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Standards publications referred to

BS 1692 Gin blocks

BS 2045 Preferred numbers

BS 4318 Recommendations for preferred metric basic sizes for engineering

BS 4429 Rigging screws and turnbuckles

DD 29 Rules for and guide to the use of preferred numbers and preferred sizes

ISO 3 Preferred numbers — Series of preferred numbers

ISO 497 Guide to the choice of series of preferred numbers and series containing more rounded values of preferred numbers

NOTE. Further copies of the insert PD 6481C : 1977 'Preferred numbers and preferred sizes' are available in sets of 10, price group 4, from the BSI Sales Department, Newton House, 101 Pentonville Road, London N1 9ND.

Recommendations for the use of preferred numbers and preferred sizes

1. Introduction

Because of the absence of agreed rules for the application of preferred numbers and preferred sizes, confusion has arisen regarding their use. National (and international) standards show inconsistencies in the choice of values for characteristics or sizes, and these have grown to a significant extent from the lack of clear guidance on the circumstances where the theoretical *preferred numbers* should be used or where the rounded-off *preferred sizes* should be used. This document has therefore been produced to give general recommendations on this subject. It supersedes both BS 4318 and DD 29.

It is appreciated that designers and standards engineers may be compelled to make use of sizes outside the preferred ranges because of certain overriding considerations, such as the need to comply with established standards in specific fields of the kind listed in appendix A. Nevertheless, a considerable area of freedom exists and a disciplined approach to the selection of sizes would be beneficial locally, nationally and, finally, internationally.

2. Preferred numbers

The preferred number system is internationally standardized in ISO 3 (which is reproduced in BS 2045). It is also referred to as the Renard or R series.

The system provides a geometric series, i.e. one in which there is a constant ratio between each figure and the succeeding one, within a decimal framework. Thus the R5 series has five steps between 1 and 10, the R10 series ten steps between 1 and 10, the R20 series twenty steps and the R40 series forty steps, giving increases between steps of approximately 60 %, 25 %, 12 % and 6 % respectively. It is shown in figure 1 in diagrammatic form, which illustrates the geometric progression of the series.

The use of the preferred number series confers several important advantages, in particular those outlined below.

(a) The series can be extended in either direction by multiplying by the appropriate power of 10. Values can therefore be applied to any magnitude of a quantity.

(b) All the R5 series values are found in the R10 series, the R10 values in the R20 series, and so on. This makes it easy to insert additional values in chosen series.

(c) The products, quotients and powers of preferred numbers are also preferred numbers (allowing for slight differences in rounding). This means, for example, that the area of a square or rectangular figure whose sides are preferred numbers is also a preferred number, while the volume of a rectangular container whose sides are preferred numbers is also a preferred number.

(d) In the R10 and subsequent series the number 3.15 is found. Since this is very nearly equal to π, it follows that if the diameter of a circle is a preferred number the circumference is also a preferred number. Moreover, since 4 is a preferred number (see figure 1, first choice), the area of that circle is also a preferred number. This is useful when dealing with peripheral speeds, cylindrical and spherical areas, power transmission through cables, flow through pipes etc.

However, the preferred number series suffer from two disadvantages. First, the gaps between the steps become very large at the top end of the scale, and second, they contain values that are awkward and difficult to use in most design and production environments. It is for these reasons that they have not found universal acceptance for linear measurement.

3. Examples of the use of preferred numbers

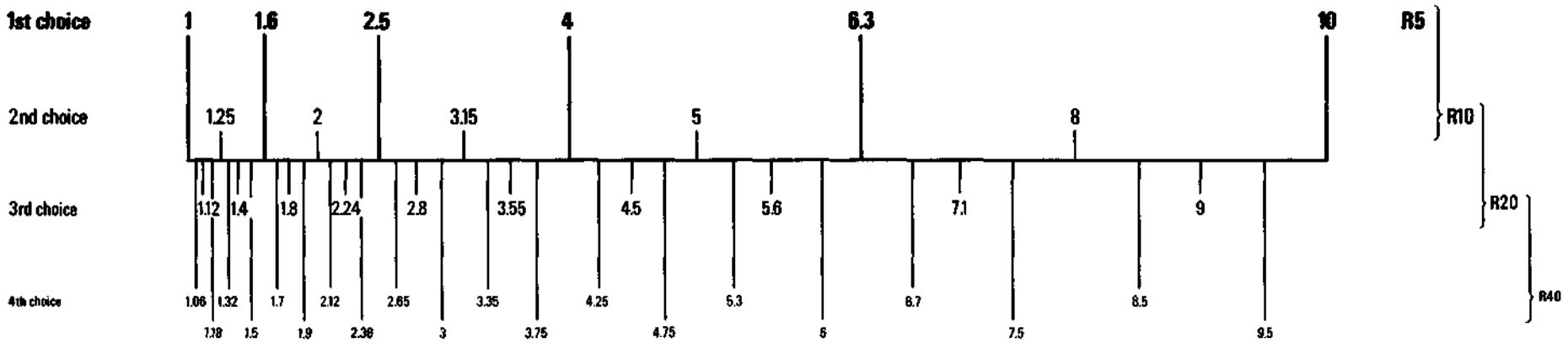
Typical examples of the use of the preferred number series are given below.

