

Specification for

Powder metallurgical products (P.M. Products) —

**Part 1: Sintered metal components for
general engineering purposes**

Co-operating organizations

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

- Board of Trade
- British Cast Iron Research Association
- British Constructional Steelwork Association
- British Electrical and Allied Manufacturers' Association
- British Ironfounders' Association
- British Mechanical Engineering Confederation
- British Railways Board
- British Steel Industry
- Council of Ironfoundry Associations
- Council of Iron Producers
- Crown Agents for Oversea Governments and Administrations
- Department of Employment and Productivity (H.M. Factory Inspectorate)
- Engineering Equipment Users' Association
- Federation of Civil Engineering Contractors
- Institute of British Foundrymen
- Institute of Iron and Steel Wire Manufacturers
- Institute of Marine Engineers
- Institution of Civil Engineers
- Institution of Mechanical Engineers (Automobile Division)
- Institution of Production Engineers
- Institution of Structural Engineers
- Joint Iron Council
- Lloyd's Register of Shipping
- Ministry of Defence, Army Department
- Ministry of Defence, Navy Department*
- National Association of Drop Forgers and Stampers
- National Physical Laboratory (Ministry of Technology)
- Oil Companies Materials Association
- Royal Institute of British Architects
- Shipbuilders and Repairers National Federation
- Society of British Aerospace Companies Ltd.
- Society of Motor Manufacturers and Traders Ltd.*
- Stainless Steel Development Association
- Steel Castings Research and Trade Association
- Tin Research Institute

The Government department and scientific and industrial organization 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 Hard Metals Association
- British Metal Sinterings Association
- British Mining Tools Association
- British Non-Ferrous Metals Research Association
- Copper Development Association
- Institute of Metals
- Individual manufacturers

This British Standard, having been approved by the Iron and Steel Industry Standards Committee, was published under the authority of the Executive Board on 27 October 1969

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Foreword

This standard makes reference to the following British Standards:

BS 18, *Methods for tensile testing of metals*.

BS 427, *Method for Vickers hardness test*.

BS 1131, *Plain bearings (metal) — Part 5: Bronze oil-retaining bushes and thrust washers*.

BS 2071, *Soxhlet extractors*.

The revision of this British Standard has been authorized by the Iron and Steel Industry Standards Committee, and arose from two facts, firstly a request by the British Metal Sinterings Association that such a revision should be undertaken, and secondly because The International Organization for Standardization (ISO) has set up a new Technical Committee ISO/TC 119, "*Powder metallurgical materials and products*".

The 1955 edition of this standard was largely confined to methods of testing, whereas information is now required on the material specifications of P.M. products. The present revision therefore includes a section dealing with general requirements and a section dealing with materials. As an aid to selection, some notes on factors affecting the choice of materials for P.M. products are given in the materials section.

The standard makes recommendations for the testing of the finished sintered product as distinct from the metallic powder from which it was made, and also recommends the test pieces to be used for mechanical testing as the normal British Standard test pieces designed for metal products are not suitable for the small components to which this standard applies.

The whole standard has been based on the metric system.

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 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.

Introduction

In specifying P.M. materials, liaison with prospective suppliers is more than usually necessary. This is because sintered materials have certain properties which are not normally covered in material specifications. Also, the achievement of particular shapes or tolerances may necessitate the employment of a different composition than would be the case if the properties of the finished P.M. part were the only consideration. Additionally, it is not necessarily appropriate to specify properties for the sintered metal component which are identical to those of the wrought or cast component which would otherwise be used. If the P.M. parts are to be given a surface treatment, machined, hardened or joined, liaison between the purchaser and the supplier is essential at the enquiry and order stage to ensure suitable material being offered.

1 General requirements

1.1 Scope

This Part 1 of this British Standard specifies the requirements, together with the methods of testing, for P.M. products in a range of materials used for general engineering purposes, including bearings.

It does not apply to products used as filters, magnetic materials or electrical contacts, nor does it apply to frictional materials, "hard metal", "heavy metal", or refractory materials, for which separate parts of the standard are being prepared.

