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Specification for limits and tolerances on plain limit gauges

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Contents

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 12, an inside back cover and a back cover.

Foreword

This British Standard is published by BSI and came into effect on 30 November 2008. It was prepared by Technical Committee TDW/4, *Technical product realization.*

Supersession

BS 969:2008 supersedes BS 969:1982, which is withdrawn.

Information about this document

This British Standard has been fully revised to bring it up to date.

The start and finish of text introduced or altered by Corrigendum No. 1 is indicated in the text by tags [C1⟩ ⟨C1].

Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its requirements are expressed in sentences in which the principal auxiliary verb is "shall".

Commentary, explanation and general informative material is presented in notes in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

1 Scope

This British Standard specifies tolerances and limits for simple forms of limit gauges, such as cylindrical plain plug, ring and gap gauges, for which gauge limits have not been stipulated.

It specifies gauge tolerances for workpiece tolerances in the range between 0.009 mm and 3.200 mm and how gauge limits are related to the workpiece limits. It also specifies types of gauge according to size and minimum workpiece tolerance.

NOTE Where a workpiece tolerance is outside the range 0.009 mm to 3.200 mm, or if it is not possible to conform to Table 2 regarding type of gauge, gauge tolerance and workpiece size, direct measurement should be used.

The gauge tolerances specified are such that the size of any workpiece accepted by a gauge lies within the boundaries constituted by the workpiece limits. Furthermore, the magnitude of the gauge tolerances is consequent upon the amount of the workpiece tolerance only. A wear allowance is provided on all GO gauges, i.e. those that control the maximum material condition of the workpiece.

2 Terms and definitions

For the purposes of this British Standard the following terms and definitions apply.

2.1 maximum material limit of size
dimension defining the maximum material condition of a feature at the maximum limit of size for an external feature and at the minimum limit of size for an internal feature

NOTE A shaft is an example of an external feature and a hole is an example of an internal feature.

2.2 least material limit of size
dimension defining the minimum limit of local size for an external feature or maximum limit of local size for an internal feature

NOTE A shaft is an example of an external feature and a hole is an example of an internal feature.

2.3 GO gauge
gauge that controls the maximum material limit of size of the workpiece

2.4 NOT GO gauge
gauge that controls the least material limit of size of the workpiece

2.5 workpiece tolerance
difference between the high and low limits of size of the workpiece

3 Gauge limits and tolerances

3.1 Gauge limits

Where workpiece limits only are supplied to the gauges manufacturer (i.e. the purchaser does not state the required gauge limits), gauge limits for workpiece tolerances shall be as specified in Table 1 (Annex A gives examples of the application of Table 1. Annex C gives the gauge size limits in imperial units).

NOTE It will be seen that gauge tolerance increases with workpiece tolerance only. To appreciate this apparent disregard of workpiece size, it should be remembered that the size factor plays its proper part when the workpiece tolerance is fixed initially.

3.2 Tolerances on gauge types

The minimum tolerance on gauges shall be as specified in Table 2 (Annex C gives the minimum gauge tolerances in imperial units).

NOTE 1 In most cases it is uneconomical to manufacture, and impractical to use, limit gauges with tolerances on sizes smaller than those specified in Table 2.

NOTE 2 The GO gauges should be of full form and the NOT GO gauges should be designed to make contact at only the two ends of a diameter. The principle and reservations are described in Annex B.

NOTE 3 Recommended gauge designs are given in BS 1044-1.

4 Hardness

The hardness of the gauging surface shall be not less than 700 HV (600 HRC).

NOTE It is recommended that plain plug gauges of less than 6 mm nominal diameter should be suitably tempered on the relieved section to avoid breakage in use.

5 Marking

5.1 Gauges shall be marked with:

a) the limiting size of the workpiece which the gauge controls;

b) GO or NOT GO, as appropriate.

5.2 Gauges can also be marked with:

a) the manufacturer's name or trade mark;

b) a serial number.

