BRITISH STANDARD

BS 6043-4.11: 1991

Methods of sampling and test for

Carbonaceous materials used in aluminium manufacture —

Part 4: Cold ramming pastes —

Section 4.11 Determination of the thermal expansion of baked rammed paste

NOTE It is recommended that this Section be read in conjunction with the general information in BS 6043-4.0, published separately.

Confirmed November 2008

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Chemicals Standards Policy Committee (CIC/-) to Technical Committee CIC/24, upon which the following bodies were represented:

Aluminium Federation
British Ceramic Research Ltd.
Chemical Industries Association
Institute of Petroleum
Refractories Association of Great Britain

This British Standard, having been prepared under the direction of the Chemicals Standards Policy Committee, was published under the authority of the Standards Board and comes into effect on 30 September 1991

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Contents

Foreword

This Section of BS 6043 has been prepared under the direction of the Chemicals Standards Policy Committee to provide a method of test for cold ramming pastes used in the production of aluminium. There is no corresponding International Standard; however, it is intended, upon publication of this Section of BS 6043, that it be offered to the International Organization for Standardization (ISO) for possible adoption as an International Standard.

It is essential to use BS 1902-5.3 and BS 6043-4.1, BS 6043-4.6 and BS 6043-4.7 in conjunction with this Section of BS 6043.

This standard describes a method of test only, and should not be used or quoted as a specification defining the characteristics of a product. Reference to this Section should indicate that the method of test used is in accordance with BS 6043-4.11:1991.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 4, 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 Section of BS 6043 describes a method for the measurement of the reversible linear thermal expansion of test pieces prepared from baked rammed cold ramming paste used in aluminium manufacture.

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

2 Principle

A baked test piece of known dimensions is produced from a test sample of the cold ramming paste by compaction under regulated conditions followed by baking according to a defined programme. A thermal expansion test piece, of standard dimensions, is cut from the baked test piece then heated at a specified uniform rate and its change in length and temperature measured, either continuously or at regular and frequent intervals during heating. The thermal expansion relative to the length at ambient temperature is calculated for the temperature of the thermal expansion test piece and the results are either plotted as a graph or expressed as a mean coefficient of expansion for a given temperature range.

3 Apparatus

3.1 *Ordinary laboratory apparatus*, and the apparatus described in **3.2** to **3.4**.

3.2 *Ramming apparatus*, and the other apparatus described in clause **4** of BS 6043-4.7:1991.

3.3 *Thermal expansion apparatus*, described in clause **5** of BS 1902-5.3:1990 modified as shown in Figure 1 to allow continuous purging of the furnace with inert gas.

3.4 *A supply of inert gas*, e.g. oxygen-free nitrogen, to prevent oxidation of the thermal expansion test piece at temperatures up to 1 100 °C, with means for controlling and measuring the flow rate.

4 Sampling

Prepare a representative laboratory sample of cold ramming paste in accordance with BS 6043-4.1.

5 Preparation of test sample

Prepare a test sample from the laboratory sample (see clause **4**) by the method described in **7.1** and **7.3** of BS 6043-4.7:1991.

6 Procedure

6.1 Preparation of baked test piece

Prepare a rammed test piece by ramming the test sample (see clause **5**) by the procedure described in **8.2** of BS 6043-4.7:1991 using the ramming apparatus (**3.2**). If the cold ramming paste requires pre-curing before being baked, pre-cure the test piece in accordance with **8.3** of BS 6043-4.7:1991. Bake the rammed test piece in accordance with **8.4** of BS 6043-4.7:1991.

NOTE A baked test piece prepared as described in **6.1** may first be used for the determination of electrical resistivity by the method described in BS 6043-4.8.

6.2 Preparation of thermal expansion test pieces

Cut the baked test piece (see **6.1**) to produce a minimum of three thermal expansion test pieces of length 75 ± 2 mm and cross-sectional dimension either 10 ± 2 mm square or 10 ± 2 mm in diameter. Carefully place the thermal expansion test pieces in an oven controlled at 110 ± 5 °C for 2 h then allow them to cool to ambient temperature in a desiccator. Weigh the test pieces to the nearest 0.001 g, then repeat the operations of heating for 2 h at 110 ± 5 °C, cooling and weighing until consecutive weighings do not differ by more than 0.01 g. Store the thermal expansion test pieces in the desiccator until required.