1.2 Definitions

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

1.2.1

bulk volume

the volume of the solid material plus the volume of the sealed and open pores

1.2.2

bulk density

the ratio of the mass of a sintered part to its bulk volume

1.2.3

apparent porosity

the ratio of the volume of the open pores to the bulk volume of a sintered part expressed as a percentage

1.3 Chemical composition

1.3.1 For non-ferrous alloys, and for certain ferrous alloys, where a given chemical composition is necessary for the proper functioning or treatment of the part, the chemical compositions are mandatory where specified in Section 2. In all other cases chemical compositions are given for the guidance of the purchaser, and other compositions may be supplied by agreement.

1.3.2 In those cases where the chemical composition is mandatory, the manufacturer shall supply certificates of analysis if specified on the enquiry and order.

1.3.3 The frequency of analysis and the elements to be determined shall be agreed between the purchaser and the manufacturer.

1.4 Freedom from defects

The P.M. parts, as delivered to the purchaser, shall be free from harmful defects and shall meet any dimensional requirements specified by the purchaser and agreed with the supplier. In the event of any parts showing defects during subsequent manufacturing operations, such parts shall be deemed not to comply with the requirements of this British Standard, notwithstanding any previous certificate of satisfactory testing, provided the parts have not been improperly treated after delivery.

1.5 Marking

When agreed between the purchaser and the manufacturer and stated in the enquiry and order each part shall be legibly marked, where practicable, with the number of this British Standard and the designation of the material. Small parts may be bundled and the identification stamped on the tag attached to each bundle.

1.6 Selection of pieces for test

1.6.1 It is recommended that, where possible, the tests should be applied to the parts themselves, but where this is not possible, separately sintered test pieces should be used, provided they are manufactured under similar conditions to those in which the parts they represent are manufactured, and provided they are taken from the same batch of mixed powder.

1.6.2 In the case of separately sintered test pieces, the values found represent the quality of the material from which the parts are manufactured, but may not represent the properties of the sintered parts. Where the section and shape is widely different from the test piece, an unavoidable density variation may occur in the component.

1.6.3 Tests specified in 1.7, 1.8 and 1.9 shall be carried out, wherever practicable, on the complete P.M. part.

1.6.4 In cases where the pieces for test are so large as to make it impractical to test them in one piece, it may be necessary to reduce their volume by subdivision. Except where otherwise specifically agreed (see 1.6.5), all the pieces of such a subdivision shall be subjected to the test procedures specified in 1.7, 1.8 and 1.9. The properties shall be determined from the appropriate weights of the whole of the component whether the part is tested as a whole or in separate pieces.

1.6.5 In the case of density determination where the service requirements demand such determination on part sections of P.M. parts, the method of test shall be agreed between the purchaser and the manufacturer and stated on the enquiry and order.

1.7 Bulk density of p.m. parts

1.7.1 Principle of measurement. The part under test is first weighed in air and then the volume determined by water displacement, after which the density of the material is calculated. In practice the complete component (see 1.6.3 and 1.6.4) shall first be freed from all oil, using one of the methods given in 1.7.2. The density determination shall then be carried out using, as appropriate, the method set out in 1.7.3 or 1.7.4.

1.7.2 Removal of impregnant. As desired, either of the following methods may be used:

1.7.2.1 The part shall be freed from impregnant by extraction in a Soxhlet apparatus¹⁾ using suitable solvent.

1.7.2.2 The impregnant may be removed by extracting with a suitable solvent. The parts are placed in a suitable vessel containing approximately 15 to 20 times their volume of solvent. The solvent requires frequent changing.

1.7.2.3 Whether the method described in 1.7.2.1 or 1.7.2.2 is used, residual solvent shall be removed by maintaining the part at $105 \pm 5^\circ\text{C}$ for 1 h. Alternate extraction and drying shall be continued until the dry weight is constant to within 0.1 %.

1.7.2.4 Where agreed between the purchaser and the manufacturer, other methods may be used.

1.7.3 Method of determination of density. If the weight of the part is substantially less than 10 g, two or more parts shall be taken, to make up the weight to approximately 10 g.

