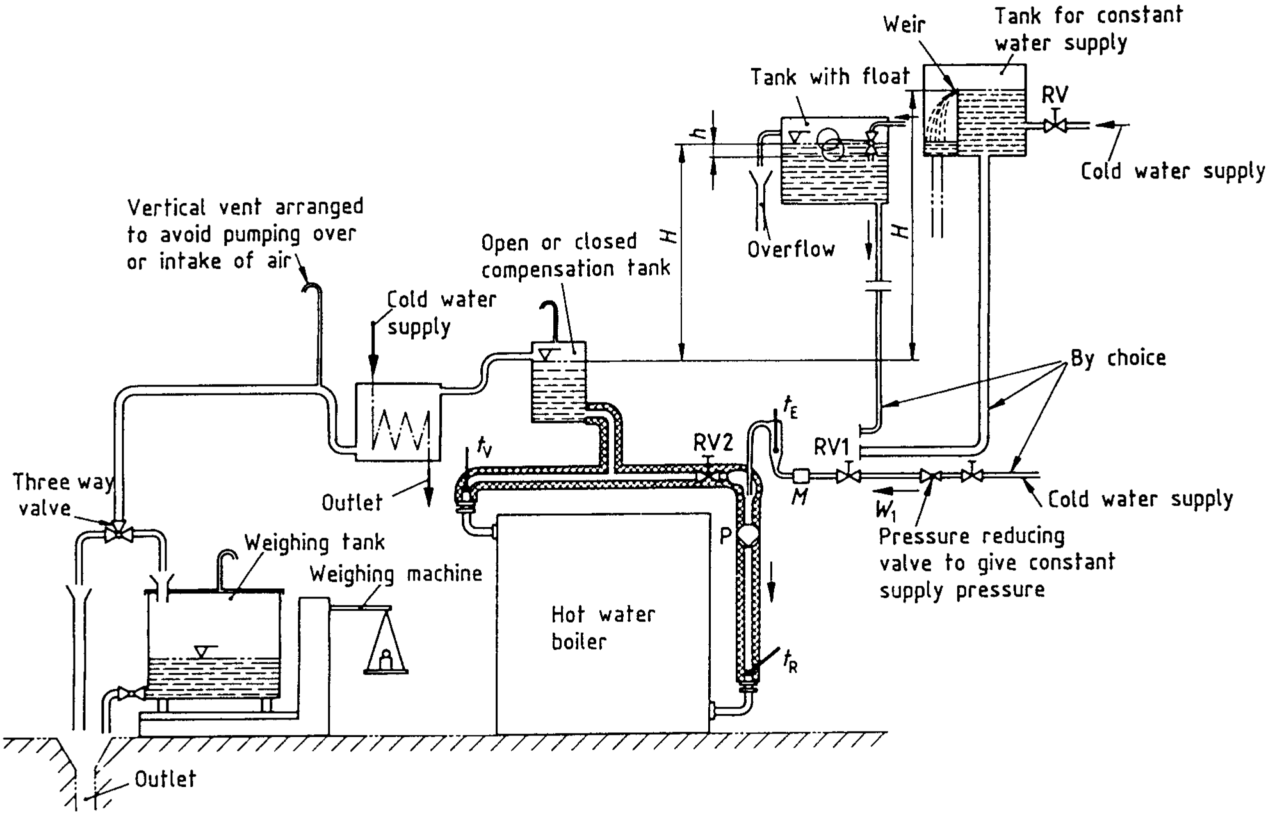


Figure A.2 — Test rig with short-circuit section and three possible arrangements for cold water supply

A.7 Calculation of the rated heat output Q_N

a) For tests using the test rig with short-circuit section (Figure A.2)

$$Q_N = W_1 \cdot c_{W_1} \cdot (t_v - t_E) \qquad \text{in W} \qquad (8)$$

where

W_1 mass flow of cold water entering the system and of the hot water flow leaving the system in kg/s;

c_{w1} specific heat capacity of water at $\frac{t_R + t_E}{2}$ in J/(kg·K);

t_E temperature of the entering cold water in °C;

t_V exit temperature of the water (flow temperature) in °C;

b) For tests using the test rig with heat exchanger (Figure A.1)

$$Q_N = W_2 \cdot c_{W_2} \cdot (t_A - t_E) + Q_V \qquad \text{in W} \qquad (9)$$

where

W_2 cooling water flow rate in kg/s;

c_{W_2} specific heat capacity of the water at $(t_{WA} + t_E)/2$ in J/(kg·K);

t_{WA} outlet temperature of the cooling water in °C;

Q_v heat loss from the test rig as shown in Figure A.1 at the temperature at which the test was performed in W.