(a) *Machine tools.* Belgian standard NBN 123 for machine tools adopts the R20 series (1; 1.12; 1.25; 1.40 etc.) for the range 1 r/min to 1000 r/min, but this series can of course be extended. The basis of this application is that cutting speed is a function of spindle speed, and that differences of cutting speed of less than 12 % are not significant. The preferred number spindle speeds provide, for any given workpiece diameter, a range of cutting speeds increasing by increments of 12 %.

(b) *Lifting equipment.* Norwegian Standard NS 2675 standardizes the lifting capacities of cranes, using a range comprising the R10 series (1; 1.25; 1.6 etc.). Again, in designing a series of sizes for cranes a significant increment between consecutive sizes is required, and a geometric series is ideal. An example from the UK in an allied field is BS 4429 for rigging screws and turnbuckles; here, the range of sizes is based on safe working loads (i.e. the principal characteristic of the articles), and the R10 series of preferred numbers is used. Similarly, the ranges of sizes of terminal fittings for wire rope and chain are based on safe working loads that increase in accordance with the R10 series. This is also illustrated by BS 1692 for gin blocks, which are classified by safe working loads in series of values according to the R10 series.

It should be noted that in each of these cases the preferred numbers are applied to the primary functional characteristic of the product, i.e. to the spindle speeds of machine tools, the lifting capacities of cranes, and so on.

Preferred numbers



The series may be extended in either direction by multiplying or dividing by 10, 100, 1000 etc.