The dry part shall be weighed in air to the nearest 0.01 % (A). The part(s) shall then be impregnated with a mineral oil of viscosity between 30 cSt²⁾ and 70 cSt at 40°C by immersion for at least 10 min at a temperature of $65 \pm 5^\circ\text{C}$. The part(s) shall then be cooled to room temperature in the oil or rapidly transferred to an oil bath at room temperature. After removal from the oil, the part(s) shall be wiped to remove excess oil from the surface. Alternatively, the vacuum method of impregnation as specified in 1.8.2 may be used.

¹⁾ BS 2071, "Soxhlet extractors."

²⁾ 1 cSt = $10^{-6} \text{ m}^2/\text{s}$.

The part(s) shall then be hung on a piece of fine wire and the part and wire shall be weighed in air to the nearest 0.01 % (B_1). The part(s) are then immersed in water and weighed to the nearest 0.01 % care being taken to dislodge any adhering air bubbles from the part(s) or the wire on which it is hanging (C).

When the weighing is carried out at a temperature of 20 ± 5 °C, the bulk density of the component D is given by the formula:

$$D = \frac{A}{(B_1 - C)} \text{ g/cm}^3$$

where A = weight of the dry part in g;

B_1 = weight of the impregnated part and suspension wire in g;

C = weight of the impregnated part and suspension wire, immersed in water, in g.

NOTE For the purpose of this formula the density of water is considered to be 1.0.

1.7.4 Alternative method for small parts. Unless specific test methods are agreed between the purchaser and supplier, one of the following methods may be used:

1.7.4.1 The parts shall be weighed in air (weight A) a total weight of 10 g to the nearest part should be used. The parts shall then be oil impregnated in accordance with the procedure laid down in **1.7.3**.

A suitable density bottle shall be filled with water and weighed with the parts outside of the bottle (weight G). The parts shall then be placed inside the bottle, still containing the water. Any entrapped air shall be removed by shaking the bottle which is then topped up with fresh water, and the stopper carefully replaced allowing the displaced water to escape.

Care should be taken to ensure that all the water is removed from the outside of the bottle and that the bottle is not warmed by the hand. The bottle, water and parts shall then be reweighed (weight H).

All weighings shall be accurate to within 0.01 %.

The density of the parts D may then be calculated as follows:

$$D = \frac{A}{(G - H)} \text{ g/cm}^3$$

where A = weight of the dry parts in g;

G = weight of the water filled density bottle plus impregnated parts outside of bottle in g;

H = Weight of the water filled density bottle with impregnated parts inside bottle in g.

1.7.4.2 The method laid down in **1.7.3** may be used for density determination of small parts, providing the wire is not more than 0.10 mm in diameter, and that several parts are used each time a determination is made. Adequate care shall be exercised to ensure that air is not entrapped between the components being tested.

1.8 Apparent porosity

1.8.1 Principle of measurement. The apparent porosity P is the volume of the intercommunicating void expressed as a percentage of the total volume of the sintered component.

The complete component (see **1.6.3** and **1.6.4**) shall first be freed from all oil, using one of the methods given in **1.7.2**. The apparent porosity is then determined using, as appropriate, the methods in **1.8.2** or **1.8.3**.

1.8.2 Method of determination of apparent porosity. If the weight of the parts is substantially less than 10 g, two or more parts shall be taken.

The dry part shall be hung on a piece of fine wire and weighed in air to the nearest 0.01 %. Impregnation of the part shall then be carried out by immersion in an oil, the viscosity of which lies between 30 cSt³⁾ and 70 cSt at 40 °C. The oil shall be heated to a temperature of 65 ± 5 °C to facilitate impregnation. The pressure in the oil container shall be reduced to less than 50 mmHg for 20 min, or until no air bubbles escape from the component. At the end of this period the container shall be restored to atmospheric pressure and the component left in the oil for a time equal to that required under vacuum. The oil shall be at room temperature at the end of the impregnation operation. After removal from the oil, the part shall be wiped to remove excess oil from the surface. The impregnated part shall then be reweighed, first in air and then in water, taking care to dislodge any adhering air bubbles from the part or the wire on which it is hanging.