BRITISH STANDARD

BS 4309:1968

Methods of

Measuring the performance of laboratory electric resistance furnaces

Confirmed December 2011

Co-operating organizations

The Laboratory Apparatus Industry Standards Committee, under whose supervision this British Standard was prepared, consists of representatives from the following Government departments and scientific and industrial organizations:

Agricultural Research Council
Association for Science Education
Association of Scientific Workers
Board of Trade
British Chemical Ware Manufacturers' Association
British Laboratory Ware Association*
British Lampblown Scientific Glassware Manufacturers' Association
British Pharmacopœia Commission
British Scientific Instrument Research Association*
Chemical Industries Association
Glass Manufacturers' Federation*
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Pharmaceutical Society of Great Britain
Royal Institute of Chemistry
Scientific Instrument Manufacturers' Association*
Society for Analytical Chemistry
Society of Chemical Industry
Society of Glass Technology
Standardization of Tar Products Test Committee

The Government departments and scientific and industrial organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard:

British Coke Research Association
British Electrical and Allied Manufacturers' Association
Ministry of Technology, National Engineering Laboratory

This British Standard, having been approved by the Laboratory Apparatus Industry Standards Committee and endorsed by the Chairman of the Chemical Divisional Council, was published under the authority of the General Council on 25 October 1968

The following BSI references relate to the work on this standard:
Committee reference LBC/19
Draft for comment D65/4302

ISBN 0 580 00143 1

Amendments issued since publication

Amd. No.	Date	Comments

Contents

Foreword

This standard makes reference to the following British Standard:

BS 1041, *Code for temperature measurement — Part 4: Thermocouples.*

Arising out of a suggestion from the British Scientific Instrument Research Association, the Laboratory Apparatus Industry Standards Committee authorized the preparation of a British Standard for methods of describing and measuring the performance characteristics of laboratory furnaces, and in the first place of electric resistance furnaces. The representative technical committee constituted for the purpose was thus not asked to specify appropriate *performance requirements* for furnaces, as had been done in the standards for various types of laboratory ovens[1)].

The reason for this different approach was the opinion that the wide range of electric furnaces and of their uses would make unprofitable any attempt to lay down requirements in numerical terms for the various performance characteristics. Nevertheless, it was felt that a list of definitions relating to performance and a statement of general principles of measurement would provide a basis on which specifications of performance could be drawn up to the mutual advantage of manufacturer and purchaser.

In all standards of performance for ovens and furnaces not designed for heat treatment of specific loads, the problem of whether to test the equipment with a charge or empty has to be resolved. Since the type of load can have a very marked effect on certain characteristics such as the distribution of temperature in the furnace, no one load can be regarded as a representative working load. It was therefore decided to recommend that furnaces whose performance is specified by reference to the standard should be tested empty. Test results on this basis will enable fair comparisons to be made; the user should bear in mind that the load will probably affect some aspects of the performance of the furnace. If precise temperature values are important the temperature distribution in the load itself should be measured.

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.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 3 and a back cover.

[1)] BS 2648, "*Performance requirements for electrically heated laboratory drying ovens*", BS 3421, "*Performance of electrically heated sterilizing ovens*" and BS 3718, "*Laboratory humidity ovens (non-injection type)*".

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 British Standard defines the important performance characteristics of general purpose laboratory electric resistance furnaces of box or tube form (the latter for use either horizontally or vertically) with exposed or concealed heating elements, and recommends appropriate methods of measuring these characteristics.

The standard is intended to apply to furnaces with rating up to about 8 kW and maximum temperature not exceeding 1 600 °C.

The tests are primarily intended for the following:

1) Furnaces with atmospheres of air (they may, however, be applied to furnaces with other atmospheres, e.g. reducing atmospheres, where appropriate).

2) Furnaces with static atmospheres or mechanical re-circulation.

3) Furnaces fitted with control devices, either as supplied or fitted for the purpose of the tests only (see Clause **3**).

NOTE It should be understood that this British Standard does not *specify* any type of furnace as to its performance or safety; or in any other way. It would thus be meaningless to state that a furnace "complies with the requirements of BS 4309", and such a form of words should not be used.

2 Definitions

For the purposes of this British Standard the following definitions apply:

2.1
working space

the space within which the stated performance of the furnace is achieved

2.2
furnace temperature

the temperature at the centre of the working space or at some other defined point in the working space

2.3
furnace temperature (indicated)

the temperature indicated by a suitable device installed by the manufacturer or in accordance with his instructions

2.4
maximum temperature

the highest temperature at which the furnace is designed to operate without unduly shortening its useful life

NOTE The criterion by which a useful furnace life is defined depends to a large extent on the nature of the employment of the furnace. For instance, a greater rate of deterioration of the heating elements or insulation at maximum temperature may be tolerated for experimental work than for a long-term heat treatment process. For this reason the length of time for which a furnace can be operated at maximum temperature is not defined in this standard. Furnace manufacturers should be prepared to state whether the quoted maximum temperature relates to short or to long periods of operation.

