BRITISH STANDARD

BS 2648:1955

Incorporating Amendment Issued June, 1956 (PD 2517)

Performance requirements for

Electrically-heated laboratory drying ovens

Confirmed December 2011

Co-operating organizations

The Scientific Glassware and Related 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:—

Admiralty*
Air Ministry
Association of British Chemical Manufacturers
Association of Scientific Workers
Board of Trade
British Association for the Advancement of Science
British Chemical Ware Manufacturers' Association
British Laboratory Ware Association*
British Lampblown Scientific Glassware Manufacturers' Association
British Pharmacopoeia Commission
British Scientific Instrument Research Association*
Chemical Society
Department of the Government Chemist*
D.S.I.R. — Chemical Research Laboratory
Glass Manufacturers' Federation
Institute of Petroleum
Ministry of Education
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National Physical Laboratory
Oil Companies Materials Committee
Royal Institute of Chemistry
Science Masters' Association
Society for Analytical Chemistry*
Society of Chemical Industry
Society of Glass Technology
Standardization of Tar Products Tests 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 Coal Utilization Research Association
British Dairy Farmers' Association
Central Electricity Authority
Milk Marketing Board
Ministry of Agriculture, Fisheries and Food
National Institute for Research in Dairying
Individual manufacturers

This British Standard, having been approved by the Scientific Glassware and Related 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 29th December 1955

The following BSI references relate to the work on this standard:—
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Amendments issued since publication

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PD 2517	June 1956	Indicated by a sideline in the margin

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Foreword

In order to keep abreast of progress in the industries concerned, British Standards are subject to periodical review. Suggestions for improvements will be recorded and in due course brought to the notice of the committees charged with the revision of the standards to which they refer.

A complete list of British Standards, numbering over 6000, fully indexed and with a note of the contents of each, will be found in the British Standards Yearbook, which may be purchased from BSI Sales Department. It may also be consulted in many public libraries and similar institutions.

This standard makes reference to the following British Standard:—

BS 593, *Laboratory thermometers.*

This British Standard has been prepared under the authority of the Scientific Glassware and Related Apparatus Industry Standards Committee. A representative technical committee was set up following a request from the dairying industry that a British Standard should be prepared for laboratory ovens.

The committee decided to concentrate in the first place on the performance requirements of the type of electrically-heated oven widely used for the determination of moisture by drying at or near 100 °C. Workers in many laboratories were invited to supply information on the performance of their ovens and to comment on tentative standards suggested by the committee. After the replies had been considered, typical ovens were submitted to a comprehensive programme of tests devised by the committee, with the co-operation of the British Scientific Instrument Research Association and the British Laboratory Ware Association. The limits specified in this standard will satisfy the requirements of most users without unduly increasing the cost of manufacture.

While not desiring to exclude existing designs of oven incorporating adjustable speed fans or adjustable ventilation ports, the committee found no evidence that either of these facilities for adjustment confers an advantage in performance. It is therefore recommended that no provision for restricting the air flow or for altering the speed of the fan (if present) should be made.

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 and ii, pages 1 to 5 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 British Standard specifies the performance requirements of electrically-heated laboratory ovens of the type used for the determination of moisture by drying within the temperature range 95 °C to 110 °C, and having external provision for manual adjustment to any desired temperature within that range. Ovens having a wider temperature range are not excluded provided they comply with the other requirements of this standard.

The standard applies to ovens with an internal space of about 1 to 3 cu. ft which are ventilated by convection, whether or not they are fitted with internal fans to assist the circulation of air; it does not apply to vacuum ovens or to forced draught ovens.

2 Definitions

For the purposes of this British Standard, the following definitions shall apply:—

working space

that portion of the internal space which is above the lowest shelf and not less than 3 cm from any wall (including the roof)

oven-temperature

the temperature at the centre of the working space

temperature variation

the difference at any moment between the temperature at the centre of the working space and at any other point in the working space

temperature fluctuation

the short-term changes in temperature at any point in the working space

temperature drift

any long-term changes in oven temperature during continuous operation of the closed oven

temperature overshoot

any excess of actual over desired oven temperature during a heating-up period

3 Conditions of test

The performance of the oven shall be tested with vents fully open and with the shelves in position, but with the oven otherwise empty[1)]. Measurements shall not commence until at least two hours after the oven has been switched on.

In any test to determine the rate of ventilation of an oven the door-joint and all other possible sources of leakage shall be effectively sealed.

4 Measurement of temperature

The oven temperature shall be measured by means of a mercury-in-glass thermometer with the unshielded bulb as near as practicable to the centre of the working space. The oven shall be so constructed that a thermometer can be conveniently inserted for this purpose. The thermometer used shall have a bulb capacity not greater than 0.5 ml and a maximum error not greater than 0.3 °C, and the error over any interval of 10 °C shall not vary by more than 0.3 °C[2)].

Temperature variation and temperature fluctuation shall be measured by means of loaded thermocouples of the type described in Appendix A.

