

Specification for

Parallel screw threads of Whitworth form

UDC 621.882.082.2

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Amendments issued since publication

Amd. No.	Date	Comments

This British Standard, having been approved by the Mechanical Engineering Industry Standards Committee and endorsed by the Chairman of the Engineering Divisional Council, was published under the authority of the General Council on 26 September 1956

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First published as BS 84:1918 and BS 92:1919
First revision as BS 84 (incorporating BS 92) May 1940
Second revision September 1956

The following BSI references relate to the work on this standard:—
Committee reference MEE/1/12
Draft for comment CT(MEE)6884

ISBN 0 580 32662 4

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Foreword

This standard makes reference to the following British Standards:

BS 919, *Screw gauge limits and tolerances*.

BS 1157, *Tapping drill sizes*.

BS 1916, *Pt. 2. Guide to the selection of fits*.

BS 2517, *Definitions for use in mechanical engineering*.

This revised British Standard has been prepared, under the authority of the Mechanical Engineering Industry Standards Committee, to supersede BS 84:1940, "*Screw threads of Whitworth form*". It applies to threads of Whitworth form used for general engineering purposes and is not intended to apply to special applications such as those requiring interference fits.

The standard includes tables of basic sizes, limits and tolerances for British Standard Whitworth (B.S.W.) and British Standard Fine (B.S.F.) screw threads. In addition it now provides a "Selected Thread" series of recommended diameter-pitch combinations for use in applications where the standard coarse (B.S.W.) and fine (B.S.F.) pitch series have insufficiently fine pitches.

The British Standard Pipe parallel thread series was incorporated in BS 84:1940 as a fine thread series for general engineering purposes, and though this series was not intended for pipe joints it has been extensively used on certain types of pipe fittings, such as unions, compression type connections, etc., where the pressure seal is not made on the threads. This has caused some confusion with the pipe threads specified in BS 21¹⁾ where the pressure seal is, in fact, made on the threads. It has, therefore, been decided to publish the tables of basic sizes, limits and tolerances for the British Standard Pipe parallel thread series given in BS 84:1940 in a new standard, BS 2779, "*Fastening Threads of B.S.P. Sizes*," now in course of preparation. This standard, in addition to BS 21, which is now being revised, will come under the aegis of the Pipe Threads Committee of BSI and these two standards will then include recommended limits and tolerances for all B.S.P. threads whether or not the pressure seal is made upon the threads.

The new "Selected Thread" series will, in most cases, be more suitable for use in new designs than the BS Pipe parallel thread series in cases where an extra fine pitch thread is required, and its use is strongly recommended.

In revising this standard, advantage has been taken of the experience gained in the use of BS 84:1940, to modify it to conform to modern thread tolerancing practice. Thus an allowance (minimum clearance) is provided on certain classes of bolts of sizes up to and including $\frac{3}{4}$ in. diameter; the recommended associations of classes of bolts and nuts include nuts having larger effective diameter tolerances than the corresponding sizes of bolts. Three classes of tolerance are provided for bolts, the Close, Medium and Free Classes, equivalent to the old Close, Medium and Free Fit bolts. The allowance is provided on bolts in the Medium and Free Classes by reducing the maximum bolt limits below basic size. The purpose of this allowance is to provide for the threads to be plated if necessary, the plating encroaching within the allowance; it also guarantees easy assembly of maximum metal bolts and nuts, thus facilitating the use of torque wrenches. Two classes of tolerance for nuts are recommended, a Medium Class and Normal Class, identical with the old Medium and Free Fit nuts respectively. The old Close Fit (now termed Close Class) nuts, are now regarded as non-preferred but, in view of their usage in the past and for special needs, their limits and tolerances are given in an Appendix to the standard.

All screw threads made in accordance with this revised standard will assemble with the corresponding nominal sizes of mating screw threads made to BS 84:1940.

¹⁾ BS 21, "*Pipe threads*".

It will be observed that no change has been made in the general three-part formula used as a basis for tolerancing effective diameters, and the formulae used for tolerancing the other thread elements also remain unchanged from those in BS 84:1940; the reason for this is to minimize any changes in the sizes of the gauges used to control the size of the finished work.

The table of recommended diameter-pitch combinations for screw threads in the “Selected Thread” series follows very closely the corresponding Table in BS 1580, “*Unified Screw Threads*”.

In revising the standard the following amendments issued subsequent to BS 84:1940 have been incorporated in the text, with the exception of that part of the amendments dealing with B.S.P. threads, and Amendments Nos. 1 and 2 have been restricted to lengths of engagement of bolt and nut up to 15 pitches.

Amendment No. 1, June 1942, provided simplified tables of tolerances for threads not in the three standard diameter-pitch series (B.S.W., B.S.F. and B.S.P.), based on a length of engagement of bolt and nut of 10 pitches, but applicable in practice to all reasonable lengths of engagement.

Amendment No. 2, April 1943, specified that the tolerances given in the three standard diameter-pitch series should apply to all lengths of engagement.

Amendment No. 3, August 1945, provided information about truncated Whitworth form screw threads.

Amendment No. 4, December 1949, gave extensions of tables of limits and tolerances for the larger sizes of standard diameter-pitch combinations of Whitworth form.

In conclusion it may be asked why the revision of this standard has been undertaken in view of the standardization of the Unified thread in BS 1580. The reason is that Whitworth threads will undoubtedly continue to be used for many years, especially on replacements or spare parts.

