

Methods for

Assessing thermal performance of boilers for steam, hot water and high temperature heat transfer fluids —

Part 1: Concise procedure

Confirmed December 2011

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Refrigeration, Heating and Air Conditioning Standards 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 Radiator Manufacturers Association Ltd.
- British Coal
- British Combustion Equipment Manufacturers Association
- British Foundry Association
- British Gas Corporation
- Building Services Research and Information Association
- Chartered Institution of Building Services Engineers
- Department of Energy (Energy Efficiency Office)
- Department of Energy (Gas Standards)
- Department of the Environment (Property Services Agency)
- Domestic Solid Fuel Appliances Approval Scheme
- Engineering Equipment and Materials Users Association
- Health and Safety Executive
- Hevac Association
- Institute of Domestic Heating Engineers
- Society of British Gas Industries

The following bodies were also represented in the drafting of the standard, through sub-committees and panels:

- Association of Consulting Engineers
- British Paper and Board Industry Federation (PIF)
- Institution of Chemical Engineers
- Institution of Mechanical Engineers
- National Industrial Fuel Efficiency Service
- Water-tube Boilermakers' Association

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Foreword

This Part of BS 845 has been prepared under the direction of the Refrigeration, Heating and Air Conditioning Standards Committee. Together with BS 845-2 it supersedes BS 845:1972, which is withdrawn.

The revised edition of BS 845 describes, in two Parts, the procedures that should be used and the data that should be collected in order to obtain an assessment of the thermal performance of steam, hot water or high temperature heat transfer fluid boilers, generally of output greater than 44 kW. The results may be based on either the net or the gross calorific value of the fuel.

The procedures described in this British Standard are for thermal performance only but are based on the assumption that boilers are operated during the assessment in such a manner as to comply with relevant safety requirements and the requirements of national environmental legislation.

BS 845 is published in two Parts as follows.

— *Part 1: provides a concise but complete procedure and is convenient for boilers which are thermodynamically simple, i.e. having a single major source of heat input and a simple circuit for water, steam or high temperature heat transfer fluid;*

— *Part 2: provides a comprehensive procedure suitable for all boilers including those with multiple thermal flows to and from the boiler.*

Part 1 applies to boilers which do not condense moisture out of the flue gases. As experience is gained in industry with boilers with this facility, consideration will be given to publishing an addendum to give additional requirements in this respect.

Part 1 provides a straightforward procedure at minimum cost. It is intended to be used in connection with the testing of sectional cast iron, welded steel, shell and simple water-tube boilers for steam, hot water or high temperature heat transfer fluid. More complex boilers should be assessed in accordance with BS 845-2 but, in this context, no definitive division of boilers is possible.

Part 1 is concerned with boilers having conventional firing equipment and fired with solid fuels as normally supplied, fuel oil of standard grades, liquified petroleum gases or natural gas. It may be used also for assessments to be made where plant includes a special form of firing or involves the combustion of an unconventional fuel, the characteristics of which are not readily obtainable, but in such cases heat output should be measured in place of heat input as described in the following paragraph. Where a more detailed assessment is required, Part 2 of this standard should be used.

Part 1 uses the indirect (losses) procedure, in which the heat input is measured or, if not possible, the thermal output and the losses are established. Where the heat input cannot be measured conveniently the heat output may be measured as an alternative provided that the necessary accuracy of measurement can be achieved.

An assessment in accordance with this Part of BS 845 may be required on the following occasions:

- a) after the commissioning of new plant or after the recommissioning of modified plant in order to verify compliance with a specification or contractual obligation;
- b) whenever the user wishes to determine the current performance of the plant either on a routine basis or due to change of load or other operating conditions or when a change of fuel or a modification to the plant is being considered;
- c) whenever the user wishes to check combustion conditions.

Regular assessments in accordance with this Part of BS 845 will enable boiler plant to be monitored in normal operation for optimum efficiency in the interests of fuel conservation.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their 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 to iv, pages 1 to 16, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This Part of BS 845 describes a concise procedure for conducting thermal performance assessments, using the indirect (losses) procedure, to give results within a tolerance of ± 2 percentage points¹⁾ for boilers for steam, hot water or high temperature heat transfer fluids and for presenting the results in tabular form. Test results are based on either the gross or the net calorific value of the fuel.

This concise procedure provides a convenient means for assessing boilers which are thermodynamically simple, i.e. having a single major source of heat input and a simple circuit for water, steam or high temperature heat transfer fluid, and that do not condense moisture out of the flue gases.

NOTE The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this Part of BS 845 the following definitions apply.