A.8 Calculation of the heat input

A.8.1 *Quantity of heat supplied*

For boilers using liquid fuel the quantity of heat supplied Q_B is calculated as follows:

$$Q_B = B \cdot H_U \qquad \text{in W} \qquad (10)$$

where

B is the quantity of fuel in kg/s;
H_U is the net calorific value in J/kg.

A.8.2 *Determination of air factor and excess air*

$$\lambda = \frac{\text{the quantity of air supplied}}{L_{min}}$$

is established from the measurement of either ($CO_2 + SO_2$) and the CO content or O_2 content of the flue gases.

$$\text{excess air } e = (\lambda - 1) \cdot 100 \qquad \text{in \%}$$

If no other unburned components (e.g. H_2, CH_4, C_nH_m) are contained in the products of combustion

$$\lambda = 1 + \left\{ \frac{CO_{2max} + SO_{2max}}{(CO_2 + SO_2)_{measured} + CO_{measured}} - 1 \right\} \frac{V_{Atr\,min}}{L_{min}} \qquad (11)$$

or, if the O_2 content of the products of combustion is measured

$$\lambda = 1 + \frac{V_{Atr\,min}}{L_{min}} \cdot \frac{O_2}{21 - O_2} \qquad (12)$$

A.9 Calculation of the heat losses q_A, q_U, q_S

A.9.1 *Heat loss* q_A

The following formula applies if the air and fuel are introduced to the combustion equipment at ambient temperature, not preheated

$$q_A = \frac{V_A \cdot C_{pm,Atr}}{H_U} \cdot (t_A - t_L) \tag{13}$$

where

V_A	is the volume of products of combustion per kg or m^3 of the fuel burned in m^3/kg;
t_A	is the temperature of the products of combustion in °C;
t_L	is the temperature of the ambient air in °C;
$C_{pm,Atr}$	is the mean specific heat of the products of combustion in the range of t_L to t_A in J/(m^3·K);
H_U	is the net calorific value of the fuel in J/kg.

The volume of flue gases V_A can generally be established as follows if the combustion with the excess of air is imperfect:

a) dry flue gases

$$\begin{aligned} V_{Atr} &= V_{CO_2} + V_{SO_2} + V_{CO} + V_{N_2} + V_{O_2} \\ &= \frac{V(CO_2 + SO_2) + V_{CO}}{(CO_2 + SO_2)_{measured} + CO_{measured}} \end{aligned} \quad \text{in m}^3\text{/kg or m}^3\text{/m}^3; \tag{14}$$

where

V_{CO_2}	is the volume of carbon dioxide CO_2 in m^3/kg or m^3/m^3;
V_{SO_2}	is the volume of sulphur dioxide SO_2 in m^3/kg or m^3/m^3;
V_{CO}	is the volume of carbon monoxide CO in m^3/kg or m^3/m^3;
V_{N_2}	is the volume of nitrogen N_2 in m^3/kg or m^3/m^3;
$(CO_2 + SO_2)_{measured}$	is the measured proportion of $(CO + SO_2)$ in the flue gases in m^3/m^3;
$CO_{measured}$	is the measured proportion of CO in the flue gases in m^3/m^3.