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 to iv, pages 1 to 47 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 relates to parallel screw threads, having the Whitworth form of thread, used for general engineering purposes. It is not intended to apply to threaded pipe joints, screw threads associated with interference fits, such as those on the “metal-ends” of studs and in the corresponding tapped holes, or to screw threads which are subject to high temperature.

This standard includes:

- a) A coarse thread series, the British Standard Whitworth (B.S.W.) Series, from $\frac{1}{8}$ in. to 6 in. diameter.
- b) A fine thread series, the British Standard Fine (B.S.F.) Series, from $\frac{3}{16}$ in. to $4\frac{1}{4}$ in. diameter.

NOTE The tables of limits and tolerances in the B.S.F. Series extend up to the 3 in. size only, since nominal sizes above 3 in. are rarely used.

- c) A supplementary Selected Thread Series from $\frac{1}{4}$ in. diameter upwards.
- d) Screw threads of Truncated Whitworth form (Appendix A). Supplementary information is given in Appendix A to Appendix E.

2 Nomenclature and definitions

For the nomenclature and definitions of terms used in this standard, see BS 2517, “Definitions for use in Mechanical Engineering”.

3 Form of Whitworth screw thread

The basic (and design) form of the Whitworth thread is shown in Figure 1. It is a symmetrical V-thread in which the angle between the flanks, measured in an axial plane, is 55° ; one-sixth of the sharp vee is truncated at top and bottom, the thread being rounded equally at crests and roots by circular arcs blending tangentially with the flanks, the theoretical depth of thread being thus 0.640327 times the nominal pitch. The basic thread depths calculated from the above definition are rounded off to the nearest 0.0001 in.

4 Classes of bolts and nuts

Three classes of tolerances for bolts and two classes for nuts²⁾ are provided as follows:

Close class bolts. The close class³⁾ applies to screw threads requiring a fine snug fit, obtainable consistently only by the use of the highest quality production equipment supported by a particularly efficient system of gauging and inspection. It should be used only for special work where refined accuracy of pitch and thread form are particularly required.

Medium class bolts and nuts. The medium class applies to the better class of ordinary interchangeable screw threads.

Free class bolts. The free class applies to the majority of bolts of ordinary commercial quality.

Normal class nuts. The normal class applies to ordinary commercial quality nuts; this class is intended for use with medium or free class bolts.

The relative magnitudes and dispositions of the effective diameter tolerance zones⁴⁾ for the recommended combinations of classes are shown in Figure 2.

It will be noted that the lower limit of the nut is always basic size. No allowance is provided for close class bolts, but for medium and free class bolts an allowance is provided between the lower limit for the nut (basic size) and the upper limit for the bolt on sizes $\frac{3}{4}$ in. nominal diameter and below. The allowance amounts to $0.3 \times$ medium class bolt effective diameter tolerance for nominal sizes of $\frac{3}{4}$ in. down to $\frac{1}{4}$ in. The allowance for nominal sizes less than $\frac{1}{4}$ in. is the same as that for the $\frac{1}{4}$ in. size.

Since it is more difficult to control the threading of nuts than bolts the recommended classes of nuts to be associated with close and medium class bolts have effective diameter tolerances 50 per cent greater than those of the associated bolts.

²⁾ The terms “bolts” and “nuts” are used in a general sense to designate external and internal threads respectively.

³⁾ Limits and tolerances for close nuts are given in Appendix E.

⁴⁾ For the bases of the tolerances and allowances see Appendix B.

The choice of fit for a particular purpose rests with the designer. A close class bolt would usually be assembled with a medium class nut, and a medium or free class bolt with a normal class nut, but in special circumstances different combinations of classes may be specified for mating bolts and nuts if desired.

Information about plating, as applied to the various classes of bolts and nuts, is given in Clause 6.

5 Standard diameter — pitch series: Limits and tolerances

The basic sizes for the B.S.W. and B.S.F. series are given in Table 1 and Table 7 respectively.

Limits and tolerances for the major, effective and minor diameters for the various classes are given in Table 2 to Table 6 for the B.S.W. series and in Table 8 to Table 12 for the B.S.F. series. Limits and tolerances for close class nuts in the B.S.W. and B.S.F. series are given in Appendix E.

In these tables, the effective diameter tolerances, which are intended to include the diametral effects of pitch and angle error (see Appendix C), have been calculated from the general formula (see page 40) taking the length of engagement as being equal to the nominal diameter of the thread. In order to reduce to a minimum the number of NOT GO gauges required, the tolerances for the B.S.W. and B.S.F. series of threads, although calculated for the lengths of engagement just quoted may, however, be regarded as applicable to lengths of engagement up to fifteen pitches. The tolerances quoted for the major and minor diameters of threads belonging to the B.S.W. and B.S.F. series may be accepted for any length of engagement.

Following existing practice, no tolerance is specified for the major diameters of the nuts, but only a minimum size, which is the same as the basic major diameter. The major diameters of nuts will be controlled in practice by the major diameters of the taps or other screwing tools used to cut the threads.