5 Manual adjustment of temperature setting

The external provision for manual adjustment of temperature shall be such that an oven temperature can be attained within 0.5 °C of any desired temperature in the range 95 °C to 110 °C.

6 Temperature variation

The temperature variation, measured as described in Appendix B, shall not exceed 2.5 °C.

7 Temperature fluctuation

The temperature fluctuation, measured as described in Appendix C, shall not exceed 1.0 °C over a period of 30 minutes.

[1)] Experience has shown that the effect of loading an oven is to disturb the temperature conditions to an extent depending on the quantity and nature of the particular loading material. As it is impossible to specify a standard condition of loading which would represent the wide range of uses to which these ovens may be put, the tests have been specified for the empty oven.
[2)] Thermometer B 110C/Total of BS 593 "Laboratory thermometers" is suitable.

8 Temperature drift

The difference between the highest and lowest oven temperature recorded during 72 hours of continuous operation without alteration to the thermostat setting shall not exceed 1.0 °C[3]. For this purpose the oven temperature shall be measured at least thrice daily at intervals of at least three hours.

9 Reproducibility of oven temperature

The initial oven temperature shall be regained to within 1.0 °C after the oven has been switched off, allowed to cool for at least six hours and switched on again for at least two hours, without any alteration to the thermostat setting.

10 Time of temperature recovery

An oven temperature of 99 °C shall be regained in not more than 20 minutes after the temperature has been reduced from an initial steady value of 100 °C by opening the oven door fully for one minute.

11 Temperature overshoot

Any temperature overshoot induced by the procedure described in Clause **10** shall not result in the temperature exceeding 103 °C, and a temperature of 101 °C shall not be exceeded for longer than 10 minutes.

12 Ventilation rate

The rate of ventilation shall be measured with the oven in operation at a temperature exceeding that of the room by 80 ± 2 °C. It shall be not less than 800 litres per hour, measured at the temperature and pressure obtaining in the laboratory at the time of test by either of the methods of test described in Appendix D or by any other method which has been found to give equivalent results[4].

13 Marking

Each oven shall have permanently and legibly marked on it:

a) An identification number.

b) The manufacturer's or vendor's name or registered trade mark.

c) The number of this British Standard, i.e. BS 2648[5].

[3] The temperature limits specified in Clauses **7** and **8** are similar, but it should be pointed out that temperature fluctuation refers to measurements using a thermocouple at any point in the oven, whereas temperature drift refers to measurements using a mercury-in-glass thermometer at the centre of the oven; thus steadier readings may be expected for the latter.

[4] It is important that the method used should impose no appreciable restraint upon the flow of air through the oven.

[5] The mark "BS 2648" on the product is an indication by the manufacturer that it purports to comply with the requirements of this British Standard.

Appendix A Construction and use of loaded thermocouple

The loaded thermocouple shall be constructed by attaching with a minimum of solder one end of a length each of iron and of constantan[6] No. 30 S.W.G. (0.012 4 in.) insulated wire to a flat about 2 mm in diameter, ground on a $^{3}/_{16}$-in. diameter steel ball.

A circuit including the thermocouple, a cold junction and measuring device (e.g. a critically-damped galvanometer) shall be established, sufficiently sensitive to allow temperature measurement to within 0.1 °C.

The thermocouple shall be calibrated and the ball shall then be cleaned and thinly but uniformly blackened by coating with a colloidal graphite preparation[7].

Except as indicated in Appendix B, the thermocouple shall not be used less than 3 cm from a shelf or other part of the oven. The leads may be brought out through a split rubber stopper inserted in the thermometer aperture.

Appendix B Measurement of temperature variation

Two of the loaded thermocouples described in Appendix A shall be used differentially, the free ends of the constantan leads being joined together. The temperature differences shall be measured with one thermocouple as near as possible to the centre of the working space and the other placed in turn at:

a) the upper corners of the working space;

b) points as near as possible to the centres of the four sides of the working space;

c) points vertically above the lower corners of the working space and 1 cm above the lowest shelf; where this shelf has more than one position the lowest shall be used for this test.

In the case of horizontal cylindrical ovens the test points are defined with reference to a concentric cylinder of radius 3 cm less than the internal radius of the oven extending between planes parallel to, and 3 cm inwards from, the door and back wall. The working space is the space within the segment of this cylinder lying above the lowest shelf. The positions of the four "lower corners" of the working space are unambiguous; the "upper corners" are taken to be on the cylinder defining the upper part of the working space, at points vertically above the lower corners. The "centres of the four sides of the working space" are defined by the midpoints of the four lines formed by the intersection of a horizontal diametral plane with the boundaries of the working Space.

A suitable multi-junction system composed of such loaded thermocouples may be used, the temperature differences being measured with respect to a thermocouple placed as near as possible to the centre of the working space.

Whichever method is used, the mean shall be taken of at least three readings at each point tested.

[6] Any other suitable combination of metals may be used.