For oil firing the loss due to the incomplete combustion, $CO_{measured}$, can be ignored.

$$V_{Atr} = V_{Atr,min} \cdot \frac{100}{100 - 4{,}76 \cdot O_2} \tag{15}$$

where

$V_{Atr,min}$ is determined from equation (3).

b) the volume of water vapour V_W resulting from water content and the combustion of the water forming components of the fuel in m^3/kg or m^3/m^3 (the water content of the combustion air may be ignored). When the volume of water vapour is separated from the volume of dry products of combustion, equation (13) becomes:

$$q_A = (V_{Atr} \cdot C_{pm,Atr} + V_W \cdot C_{pm,\,H_2O}) \cdot (t_A - t_L) \cdot \frac{1}{H_U} \qquad (16)$$

where

$C_{pm,Atr}$ is the mean specific heat of the dry flue gas in the temperature range t_L to t_A in J/(m^3·K);

$C_{pm,\,H_20}$ is the mean specific heat of the water vapour in the temperature range t_L to t_A in J/(m^3·K).

The values for the mean specific heat of the dry flue gases related to the CO_2 content and water vapour can be taken from Figure A.3.

Equation for determination (valid up to t_A = 500 °C);

$$C_{pmAtr} = 0{,}361 + 0{,}008 \cdot \left(\frac{t_A}{1000\ °C}\right) + 0{,}034 \cdot \left(\frac{t_A}{1000\ °C}\right)^2 +$$

$$+ \left[\left\{0{,}085 + 0{,}19 \cdot \left(\frac{t_A}{1000\ °C}\right) - 0{,}14 \cdot \left(\frac{t_A}{1000\ °C}\right)^2\right\}\right] \cdot \left(\frac{CO_2}{100\ \%}\right) +$$

$$+ \left[\left\{0{,}03 \cdot \left(\frac{t_A}{1000\ °C}\right) - 0{,}2 \cdot \left(\frac{t_A}{1000\ °C}\right)^2\right\}\right] \cdot \left(\frac{CO_2}{100\ \%}\right)$$

$$C_{pmH_2O} = 0{,}414 + 0{,}038 \cdot \left(\frac{t_A}{1000\ °C}\right) + 0{,}034 \cdot \left(\frac{t_A}{1000\ °C}\right)^2$$

where:

C_{pmAtr} is the mean specific heat capacity for dry combustion t_A in W·h/(m^3·K);

C_{pmH_20} is the mean specific heat capacity for water vapour in W·h/(m^3·K).

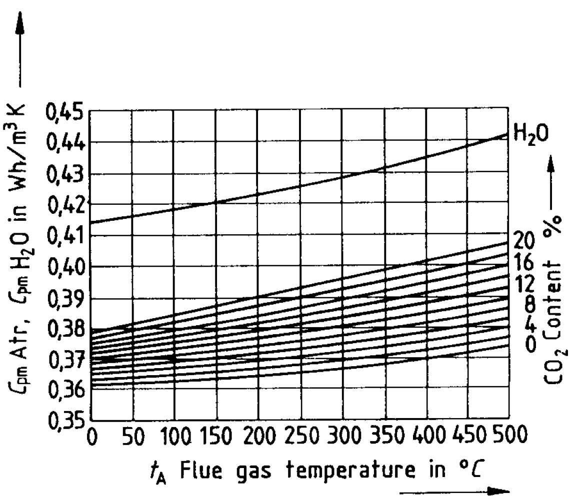


Figure A.3 — Mean specific heat capacities for dry combustion products and water vapour at flue gas temperatures up to and including 500 °C

A.9.2 *Heat loss* q_U

If the only unburnt component of the combustion products is CO (in %) the resulting loss is equal to:

$$q_U = CO \cdot V_{Atr} \cdot \frac{12,64}{H_U} \quad \text{in } \% \qquad (17)$$

A.9.3 *Heat loss* q_S

In the indirect method, it is necessary to know this loss. It can be obtained approximately by the following procedure:

The outer surface of the boiler is divided up into areas of similar temperature (insulated surfaces, doors, flue gas connections, connecting pipes, the boiler base) and their temperatures measured by means of the surface thermostat. The heat emission from the surface section is calculated as follows:

$$Q_X = F_X \cdot \alpha \cdot (t_m - t_L) \qquad (18)$$

where

- Q_X heat emission from surface section in W;
- F_X surface area of the section in m^2;
- α heat transfer coefficient in $W/(m^2 \cdot K)$;
- t_m mean surface temperature of the section in °C;
- t_L room temperature (measured at 7 point 1,5 m from the front of the boiler at a height equal to half the boiler's height) in °C.