Figure 3, Figure 4 and Figure 5 show, for the three recommended combinations of classes respectively, the relationship existing between the diametral tolerances for a $\frac{1}{4}$ in. B.S.W. bolt and nut. It will be noted that the nut minor diameter tolerances are such as to permit a tapping drill of ample size to be used, thus preventing binding at the root of the tap during the tapping operation. If full advantage is taken of the generous nut minor diameter tolerances, the crests of the nut threads will be flat. In special cases, though, where thin nuts are used, it may be desirable not to take full advantage of the tolerance on minor diameter. It will also be noted that the bolt major diameter tolerances are such as to permit crests which are not perfectly radiused (see Appendix D).

Formulae for calculating the tolerances for major, effective and minor diameters are given in Appendix B.

6 Plated threads

The following recommendations refer to the limits for screw threads which are plated with metals such as cadmium, nickel, tin or zinc, *where the usual thickness of plating is of the order of 0.0002 in.*; they do not apply to heavily plated threads.

Taking as a basis Figure 2, which shows the effective diameter tolerance zones for bolts and nuts of the various classes supplied unplated, Figure 6 shows in addition the corresponding recommended tolerance zones for bolts and nuts of nominal sizes $\frac{3}{4}$ in. and below before and after plating.

It will be noted for these sizes that plating is accommodated within the allowance in the case of the medium and free class bolts, and by adjustment of the bolt tolerance zone in the case of the close class bolts.

The interpretation of Figure 6 is as follows:—

- i) Both free and medium class bolts are suitable for plating. The finished size of the screw threads *after* plating shall not exceed the basic size.
- ii) Should it be necessary to plate close class bolts, again the finished size of the threads *after* plating shall not exceed the basic size. In order to avoid any undue restriction of the tolerance for screwing, the sizes of close class bolts *before* plating may be smaller than the lower limits specified in Table 2 and Table 8 by an amount not greater than 0.001 in.
- iii) The sizes of finished medium class and normal class nuts, whether plated or not, shall not fall below the lower limits specified in the appropriate tables of limits and tolerances.
- iv) Since the plating of medium class nuts may necessitate a reduction in the manufacturing tolerances in order that, after plating, they comply with the specified lower limits, it is strongly recommended that plated normal class nuts be used instead of medium class where plating is a requirement.

Bolts and nuts of nominal sizes above $\frac{3}{4}$ in., whether plated or not, shall comply with the limiting sizes specified in the appropriate tables with the following exception. In order to avoid any undue restriction of the tolerance for screwing, the sizes of close class bolts *before* plating may be smaller than the lower limits specified in the tables by an amount not greater than 0.001 in.

Where it is known that nuts will be plated, care should be taken that the nuts are made with minimum sizes slightly greater than basic size in order to effect satisfactory assembly after plating. Similarly, medium and free class bolts of nominal sizes above $\frac{3}{4}$ in. diameter, which are required to be plated, should be made with maximum sizes slightly less than basic size.

The above remarks apply not only to the tolerance zones for effective diameter, but equally to the tolerance zones for the major and minor diameters of plated threads. The limiting sizes of medium and free class B.S.W. and B.S.F. bolt threads before and after plating are indicated in Table 4, Table 6, Table 10 and Table 12 respectively.

Recommendations on the gauging of plated screw threads are given in an Appendix to BS 919, "*Screw gauge limits and tolerances*".

7 Stainless steel bolts

Owing to the tendency for close-fitting bolts and nuts of stainless steel to seize when tightened together, it is recommended that stainless steel bolts of nominal sizes $\frac{3}{4}$ in. and below should not be made to close class limits but rather to medium or free class limits for unplated bolts. It is recommended that stainless steel bolts of nominal sizes above $\frac{3}{4}$ in. shall have maximum and minimum limits which are 0.001 in. smaller than the values obtained from the tables.

8 Selected thread series

Recommended diameter-pitch combinations for the applications of threads of Whitworth form, for which the B.S.W. and B.S.F. diameter-pitch series are unsuitable, are given in Table 13 and Table 13A.

Two tables of preferred diameters and associated pitches are included to meet the needs of different sections of industry, some preferring to use common fractions and others decimals. Table 13 lists the fractional, and Table 13A the decimal series. It will be noted that both tables contain, above $1\frac{1}{2}$ in. diameter, the same $\frac{1}{4}$ in. and $\frac{1}{2}$ in. steps, the difference between the two tables being that in the decimal series the intermediate $\frac{1}{8}$ in. steps have been replaced by steps to the nearest $\frac{1}{10}$ in. dimension. This enables the same diameters to be used as are recommended in BS 1916-2⁵⁾.

a) *Basic sizes.* The basic effective and minor diameters may be determined by subtracting from the basic major diameter the basic depth of thread and twice the basic depth of thread respectively (Columns 3 and 4, Table 14).

b) *Design sizes.*

i) *Nuts.* The design sizes of the major, effective and minor diameters for all classes are the same as the corresponding basic sizes.

ii) *Bolts.*

A. *Close class.* The design sizes are the same as the basic sizes.

B. *Medium and free classes. Basic major diameters of $\frac{3}{4}$ in. and below.* The design sizes are obtained from the basic sizes by subtracting the appropriate allowance given in Table 15.

Basic major diameters above $\frac{3}{4}$ in. The design sizes are the same as the basic sizes.

c) *Tolerances.* The tolerances on Whitworth Selected Threads for bolts and nuts of nominal sizes up to 20 in. are obtained from Table 16 to Table 20 inclusive. For nominal diameters above 20 in. the tolerances should be calculated from the data and formulae in Appendix B.