2.5
steady-state period

the period, during operation of the furnace from ambient temperature in specified ambient and voltage conditions, which commences when the mean power consumption has reached the minimum necessary to maintain a given mean furnace temperature

2.6
average maximum temperature

the arithmetic mean of the successive maximum furnace temperatures occurring in a specified number of temperature cycles during a steady-state period

2.7
average minimum temperature

the arithmetic mean of the successive minimum furnace temperatures occurring in a specified number of temperature cycles during a steady-state period

2.8
mean temperature

the arithmetic mean of the average maximum temperature and the average minimum temperature determined over the same specified number of temperature cycles

2.9
temperature variation

the difference between the mean temperatures at any two points in the working space, determined over the same specified number of temperature cycles

2.10
temperature fluctuation

the difference between average maximum and average minimum temperatures at any one point

NOTE Temperature fluctuation indicates the short-term changes in temperature caused by the operation of the controller. The *magnitude* of fluctuation is usually attributed mainly to the characteristics of the controller, whilst the *frequency* is also dependent on the thermal capacity of the furnace.

2.11
temperature drift

change in furnace temperature over a long period of time during a steady-state period

2.12
heating-up time

the time from switching on the cold furnace to the time when a specified indicated furnace temperature is first attained

2.13
stabilization time

the time measured from the end of the heating-up period to the beginning of the steady-state period

2.14
rating or Maximum power consumption

the maximum power requirements under any operating condition. The voltage at which the power consumption is calculated, or measured, must be stated

2.15
thermal loss

rate of loss of heat during a steady-state period

3 Test conditions

Tests to determine the values of the characteristics covered by the foregoing definitions are carried out with the furnace empty and preferably with the control system with which it is to be used, because some of the characteristics to be measured are dependent more on the controller than on the furnace. When the specification or test result is quoted for a furnace not supplied with control equipment, the control equipment used in obtaining the data on that particular furnace should be identified either by manufacturer's designation or by precise specification.

The voltage of the electricity supply must be that for which the furnace is designed and it should be kept reasonably constant throughout the tests, as should ambient conditions.

4 Temperature measuring equipment for tests

The temperature measurements should be made by means of a suitable thermocouple, or thermocouples, and measuring system. (For guidance on the use of thermocouples see BS 1041-4[2].)

The choice of a bare or a sheathed thermocouple for the temperature distribution, variation and fluctuation tests depends on the type of furnace and the nature of the test. Both types are used but where possible the use of a stationary thin-walled, narrow-bore tube, through which the thermocouple is drawn, is recommended.

5 Temperature distribution and variation

The measurements required to determine temperature variation are made at a number of specified points in the working space; these points will usually lie along the line of the axis of the furnace or along the centre line of the floor or will be distributed about the working space, whichever is the more appropriate to the normal mode of use of the furnace. Precautions must be taken to ensure that temperature drift which might occur during the measurement period does not introduce error; for example the differential method using two thermocouples connected in series may be used, or the measured temperatures may be corrected for drift by reference to the simultaneously determined mean indicated furnace temperature.

The temperature distribution is obtained by calculating the mean temperature at each of the specified points during a steady-state period. These mean values are then plotted in the form of a curve or a set of curves or a chart, from which temperature variation may be determined, if necessary by interpolation.

6 Temperature fluctuation

The temperature fluctuation is conveniently determined from the measurements made for calculation of temperature distribution.

7 Thermal loss

The mean power consumption during a steady-state period may be taken as a measure of thermal loss and may be determined either with an integrating power meter or by timing the operations of the controller if this is of the on/off type. Measurements should be made over a sufficient period of time to ensure that a true average is obtained.

8 Case temperature

Where the case temperature is important, for example where anything in actual contact with the furnace is likely to be damaged by excessive temperature, or where the operator is likely to receive burns by touching the furnace case, the temperature at specified points should be measured by a suitable thermocouple placed in contact with the case, when the furnace is operating under steady-state conditions at the manufacturer's recommended maximum temperature.

[2] BS 1041, "*Code for temperature measurement*". Part 4, "*Thermocouples*".

9 Adjacent surface temperature

The purpose of this test is to check that the heat loss from the furnace is not excessive, thereby causing damage to adjacent surfaces by overheating. The surface usually affected is the supporting surface. A standard surface, e.g. a matt black surface on a material which has a high conductivity, should be used in the test. The standard surface can be set flush with the adjacent surface to be tested in a sheet of soft wood with a thermocouple fitted to the conducting material in order to measure the surface temperature. All measurements should be taken when the furnace is operating under steady-state conditions at the manufacturer's recommended maximum temperature.

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