Approximate heat transfer coefficients relative to the temperature of the surfaces can be obtained from Figure A.4.

The loss q_S can be obtained from:

$$q_S = \frac{\sum Q_X}{Q_B} \qquad (19)$$

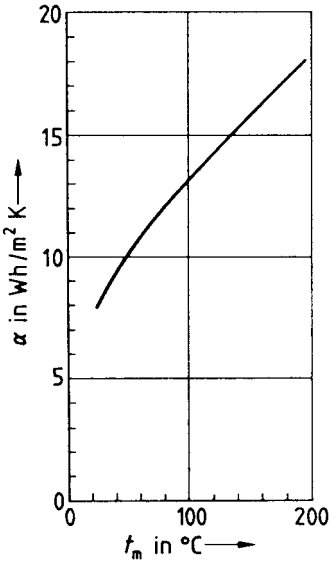


Figure A.4 — Total heat transmission figure α by radiation and free convection to the horizontal and vertical surfaces at an ambient temperature t_L = 20 °C as a function of the mean surface temperature t_m

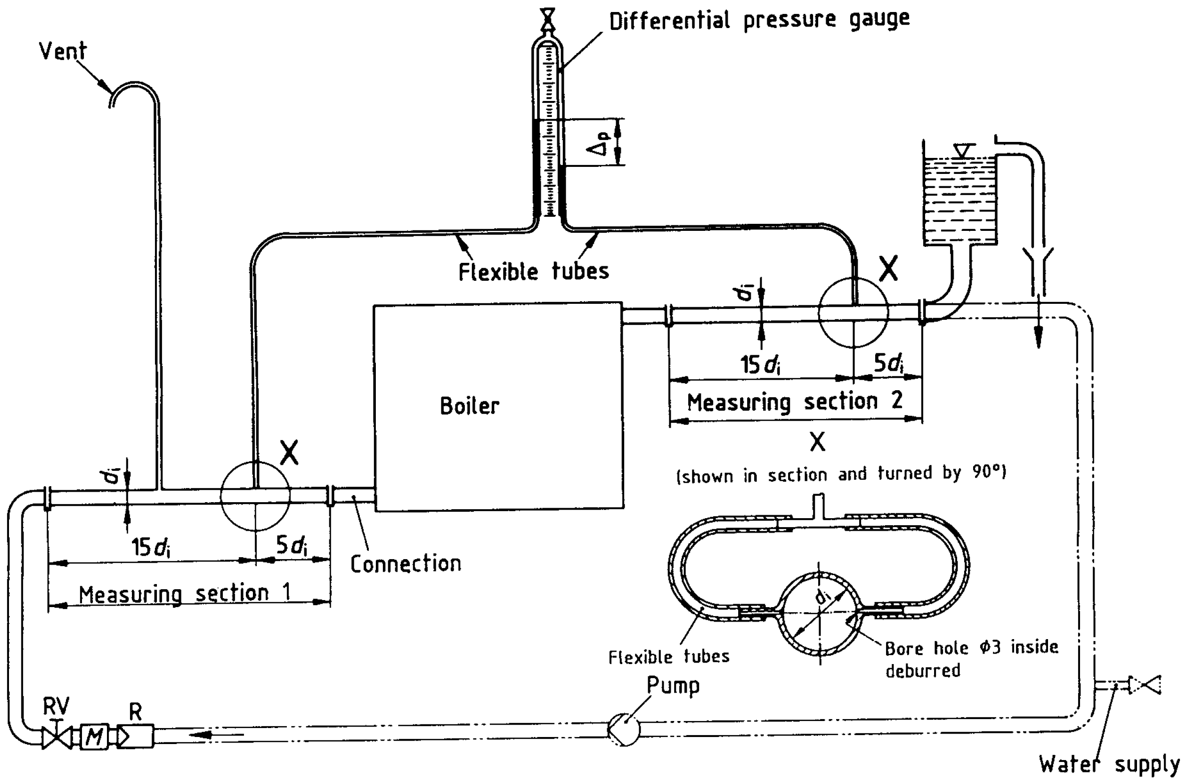


Figure A.5 — Test rig for determination of the waterside resistance (transparent flexible tubes for connections to differential pressure gauge)

A.10 Waterside resistance

A.10.1 In view of the required accuracy, it is recommended that the waterside resistance should be measured at a relatively high flow rate. After establishing the measured quantities, the required resistance values are obtained by extrapolation or interpolation.