The effective diameter tolerances have been calculated from the general formula given in Appendix B, assuming a length of engagement of the mating threads equal to ten times the pitch. The tolerances so obtained may be regarded as satisfactory for all normal lengths of engagement, say five to fifteen pitches. For exceptional lengths of engagement, if these tolerances are found to be unsuitable, the effective diameter tolerance should be calculated from the basic formula in Appendix B, giving L_e its actual value.

⁵⁾ BS 1916-2, "*Guide to the selection of fits*".

No tolerance is specified for the major diameter of the nut thread, as it is considered that this dimension will be controlled adequately by the crests of the taps or other cutting tools used to produce the threads.

All diametral tolerances on screw threads are applied unilaterally from the appropriate design size of the dimension, “minus” for a bolt and “plus” for a nut.

Examples illustrating the use of Table 14 to Table 20 when determining limits and tolerances of Whitworth Selected Screw Threads are given following Table 14.

Exceptional design requirements may, at times, necessitate the use of a screw thread of Whitworth form but having a diameter-pitch combination differing from those recommended in Table 13 and Table 13A and the relevant notes. It is recommended in such cases that the number of threads per inch should be chosen from the following series.

40 36 **32** 28 **26** 24 **20** 18 **16** 14 **12** 11 10 **8** **6** 4 threads per inch

The numbers of threads per inch in heavy type are to be regarded as preferred.

The design sizes and tolerances for such threads should be derived as stated for threads in the Selected Thread series.

9 Tolerances on effective diameter, pitch and flank angles

Errors in the pitch and flank angles of a thread virtually increase the effective diameter of a bolt and decrease the effective diameter of a nut. The minimum metal limits stated in the tables apply to the simple effective diameter (as measured along the pitch line of the thread) and the maximum metal limits apply to the effective diameter as virtually increased (for bolts) or decreased (for nuts) by the diametral equivalents of any errors present in the flank angles and in the pitch over the length of engagement (see Appendix C).

10 Designation of screw threads of Whitworth form

It is recommended that the following system should be adopted on drawings and related documents for designating the screw threads covered by the present standard.

	Designation
British Standard Whitworth series	B.S.W.
British Standard Fine series	B.S.F.

The basic major diameter of the thread and the number of threads per inch should be added to the designation. If the thread is left-hand the symbol “LH” should follow the designation.

Examples:

$\frac{1}{4}$ in. — 20 B.S.W.

$\frac{1}{2}$ in. — 16 B.S.F., LH

For screw threads of the selected diameters and pitches given in Table 13 and Table 13A, the basic major diameter and number of threads per inch should be stated, followed by the symbol “Whit. S”.

Example: 1 in. — 20 Whit. S.

Screw threads of Whitworth form but not having the selected diameter-pitch combinations given in Table 13 and Table 13A should be designated as given below:—

Example: 0.67 in. — 20 Whit.

Where it is desired to designate the class of thread tolerance, one of the four terms “close”, “medium”, “free” or “normal” should be added in brackets, together with the word “bolt” or “nut” as appropriate.

Examples:

$\frac{1}{4}$ in. — 20 B.S.W. (close) bolt.

1 in. — 20 Whit. S. (free) bolt.

$1\frac{1}{2}$ in. — 8 B.S.F. (normal) nut.

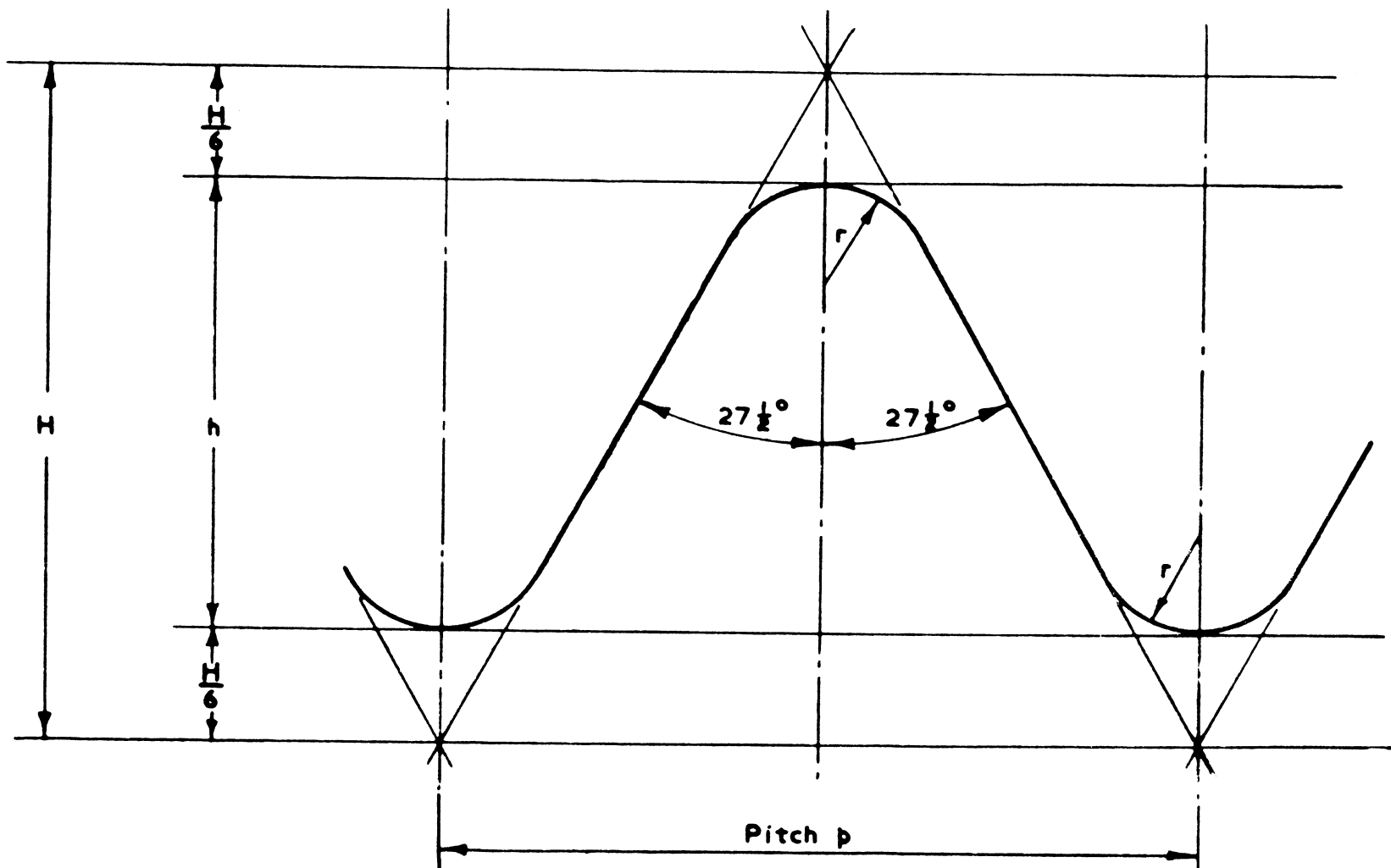
It is recommended that multiple-start Whitworth form threads should be designated as in the following example:—