Figure 1. Preferred numbers

Preferred sizes

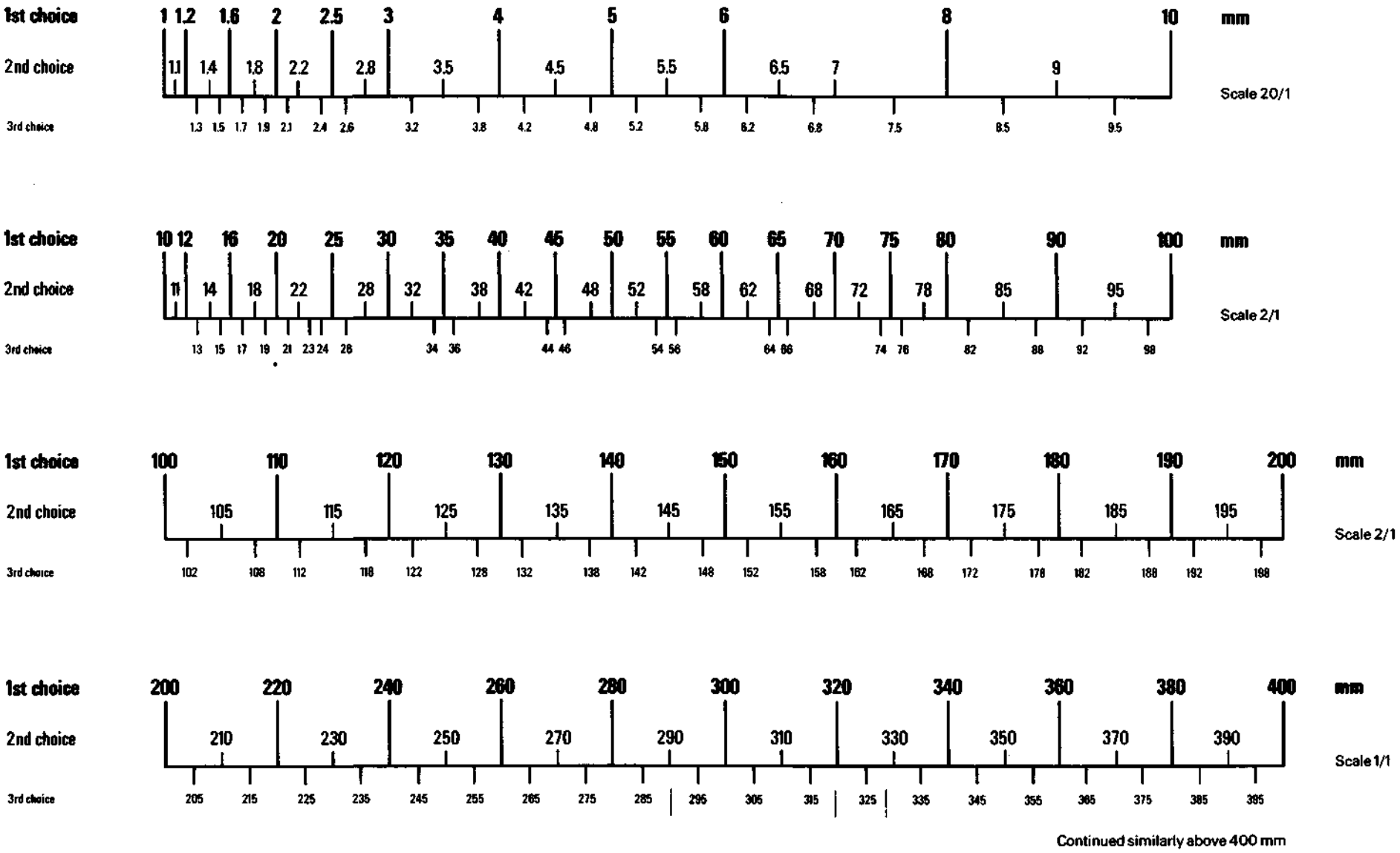


Figure 2. Preferred sizes

The use of the geometric preferred number series for these functional characteristics brings obvious advantages, with no disadvantage in respect of detailed product design and manufacture. The fact that a crane has a lifting capacity of 6.3 tonnes presents no particular design or production problems that would discourage the use of the preferred number. It is in scaling values for the primary functional characteristics of products that preferred numbers can be used to best advantage.

4. Preferred sizes

By contrast with the primary functional characteristics of a product, it is necessary to consider the choice of ranges of values for standard sizes used in product design and manufacture.

The similarity of this problem to that outlined in the preceding paragraph is immediately apparent and, bearing in mind the characteristics of preferred numbers, it might be concluded that these geometric series provide an obvious answer. In this instance, however, slightly different circumstances have to be taken into account. Formulating the detailed design of the components that make up a product is largely a question of choosing appropriate sizes for such features as the diameters, widths, lengths etc. of each component. The sizes chosen for some dimensions will be determined by design conditions, e.g. maximum permissible stress levels or rigidity. Other dimensions will be chosen on the basis of general mechanical requirements of the design, although in both cases such considerations as the use of the standard articles (e.g. screw threads), use of standard materials, tools etc. will be taken into account. Only in very few cases will these dimensions form part of a series, and this removes one of the primary incentives for using preferred numbers as basic sizes in design. Furthermore, on the score of convenience and simplicity there is an advantage to be gained from using simple, whole numbers wherever possible, and here the Renard series are open to serious criticism. Numbers such as 1.12, 1.6, 3.55, 6.3 etc. are far from simple and have no inherent merit as design sizes.

A profitable field of standardization is that of variety reduction of sizes upon which stock inventories are based. The concept of geometric series, with the accompanying logical presentation of levels of choice, is appropriate, but clearly any such series have to be compatible with the series used for basic sizes in design.

Since the numbers of the Renard series are already rounded-off from their theoretical values, more extensive rounding may be considered as a means of eliminating the inconvenient numbers in the basic series. Recognizing the practical problems of using the established series for all purposes, ISO has developed more rounded series which are published in ISO 497. This standard provides 'first rounding' series, known as R' series, and 'second rounding' series known as R'' series. They are given in BS 2045. The R'' series contains none of the inconvenient values of the original preferred numbers series. However, experience has shown that although the R'' series is more convenient for linear measurement it does not overcome all the difficulties touched on above. In particular, in the larger sizes the gaps are often too big.

The R'' series has therefore been adjusted in the light of experience for linear measurement in millimetres, and the result is shown in figure 2. It is identical with the series given in BS 4318 extended above 300 mm and with Swedish standard SMS 8. The series is derived from the R'' series up to 200 mm and is extended arithmetically above that in steps of 20 mm (first choice), 10 mm (second choice) and 5 mm (third choice).

5. Recommendations for the application of preferred numbers and preferred sizes

Taking all normal considerations into account, the recommendations listed below suggest a basis for the general application of preferred numbers and preferred sizes throughout industry.

(a) For ranges of values of the primary *functional* characteristics (outputs and capacities) of a series of articles use the preferred number series R5 to R40 as given in figure 1.

(b) Wherever linear sizes are concerned use the preferred sizes as given in figure 2.

The presentation of preferred sizes in choices is essential to their own optimum use, since this gives designers and users a logical selection while at the same time securing the benefits of rational variety reduction. The adoption of these recommendations provides a firm basis for the reconciliation of the various relevant British Standards.

Appendix A

Some examples of British Standards which list established sizes or ranges

BS 4	Structural steel sections Part 1 Hot-rolled sections
BS 183	General purpose galvanized steel wire strand
BS 1387	Steel tubes and tubulars suitable for screwing to BS 21 pipe threads
BS 2488	Schedule of preferred numbers for the resistance of resistors and the capacitance of capacitors for telecommunication equipment
BS 2871	Copper and copper alloys. Tubes Part 1 Copper tubes for water, gas and sanitation Part 2 Tubes for general purposes
BS 3600	Dimensions and masses per unit length of welded and seamless steel pipes and tubes for pressure purposes
BS 3643	ISO metric screw threads
BS 3666	Size coding scheme for women's outerwear
BS 3979	Dimensions of electric motors (metric series)
BS 4229	Recommendations for metric sizes of non-ferrous and ferrous bars
BS 4848	Hot-rolled structural steel sections
BS 4981	System of shoe sizing and marking (*Mondopoint*)
BS 6007	Rubber-insulated cables for electric power and lighting

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Revision of British Standards
British Standards are revised, when necessary, by the issue either of amendment slips or of revised editions. **It is important that users of British Standards should ascertain that they are in possession of the latest amendments or editions.**

The following BSI reference relates to the work on this document:
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