Either before or after the main test the two measuring sections 1 and 2 are connected together at the points where they are connected to the boiler (see Figure A.5) and the resistance of these sections established for various flow rates. This resistance is then subtracted from the total resistance (measuring sections plus boiler).

A.10.2 ***Test rig for the establishment of the waterside resistance***

The inside diameter of the measuring sections 1 and 2 shall be chosen so that they are equal to the minimum connection sizes of the boiler.

By including a pump, the boiler and measuring sections can be arranged as a complete closed circuit.

For boilers with a built-in circulating pump the remaining delivery pressure available is measured and recorded.

The waterside resistance H_W of the boiler is calculated using the following formula:

$$H_W = \zeta \cdot \frac{v^2}{2} \cdot \rho \cdot 10^{-2} \text{ respectively } \zeta = \frac{2 \cdot H_W}{v^2 \cdot \rho \cdot 10^{-2}} \quad (20)$$

where:

H_w is the waterside resistance in mbar;
ζ is the resistance correction factor;
p is the 1 000 kg/m^3 density of water.

$H_W = \frac{\Delta_\rho \cdot \rho \cdot g}{10^5}$; Δ_ρ in mm; g ≈ 9,81 m/s^2

$v = \frac{W \cdot 4}{\pi \cdot d^2}$ velocity in the cross section of the connections in m/s;

W = water flow rate in m^3/s;
d = nominal diameters of the flow and return connections of the boiler in m.

A.11 Standby heat loss

A.11.1 *Test procedure*

The standby loss is determined by a test with a value of 50 K above room temperature being set at the boiler water temperature control and a pressure of – 0.05 mbar at the boiler exit which shall remain constant during the standby period. In addition all heat emission to the heating circuit shall be completely cut off. During the standby period of the burner the circulating pump which is to avoid thermal stratification in the boiler is not in operation. It starts via the water temperature controller together with the burner and shall have an overrun of 3 minutes after it is switched off. (The necessary timer is part of the test rig.)

The losses of the short-circuit section are deducted from the result of the test. It is allowable to convert other temperatures using $n = 1.15$ (see **A.11.2**).

At the end of each test period the total fuel consumption shall be measured. The standby loss shall be calculated at the end of each test period – from the beginning of the test.

The test can be finished, if two successive results differ by no more than 5 %. The smallest of the two results shall be used to calculate q_B – related to the desired value of the temperature.

Example:

$$\frac{q_{1+2} - q_1}{q_1} < 0{,}05$$

If > 0,05: $\frac{q_{1+2+3} - q_{1+2}}{q_{1+2}} < 0{,}05$

A.11.2 *Calculation*

The standby loss q shall be calculated according to the following formula:

$$q = \frac{\text{fuel consumption in the test period}}{\text{adjusted fuel consumtion per hour} \times \text{test period}} \quad (21)$$

For boiler temperature varying from the required temperature (including all tolerances) "q" is derived from the required temperature by applying an index $n = 1{,}15$:

$$q_B = q \cdot \left\{ \frac{\text{standard temperature}}{(\text{actual boiler temperature}) - (\text{actual ambient temperature})} \right\}^n = q \cdot \left(\frac{\Delta t\ 50}{\Delta t_{\text{as measured}}} \right)^{1{,}15} \quad (22)$$