2 in. 2 start, 0.2 in. lead, 0.1 in. pitch, Whit.

11 Gauges

It is recommended that the gauging system to be employed for checking screw threads of Whitworth form between the limits laid down in this standard should be that given in BS 919, "*Screw gauge limits and tolerances*".

Unless otherwise stated GO ring or calliper gauges for medium or free class bolts of nominal sizes $\frac{3}{4}$ in. and below will be supplied made to the limits for unplated bolts.

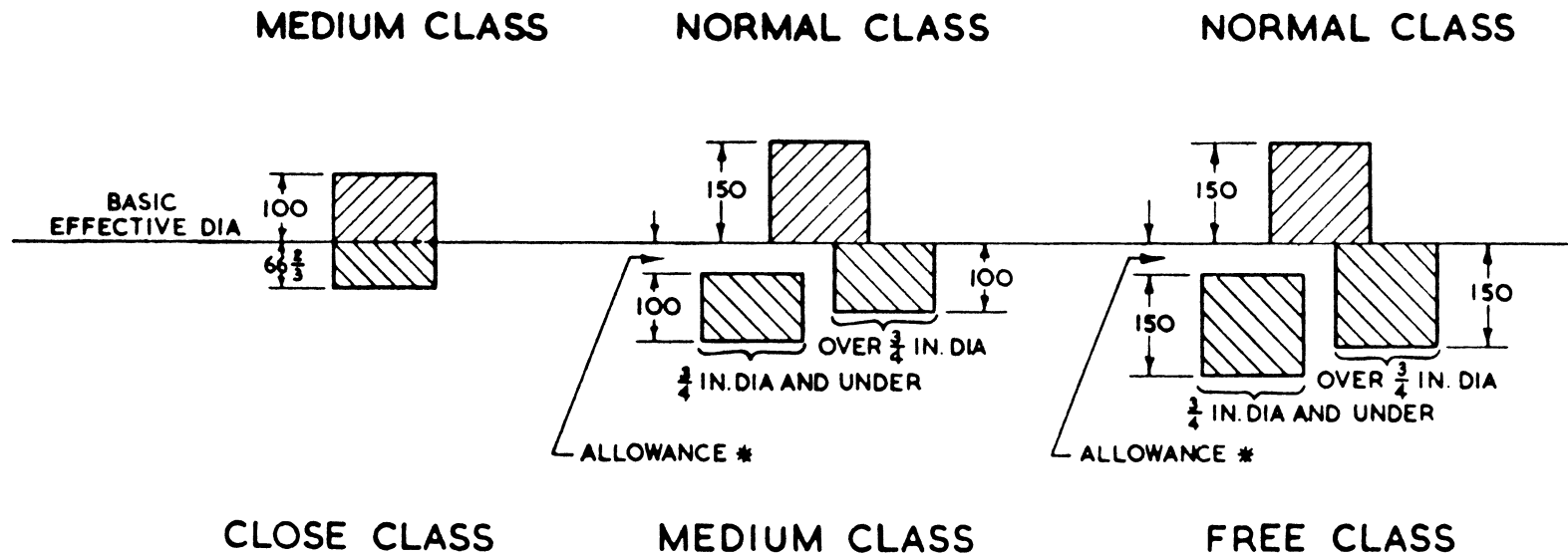


$$H = 0.960491 p \quad \frac{H}{6} = 0.160082 p$$

$$h = \frac{2}{3}H = 0.640327 p \quad r = 0.137329 p$$

Figure 1 — Basic form of Whitworth thread

NUTS



NOTE 1 The Medium Class bolt effective diameter tolerance is shown as 100 units and the other values are expressed as a percentage of this tolerance. The formula for effective diameter tolerance is given in Appendix B.