2.1

assessed losses

any thermal losses established from predetermined data

2.2

gross calorific value

the amount of heat liberated by the complete combustion, under specified conditions, of unit volume of a gas or unit mass of a solid or liquid fuel in the determination of which the water produced by combustion of the fuel is assumed to be completely condensed and its latent and sensible heat made available (see BS 526)

2.3

net calorific value

the amount of heat generated by the complete combustion, under specified conditions, of unit volume of a gas or unit mass of a solid or liquid fuel in the determination of which the water produced by the combustion of the fuel is assumed to remain as a vapour (see BS 526)

2.4

heat input

the heat content of the fuel used during the test based on the gross or net calorific value plus the sensible heat in the fuel above ambient temperature

2.5

heat output

the heat gained by the heat carrier from the boiler during the period of the test

2.6

measured losses

any thermal losses calculated from actual measurements made during the test

2.7

indirect procedure

the determination of thermal performance by the assessment of the thermal losses and the measured thermal input or output. Major thermal losses are determined directly from measured quantities; minor losses are determined directly or assessed and in the case of radiation and convection losses Appendix B gives values

2.8

radiation, convection and conduction losses

the losses from water, steam, combustion air, or gas-backed surfaces prior to the flue gas temperature measurement point and directly from flame to the floor and surroundings of the unit

2.9

test error

the combined error due to sampling, measurements, calculations and assumptions used to obtain test results. The overall effect may be positive or negative

2.10

thermal efficiency

the difference between 100 % and the total percentage losses based on either the gross or net calorific value of the fuel. This is equivalent to the ratio of the useful heat output to the heat input expressed as a percentage

2.11

turn-down ratio

the ratio of maximum and minimum fuel inputs for continuous firing in unit time specified by the manufacturer. This ratio can also be expressed in terms of boiler output provided the appropriate efficiencies are known

3 General

NOTE Where a thermal performance assessment is to be carried out after the commissioning of new plant or after the recommissioning of modified plant, it is necessary for the parties concerned to decide at the plant tendering or ordering stage on the test data required and on the test accuracy and hence the instrumentation to be used (see Appendix B).

It is also necessary for the parties concerned to decide whether the test is to be carried out by the contractor or by an independent body and by whom it is to be witnessed.

3.1 Tests shall represent the intended method and system of operation of the plant under the intended conditions of installation and normal operation.

¹⁾ One percentage point is one hundredth of the total amount concerned, in this instance, the heat input.

NOTE Attention is drawn to the need for compliance with statutory requirements relating to smoke, grit, dust, SO₂ and NO_x emission.

3.2 Tests shall be carried out at predetermined firing rates, e.g. those corresponding to boiler rated output and to any reduced output of which the firing equipment is capable automatically, e.g. low rate of fire on high/low/off equipment and middle and low rates on firing equipment which fully modulates over a range.

NOTE 1 This may necessitate manually holding the firing rate at a particular setting and will require the availability of sufficient load during the period required to establish steady state (see 5.2) and for the duration of the test.

NOTE 2 These tests will enable the rated output and turn-down ratios to be verified.

4 Instrumentation

4.1 All measurements shall be made with instruments calibrated in accordance with the manufacturer's instructions. Portable or mobile instruments shall be used unless it can be shown that the sensors of installed instruments have been located correctly (see 5.8) and the system checked for accuracy.

NOTE A range of typical instruments suitable for the tests described in this standard are listed in Table 1 and their use is acceptable within their stated limits of accuracy.

Table 1 — Typical instruments and their accuracies

Measurement	Instrument	Probable error ^a	Remarks
Fluid flow	Positive displacement	± 1 % reading	Range 10 : 1
	Orifice, nozzle or venturi	± 2 % reading	Range 3 : 1
	Pitot tube	± 2 % reading	Range 3 : 1 local flow only
	Gap meter	± 2 % reading	Range 10 : 1
	Common vane-type meter	± 2 % reading	Range 10 : 1
	Vortex-shedding meter	± 1 % reading	Range 10 : 1
	Turbine meter	± 0.25 % reading	Range 10 : 1
Gas analysis	CO colorimetric	± 10 % reading	Range to be selected
	CO ₂ Orsat	± 0.1 % CO ₂	Delicate, requires expert use
	CO ₂ compact absorption type	± 0.3 % CO ₂	Simple and robust
	CO ₂ katharometer	± 0.2 % CO ₂	Can be vitiated by other gases
	O ₂ Orsat	± 0.2 % O ₂	Delicate, requires expert use
	O ₂ compact absorption type	± 0.3 % O ₂	Simple and robust
	O ₂ paramagnetic	± 0.1 % O ₂	Robust, air calibrated
	O ₂ electrochemical cell ^b	± 0.2 % O ₂	Cell deteriorates in time
Mass	Weighbridge	± 0.5 % reading	Solid and liquid fuels
Pressure	Bourdon gauge	± 2 % full scale deflection	Robust
Temperature	Mercury-in-glass thermometer	± 1 scale division	Delicate
	Mercury-in-steel thermometer	± 1 scale division	Robust, but bulky
	Thermocouple	± 1 °C	Robust and very flexible
	Resistance thermometer	± 0.1 °C	

NOTE The above table should be regarded as a guide since new forms of portable instrument are continually becoming available (e.g. infra-red analysers and electrochemical cells for certain gas analyses) and this should be borne in mind.

^a After calibrating, where appropriate. Different makes and models of instruments may vary in the manner in which their probable reading errors are expressed.

^b Where an electro-chemical cell is used convert the result to a dry basis.