Annex B (informative)
Applicable symbols and units

Symbol	Definition	Unit
B	Fuel combustion rate per period	kg/s
$(CO_2 + SO_2)_{measured}$	Measured carbon- and sulfur-dioxide content of the gases	m^3/m^3
$CO_{measured}$	Measured carbon monoxide content of flue gases	m^3/m^3
$CO_{2,\ max}$	Carbon dioxide content	m^3/m^3
c	Carbon content	kg/kg
$c_{w1,2}$	Specific heat content of water in relation to the appropriate mean water temperature	W·s/(kg·K) or J/(kg·K)
$c_{pm,Atr}$	Mean specific heat content of the gas	$J/(m^3 \cdot K)$ or $W \cdot h/(m^3 \cdot K)$
$c_{pm,\ H2O}$	Mean specific heat of water vapour	$J/(m^3 \cdot K)$ or $W \cdot h/(m^3 \cdot K)$
d	Nominal diameter of the flow and return connections	m
e	Excess air	%
F_X	Surfaces	m^2
h	Hydrogen content	kg/kg
H_U	Net calorific value of fuel	W·s/kg or $W \cdot s/m^3$ or J/kg
H_W	Waterside resistance	mbar
L_{min}	Air requirement	m^3/kg
O_2	Oxygen content	—
O_{min}	Oxygen requirement	m^3/kg
Q	Heat output	W
Q_B	Heat input	W
Q_N	Nominal heat output	W
Q_V	Heat losses from test rig	W
Q_X	Heat emission from surface section	W
q_A	Sensible heat loss in flue gases (relative value)	—
q_B	Standby loss (relative value)	—
q	Measured standby loss (relative value)	—
q_S	Heat losses by radiation from boiler surfaces (relative value)	—
q_U	Heat loss from incomplete combustion (relative value)	—
$SO_{2,max}$	Sulfur dioxide content	m^3/m^3
s	Sulfur content	kg/kg
t_A	Flue gas temperature	°C
t_E	Temperature of entering cold water	°C
t_L	Ambient temperature	°C
t_m	Mean surface temperature	°C
t_R	Return temperature	°C
t_V	Flow temperature	°C
t_{WA}	Temperature of water leaving rig	°C
V_A	Volume of flue gases	m^3/kg
$V_{Atr,min}$	Dry flue gas volume	m^3/kg or m^3/m^3
V_{CO}	Volume of carbon monoxide	m^3/kg or m^3/m^3

Symbol	Definition	Unit
V_{CO_2}	Volume of carbon dioxide	m^3/kg or m^3/m^3
V_N	Volume of nitrogen	m^3/kg or m^3/m^3
V_{SO_2}	Volume of sulfur dioxide	m^3/kg or m^3/m^3
V_W	Volume of water vapour	m^3/kg
v	Velocity in connection cross section	m/s
W_1	Water flow rate	kg/s
W_2	Cooling water mass flow	kg/s
w	Water content	—
α	Heat transfer rate	$W/(m^2 \cdot K)$
ζ	Resistance correction factor	—
λ	Air content	—
ρ	Density	kg/m^3
η_K	Boiler efficiency	—

Annex C (informative) Performance tests

C.1 General

The performance tests of the boiler are carried out by an authorized test body using authorized test equipment. The test authorities shall be either an institute independent of the manufacturer or a test section of the manufacturer's company.

The test can be carried out by authorized neutral testers using the test rigs of manufacturers. The requirements for authorization as a test section shall be having the necessary equipment, appropriately trained staff and an experienced test section manager.

C.2 Test

C.2.1 *Type test*

The type test determines whether the individual boiler sizes of a type or range meet the requirements laid down in this standard. During the type test the boiler shall be representative of production in its design and equipment.

For boilers in a product range which has the same constructional design it is sufficient to test only the smallest and largest boiler provided the ratio of the smallest to largest boiler is less than or equal to 2:1. If, however, within the same product range, this ratio is larger than 2:1 then so many intermediate sizes shall be tested so that the ratio of 2:1 is not exceeded.

The boiler manufacturer shall ensure that all boilers of a product range, even those which have not been tested, conform to the requirements of this standard. The results of non-tested boilers are determined by interpolation based on the nominal heat output. The test rigs shah conform to the requirements of EN 304.

C.2.2 *Type verification*

Type verification is carried out 1 year after the production has started and if justified doubts exist that a boiler conforms to the standard.

The boiler to be tested shall be taken from series production. The verification test shall be carried out by a recognized test authority which is independent of the manufacturer.