NOTE 2 See Appendix E for Close Class nuts for special needs.

* See Clause 4.

Figure 2 — Effective diameter tolerance zones of recommended combinations of classes of bolts and nuts having Whitworth screw threads

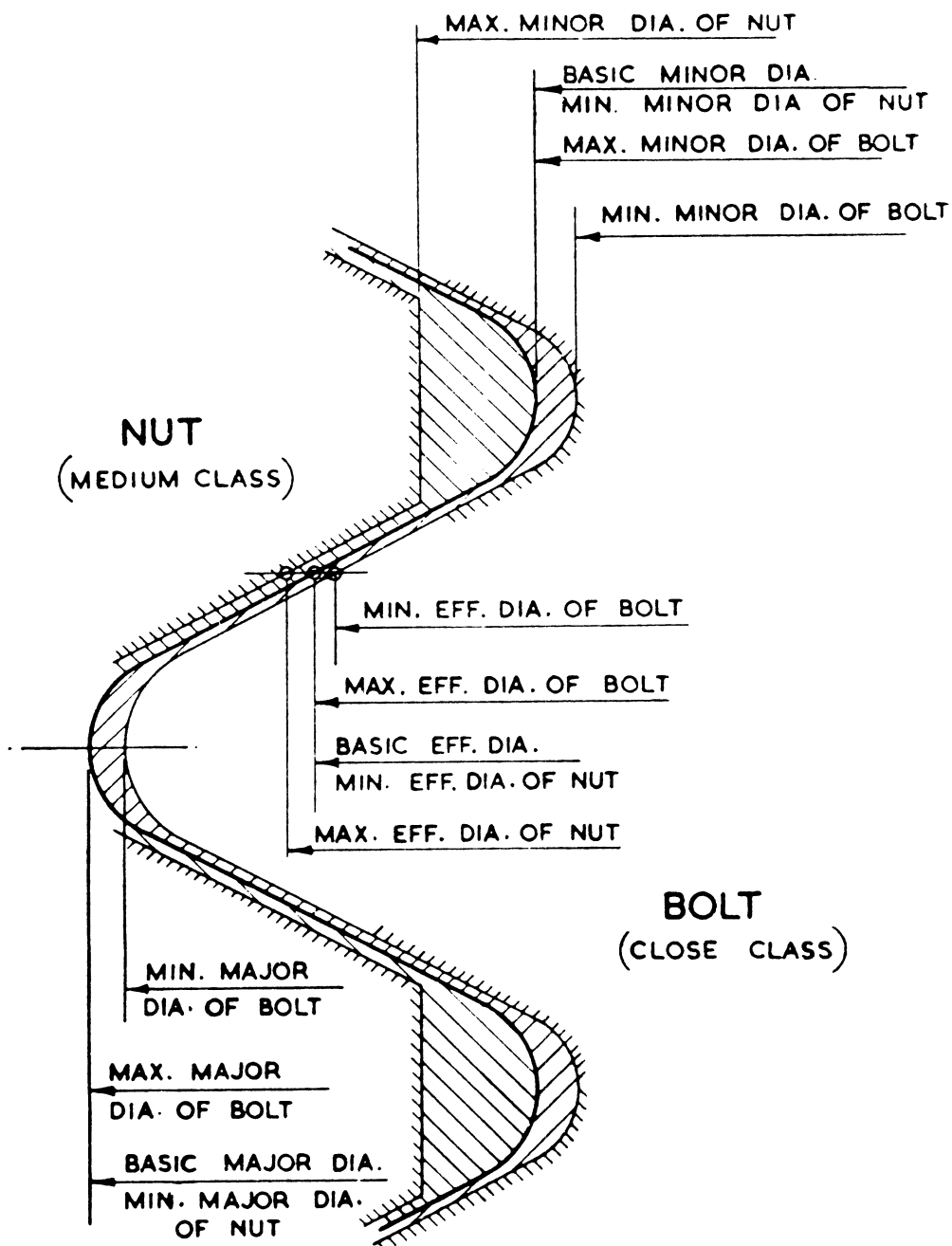
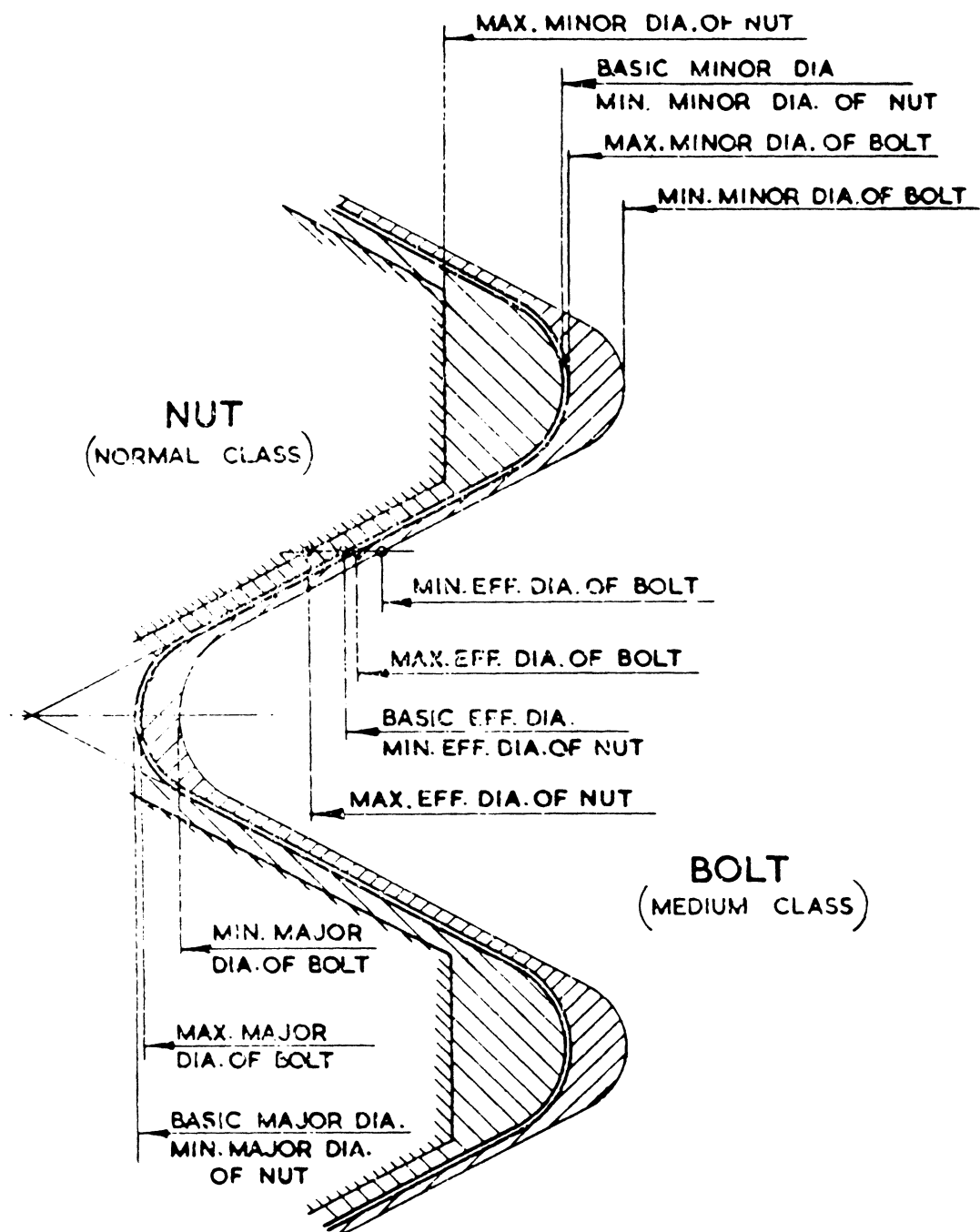
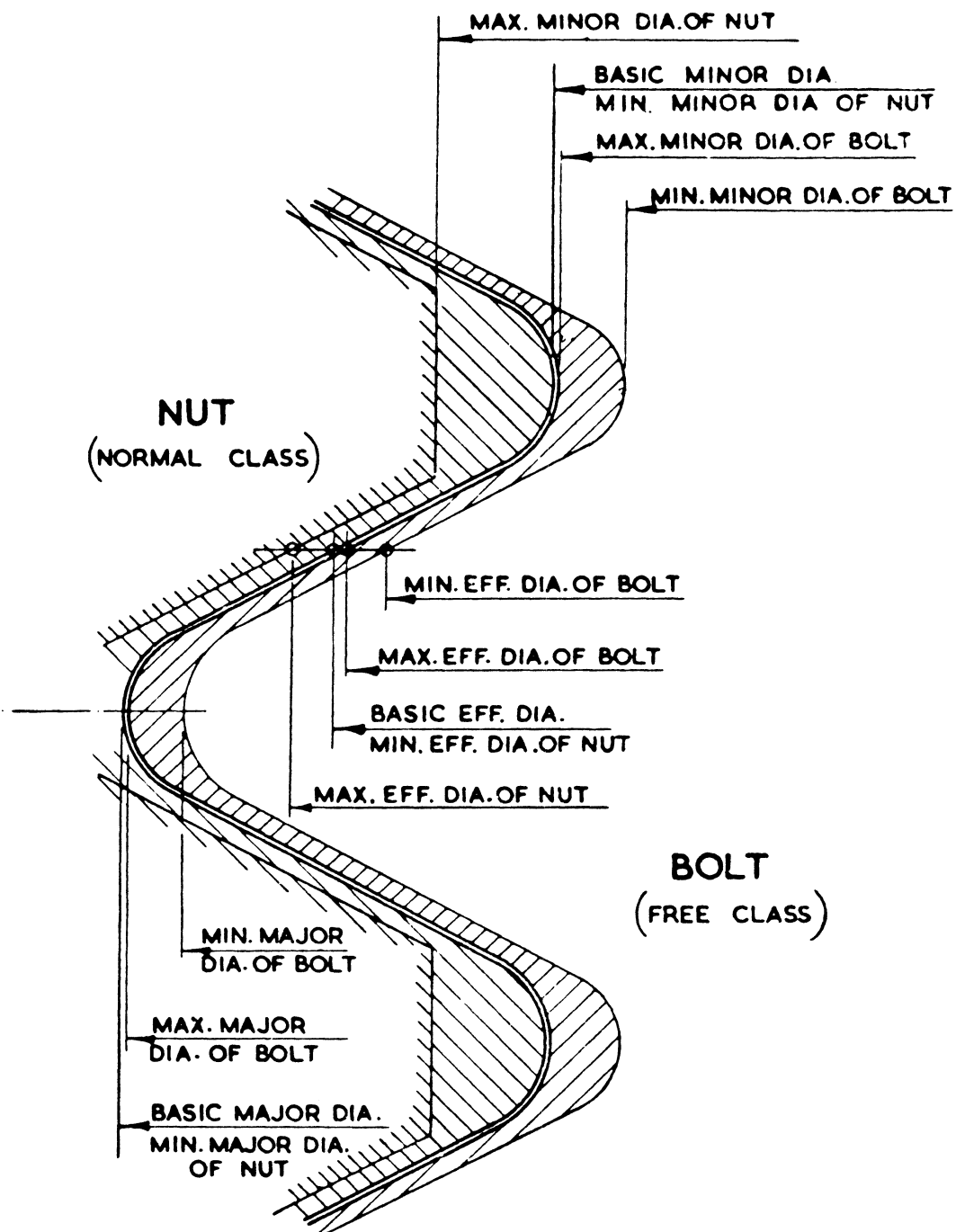