6.3 Determination

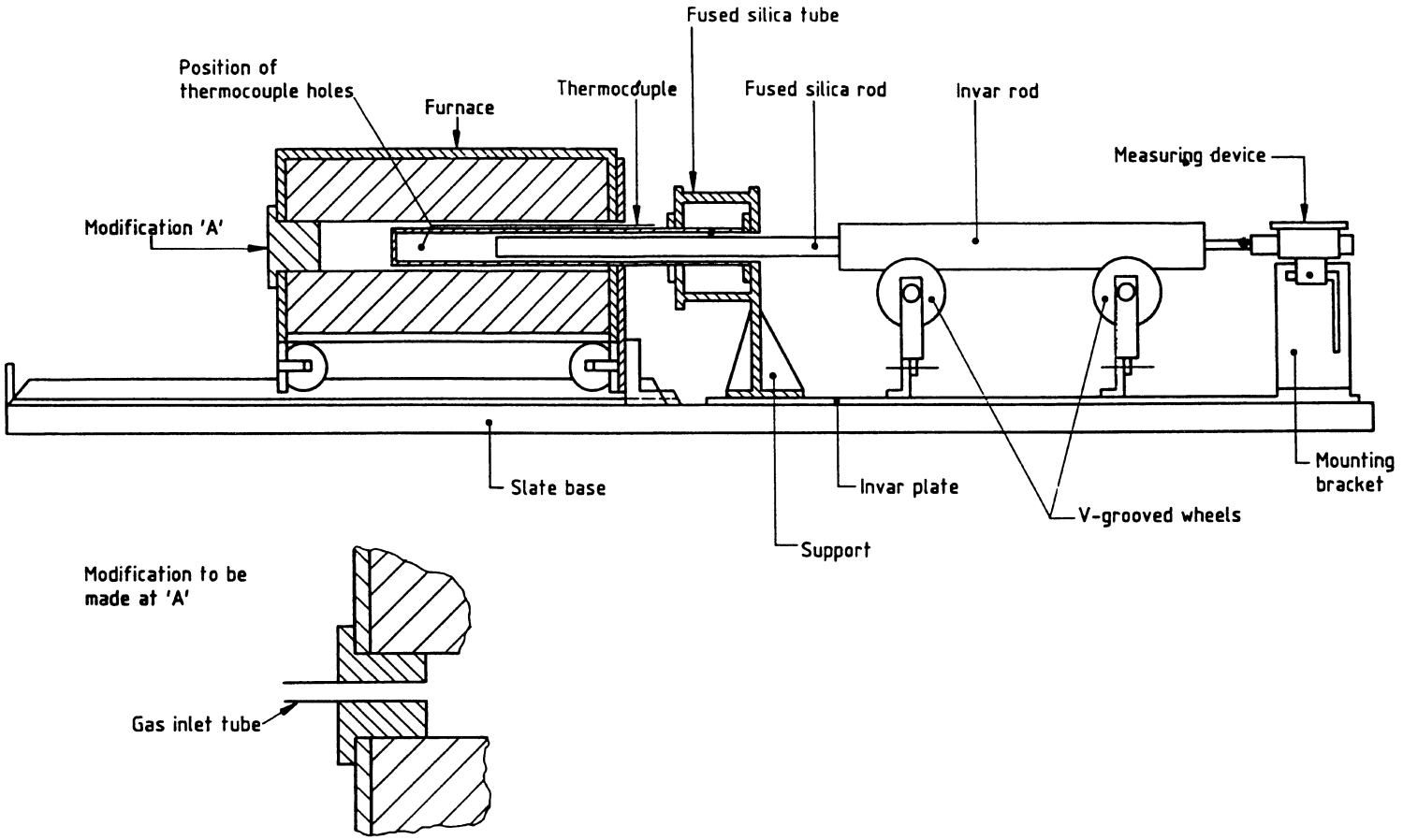
6.3.1 Connect the supply of inert gas (**3.4**) to the inlet tube on the thermal expansion apparatus (**3.3**).