[7] "Dag 479", supplied by Messis. Acheson Colloids Ltd. has been found suitable.

Appendix C Measurement of temperature fluctuation

One of the loaded thermocouples described in Appendix A shall be used in turn at the points in the working space defined in Appendix B. The temperature shall be recorded either continuously, or at intervals not exceeding three minutes, during the 30-minute test period.

Appendix D Measurement of ventilation

1 Indirect, or power-consumption method

In this method the additional power required to maintain the oven at a given temperature with its ports open, over that required to maintain the oven at the same temperature with its ports closed, is used as a measure of the quantity of air passing through the oven when the ports are open. The average power (x watts) required to maintain the oven temperature at 80 ± 2 °C above the room temperature is determined over a period of 30 minutes or longer. The ventilation ports (and, if necessary, the thermometer aperture) are now closed and the run is repeated for a similar period (y watts required). It is essential that the difference between the oven temperature and the room temperature should be the same for the two runs to within 0.2 °C. The room temperature should be measured at a point 6 ft from the oven approximately level with its base, and at least 2 ft from any solid objects.

The amount of air passing through the oven when the ports are open is given by

$$w = \frac{x-y}{c_p(t_2-t_1)} \quad (1)$$

$$V = \frac{3600w}{d} \quad (2)$$

where

c_p is the specific heat of air at constant pressure (1.003 joule per gramme)

t_1 is the room temperature

t_2 is the oven temperature

$(x-y)$ is the difference in power-consumption as defined in the first paragraph

w = weight of air, grammes per second

V = volume of air, litres per hour

d = density of air in the laboratory at time of test, grammes per litre[a]

Hence $V = \frac{3600}{1{\cdot}003\,d} \times \frac{x-y}{t_2-t_1}$

$= \frac{3590\ (x-y)}{d(t_2-t_1)}$

[a] Density of air at 760 mmHg and 20 °C is 1.205 g/l.

This formula assumes that when the ports are closed no air passes through the oven. Therefore, there must be no leakages: the door joint should be sealed with adhesive tape and all apertures, including the inlet port, should be effectively closed.

If the power consumption is measured with a wattmeter the total length of time in seconds for which the oven heaters are "on" is measured with a stopclock and the reading of the wattmeter is taken once during each "on" period. The average of the wattage readings multiplied by the total time registered by the stopclock and divided by the length of the run in seconds is taken as the power in watts required to maintain constant temperature.

If a watt-hour or kilowatt-hour meter is used the reading of the total energy consumption registered by the meter is divided by the length of the run measured as a fraction of an hour. If a domestic kilowatt-hour meter is used, the dial units are too large to enable a sufficient accuracy to be obtained over a reasonably short run, and the rotating disk with which these meters are provided is therefore used as the power consumption indicator. The meter is put in operation until the index mark on the disk is opposite the centre of the window, and is then disconnected until the start of the run.

To reduce the possible error, a long enough run is taken to give about 100 disk revolutions, and the run is preferably ended when the mark on the disk is visible. If, however, the mark is out of sight at the end of the run, an estimated fraction of a revolution is added. The run is started and stopped at corresponding points of the "on-off" heating cycle (e.g., at the moment when the heaters are switched on by the thermostat).

2 Direct method, using rotating anemometer

A small free-running turbine is used in conjunction with a stroboscope to obtain a measure in arbitrary units of the rate of flow of air from an outlet of the oven when the latter is operating under normal conditions with the ventilation ports open. A metered flow of air from a pump is passed into the oven through the inlet ports and its rate adjusted until the outlet flow measured by the anemometer is restored to its original value.

A turbine which has been found suitable consists of four or six balsa vanes, inserted into slots in a balsa hub. This turbine is of diameter approximately the same as that of the outlet port of the oven, and is supported on a vertical steel pivot (e.g., the tip of a sewing needle) by means of an inverted cup bearing, preferably of sapphire, mounted on the hub. To ensure stability, the hub is at least 1 cm in length with the vanes inserted at the lower end and the bearing at the top. The vertical pivot passes through a clearance hole bored in the hub. To secure the cup bearing in position it is pressed into the centre of an aluminium disk which is then cemented to the hub with a heat-resisting cement. A wire spider supports the pivot at the centre of a vertical tube 2 in. long and of a diameter just large enough to accommodate the turbine. The purpose of this tube is to support the assembly and to protect the turbine from draughts.

To make a measurement the oven is brought to a steady condition of operation and the anemometer placed over an open outlet port (the other ports if any, being also open). The rate of rotation of the turbine is measured with the stroboscope. A tube is then connected to the inlet port or ports with the oven heater still in normal operation and through it a metered air stream is pumped into the oven. The flow of this air stream is adjusted until the turbine is rotating at the same rate as before, and the air flow is measured. This rate of flow is the rate of ventilation of the oven.

For the purpose of this measurement, the door joint should be sealed with adhesive tape to prevent leakage of air.

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