Figure 3 — Tolerance zones for close class bolt and medium class nut $\frac{1}{4}$ in. B.S.W. (20 t.p.i.) illustrated



NOTE The maximum bolt dimensions refer to unplated bolts only.

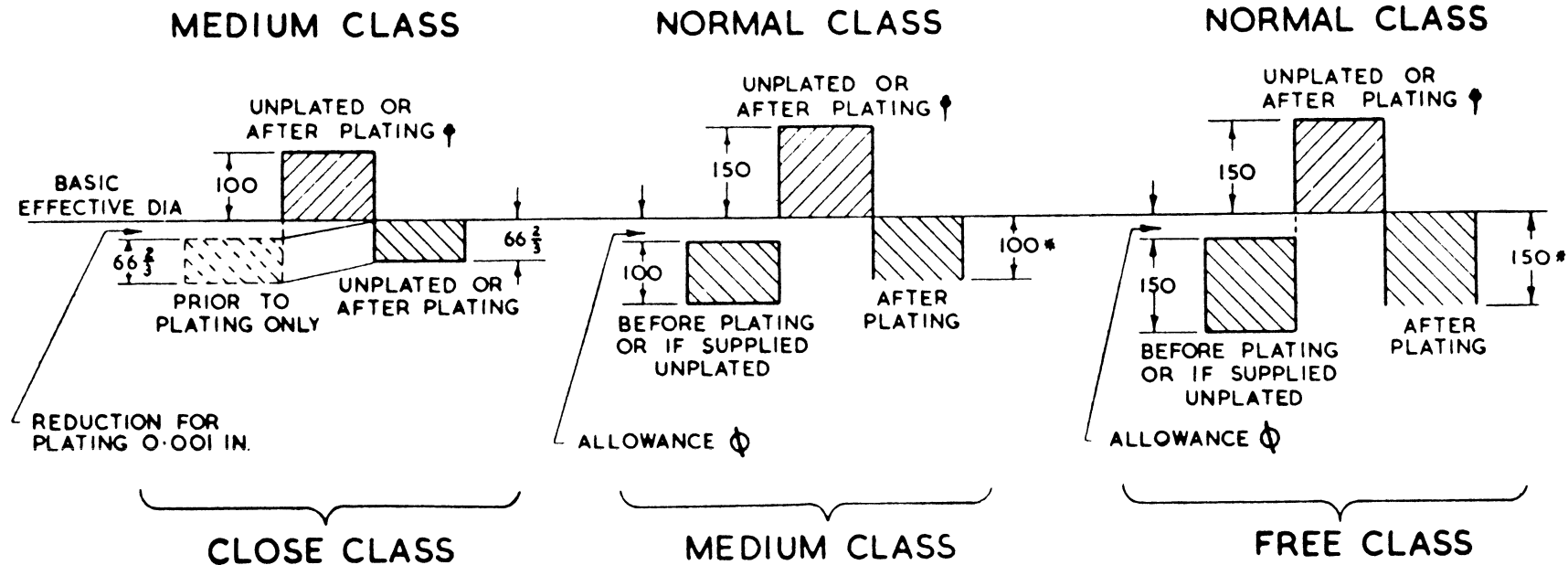
Figure 4 — Tolerance zones for medium class bolt with allowance and normal class nut. $\frac{1}{4}$ in. B.S.W. (20 t.p.i.) illustrated



NOTE The maximum bolt dimensions refer to unplated bolts only.

Figure 5 — Tolerance zones for free class bolt with allowance and normal class nut. $\frac{1}{4}$ in. B.S.W. (20 t.p.i.) illustrated

NUTS



BOLTS

ϕ See Clause

ϕ See Clause

* Approximate depending on thickness of plating

NOTE 1 Bolt Medium Class effective diameter tolerance is shown as 100 units.

NOTE 2 See Appendix E for Close Class nuts for special needs.

Figure 6 — Effective diameter tolerance zones for Whitworth bolts and nuts, unplated or before plating, and after plating (cf. Figure 2) of sizes $\frac{3}{4}$ in. nominal size and smaller