6.3.2 Calibrate the apparatus (**3.3**) by the method described in clause **7** of BS 1902-5.3:1990 whilst purging the apparatus with the inert gas (**3.4**) at a flow rate of 100 mL/min, at normal temperature and pressure, after the insertion of the test piece of reference material.

NOTE The calibration procedure described in **6.3.2** should be carried out at the start of a series of tests and subsequently at intervals not exceeding five test runs, or whenever the apparatus is serviced or parts replaced.

6.3.3 Determine the coefficient of thermal expansion and any permanent linear change in dimensions of the thermal expansion test piece (see **6.2**) in accordance with clause **8** of BS 1902-5.3:1990, whilst purging the apparatus (**3.3**) with the inert gas (**3.4**) at a flow rate of 100 mL/min, at normal temperature and pressure, after the insertion of the thermal expansion test piece.

6.3.4 Perform the operations described in **6.3.1** to **6.3.3** on at least three thermal expansion test pieces (see **6.2**).



NOTE Modified version of apparatus described in BS 1902-5.3:1990.

Figure 1 — Thermal expansion apparatus

7 Calculation and expression of results

7.1 Calculate the thermal expansion of each test piece (see **6.2**) and the mean value for all the test pieces in accordance with **7.2** and, if appropriate, **7.3**.

7.2 Correct the expansion data recorded for the thermal expansion test piece (see **6.2**) by use of the calibration data (**6.3.2**) in accordance with clause **7** of BS 1902-5.3:1990 and calculate the expansion as a percentage of the initial length of the test piece. Present the percentage expansion values against the corresponding temperatures either as a graph or in tabulated form.

7.3 Calculate a mean expansion coefficient (a), for a particular temperature range (see note), using the following equation:

$$a = \frac{L_2}{L_1 (T_2 - T_1)}$$

where

L_1 is the initial length of the thermal expansion test piece (see **6.2**) (in mm);

L_2 is the corrected change in length (see **7.2**) of the thermal expansion test piece (see **6.2**) (in mm), over the temperature range $T_2 - T_1$, in K;

T_1 is the lower temperature of the range (in °C);

T_2 is the upper temperature of the range (in °C);

NOTE Unless material exhibits an almost linear expansion curve it is not appropriate to calculate a mean expansion coefficient.

8 Test report

The test report shall include the following information:

a) a complete identification of the sample of cold ramming paste and any other treatment which it has received;

b) a reference to this British Standard, i.e. BS 6043-4.11:1991;

c) the reference material used to calibrate the apparatus (see **6.3.2**);

d) the test result expressed in accordance with clause **7**, including the temperature range over which measurement was made;

e) the initial and final length of each test piece, indicating any permanent linear change (see **6.3.3**);

f) any unusual features noted during the test;

g) any operation not included in this British Standard or regarded as optional.

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Publication(s) referred to

BS 1902, *Methods of testing refractory materials.*

BS 1902-5, *Refractory and thermal properties.*

BS 1902-5.3, *Determination of thermal expansion (horizontal method to 1 100 °C) (method 1902-503).*

BS 6043, *Methods of sampling and test for carbonaceous materials used in aluminium manufacture.*

BS 6043-4, *Cold ramming pastes.*

BS 6043-4.0, *General introduction*[1)].

BS 6043-4.1, *Methods of sampling.*

BS 6043-4.6, *Determination of maximum rammed apparent density of unbaked paste*[2)].

BS 6043-4.7, *Preparation of baked rammed test pieces and determination of baked apparent density, change in volume and loss in mass.*

BS 6043-4.8, *Determination of electrical resistivity of baked rammed paste.*

[1)] Referred to on the front cover only.
[2)] Referred to in the foreword only.

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