Annex D (informative)
Criteria for the adaptation of atomizing oil burners to heating boilers for liquid fuels

D.1 For burner/boiler units supplied together, the following does not apply.

D.2 For central heating boilers, the burner and the boiler are usually supplied separately and are assembled by the installer in situ. It is important to ensure, when assembling the two components, that the resulting unit complies with the relevant standards but, as far as possible, without requiring additional tests.

D.2.1 The European Standard EN 267 defines the working diagram of the oil burner. In the case where the boiler and the burner are delivered separately, a practical working diagram of the burner is created by the way, that the heat input is reduced by 5 %. The range of heat output/working point of the boiler shall then lie within the practical working diagram.

D.2.2 The minimum dimensions of furnaces in boilers with liquid fuel must not exceed the values of the graphs a) and b) in Figure D.1.

In Figure D.2 the length "*a*" is the distance between the nozzle and the boiler wall; to this length the value "*x*" can be added.

For burners with flame reversal and a heat output greater than 300 kW, the length "*a*" can be reduced by 20 %. As to a heat input of 10 kW and higher the reduction occurs proportionally to the heat input between 0 and 20 %.

When working with maximum heat output, the furnace diameter has to be higher than the values of graph "*b*" in Figure D.1.

D.3 The adaption has been carried out when:

— the boiler-body is in accordance with the requirements of EN 303-1 and EN 303-2,

— the atomizing burner is in accordance with the requirements of EN 267.

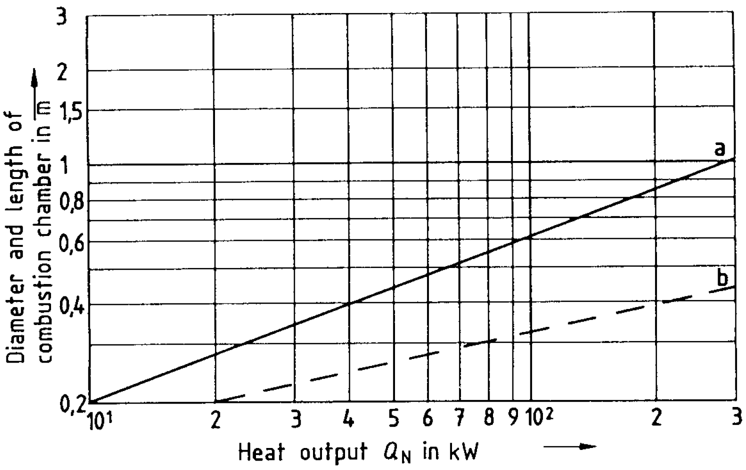
The criteria of **D.2** shall be fulfilled.

D.3.1 if not, it is necessary to make additional tests to the burner/boiler unit for the combustion quality at nominal heat input:

— starting test EN 267, **6.7.4**;

— emission limit values EN 303-2, **3.5**;

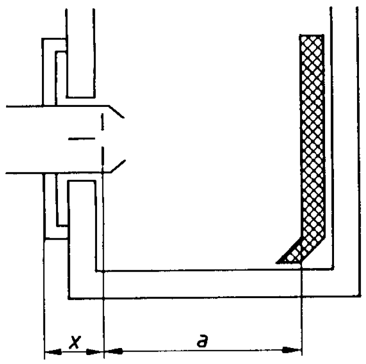
— boiler efficiency EN 303-2, Figure 1.



a: minimum length of combustion chamber

b: encircled diameter of the combustion chamber

Figure D.1 — Minimum dimensions of the combustion chamber



a: length of combustion chamber with or without fire brick

x: distance between burner flange and nozzle, given by the manufacturer

Figure D.2

[A1⟩ Annex E (informative) Hints for setting up and evaluation of the test rig

Figure 6 shows those thermal insulated pipes whose heat loss is to be taken into account for the calculation of the useful heat output of the boiler. For short, well insulated pipework circuits the losses are low. The input of heat, e.g. from a pump in the test rig, is also to be considered.

Figure 7 also shows thermally insulated pipes, and devices such as heat exchangers and expansion vessels, whose heat loss is to be taken into account for the calculation of the useful heat output of the boiler. If necessary these heat losses shall be determined in conjunction with the measurement of the pump contribution using an electrical heater as described in Annex F.

In Figure 7 the draw off heat output is to be measured and subtracted from the heat input. Because of the greater water volume and the longer pipe runs the reaction of the test rig is relatively slow. This makes it more difficult for a steady state to be established. A correction is also necessary if the outlet and return temperatures are not exactly the same at the end of the tests as at the beginning. Unless the relatively high heat losses are determined exactly the test accuracy is impaired.

The test rig shown in Figure 6 should preferably be used in order to obtain the best accuracy for determination of the efficiency at part load.

Annex F (informative) Determination of the heat losses from the test rig and the heat contributions of the circulating pump of the test rig

The boiler is taken out of the test rig in Figure 8 and the flow and return pipes are connected directly.

The pump (11) is stopped and the valves (9) on the exchanger are shut.

The pump (5) is started and operates continuously at the intended water rate.

The values $(T - T_A)$ are measured in the steady state under the following three conditions:

a) without electrical contribution from the boiler (6);

b) with an electrical contribution from the boiler (6), so as to obtain a value of $- T_A = (40 \pm 5)$ K;

c) with an electrical contribution from the boiler (6), so as to obtain a value of $(T - T_A) = (60 \pm 5)$ K;

where

T is the mean temperature value, indicated by the two probes (2);
T_A is the ambient temperature.

The measured values are plotted to determine the curve of the electrical contribution (in W) as a function of the value of $(T_1 - T_A)$ (in K).

It can be considered to be a straight line.

The equation of this straight line gives, for the water rate considered, the heat losses and contributions from the circulating pump of the test circuit as a function of $(T - T_A)$ (in K).

Annex G (informative) Determination of the time t_1

The time t_1 is measured during the test for the determination of efficiency. The boiler is started up and the time interval t_1 between the second stage oil valve being energized and this same valve being de-energized is measured. ⟨A1]

[A1› Annex ZA (informative) Clauses of this European Standard addressing essential requirements or other provisions of EU Directives

This European Standard supports essential requirements of EU Directive 92/42 EEC.

WARNING. Other requirements and other EU Directives may be applicable to the product failing within the scope of this standard.

The following clauses of this standard are likely to support requirements of Directive 92/42 EEC.

Compliance with the clauses of this standard provides one means of conforming with the specific essential requirements of the Directive concerned and associated EFTA regulations.

Essential requirement	Subject	Relevant clause
Article 5	Efficiency at full load and at part load	**5.8**

‹A1]

National annex NA (informative) Committees responsible

The United Kingdom participation in the preparation of this European Standard was entrusted by the Refrigeration, Heating and Air Conditioning Standards Policy Committee (RHE/-) to Technical Committee RHE/10 upon which the following bodies were represented:

Associated Offices Technical Committee
Association of British Solid Fuel Appliances Manufacturers
Association of Shell Boilermakers
Boiler and Radiation Manufacturers' Association Ltd.
British Coal Corporation
British Combustion Equipment Manufacturers' Association
British Foundry Association
British Gas plc
Building Services Research and Information Association
Chartered Institution of Building Services Engineers
Department of Energy (Energy Efficiency Office)
Engineering Equipment and Materials Users' Association
HETAS Ltd.
Health and Safety Executive
Institution of Chemical Engineers
Power Generation Contractors Association (BEAMA Ltd.)
Society of British Gas Industries
Waterheater Manufacturers' Association
Department of the Environment (Property Services Agency)

National annex ZB (informative) Cross-references

Publication referred to	Corresponding British Standard
EN 267:1991	BS EN 267:1991, *Methods of test for atomizing oil burners of the monobloc type*
EN 303-1:1991	BS EN 303-1, *Heating boilers — Heating boilers with forced draught burners — Part 1: Terminology, special requirements, testing and marking.*
EN 303-2:1991	BS EN 303-2, *Heating boilers — Heating boilers with forced draught burners — Part 2: Special requirements for boilers with atomizing oil burners.*

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