6 Gauges in disagreement

It is possible that similar satisfactory gauges, using a different region of the permitted gauge tolerance, may respectively accept and reject a workpiece. Such cases are likely to be rare and a dispute can be resolved by measuring the workpiece directly.

Table 1 **Gauge size limits at 20 °C for ranges of workpiece tolerance (see Figure 1)**

1	2	3	4	5	6	7
Workpiece tolerance [A]	**Tolerance, T, for GO and for NOT GO gauges**	**Wear allowance, W, for GO gauges only**	**Plug type gauges** [B]		**Ring or gap gauges** [C], [D]	
			GO	**NOT GO**	**GO**	**NOT GO**
mm	mm	mm	mm	mm	mm	mm
0.009 [D] $\leqslant$ 0.018	0.001	0.001	$L^{+0.002}_{+0.001}$	$H^{0}_{-0.001}$	$H^{-0.001}_{-0.002}$	$L^{+0.001}_{0}$
> 0.018 $\leqslant$ 0.032	0.002	0.001	$L^{+0.003}_{+0.001}$	$H^{0}_{-0.002}$	$H^{-0.001}_{-0.003}$	$L^{+0.002}_{0}$
> 0.032 $\leqslant$ 0.058	0.003	0.002	$L^{+0.005}_{+0.002}$	$H^{0}_{-0.003}$	$H^{-0.002}_{-0.005}$	$L^{+0.003}_{0}$
> 0.058 $\leqslant$ 0.100	0.004	0.004	$L^{+0.008}_{+0.004}$	$H^{0}_{-0.004}$	$H^{-0.004}_{-0.008}$	$L^{+0.004}_{0}$
> 0.100 $\leqslant$ 0.180	0.006	0.007	$L^{+0.013}_{+0.007}$	$H^{0}_{-0.006}$	$H^{-0.007}_{-0.013}$	$L^{+0.006}_{0}$
> 0.180 $\leqslant$ 0.320	0.009	0.012	$L^{+0.021}_{+0.012}$	$H^{0}_{-0.009}$	$H^{-0.012}_{-0.021}$	$L^{+0.009}_{0}$
> 0.320 $\leqslant$ 0.580	0.014	0.025	$L^{+0.039}_{+0.025}$	$H^{0}_{-0.014}$	$H^{-0.025}_{-0.039}$	$L^{+0.014}_{0}$
> 0.580 $\leqslant$ 1.000	0.025	0.048	$L^{+0.073}_{+0.048}$	$H^{0}_{-0.025}$	$H^{-0.048}_{-0.073}$	$L^{+0.025}_{0}$
> 1.000 $\leqslant$ 1.800	0.040	0.080	$L^{+0.120}_{+0.080}$	$H^{0}_{-0.040}$	$H^{-0.080}_{-0.120}$	$L^{+0.040}_{0}$
> 1.800 $\leqslant$ 3.200	0.050	0.155	$L^{+0.205}_{+0.155}$	$H^{0}_{-0.050}$	$H^{-0.155}_{-0.205}$	$L^{+0.050}_{0}$

NOTE Gauge wear and wear allowance. Provision is made for the wear of GO gauges by the introduction of a wear allowance (W) between the tolerance zone for the gauge and the maximum material limit for the workpiece. Wear allowance is not applied to the NOT GO gauge.

Gauge users have to watch for the effect of wear upon sizes of their gauges. Regular examination and measurement of gauges in use is essential so that a gauge, particularly a GO gauge which has worn outside its limit, is detected and withdrawn from service to avoid accepting workpieces exceeding the maximum material limit.

A) Difference between high (H) limit and low (L) limit shaft or hole.

B) Limits expressed with respect to H minus L for the workpiece (hole). Errors of size and form of the gauge are to be contained within these limits.

C) Limits expressed with respect to H minus L for the workpiece (shaft). Errors of size and form of the gauge are to be contained within these limits.

D) A workpiece with a tolerance less than 0.009 mm should be measured directly, or by means other than the gauges described in this standard.

Figure 1 **Relationships of workpiece and gauge tolerance zones**

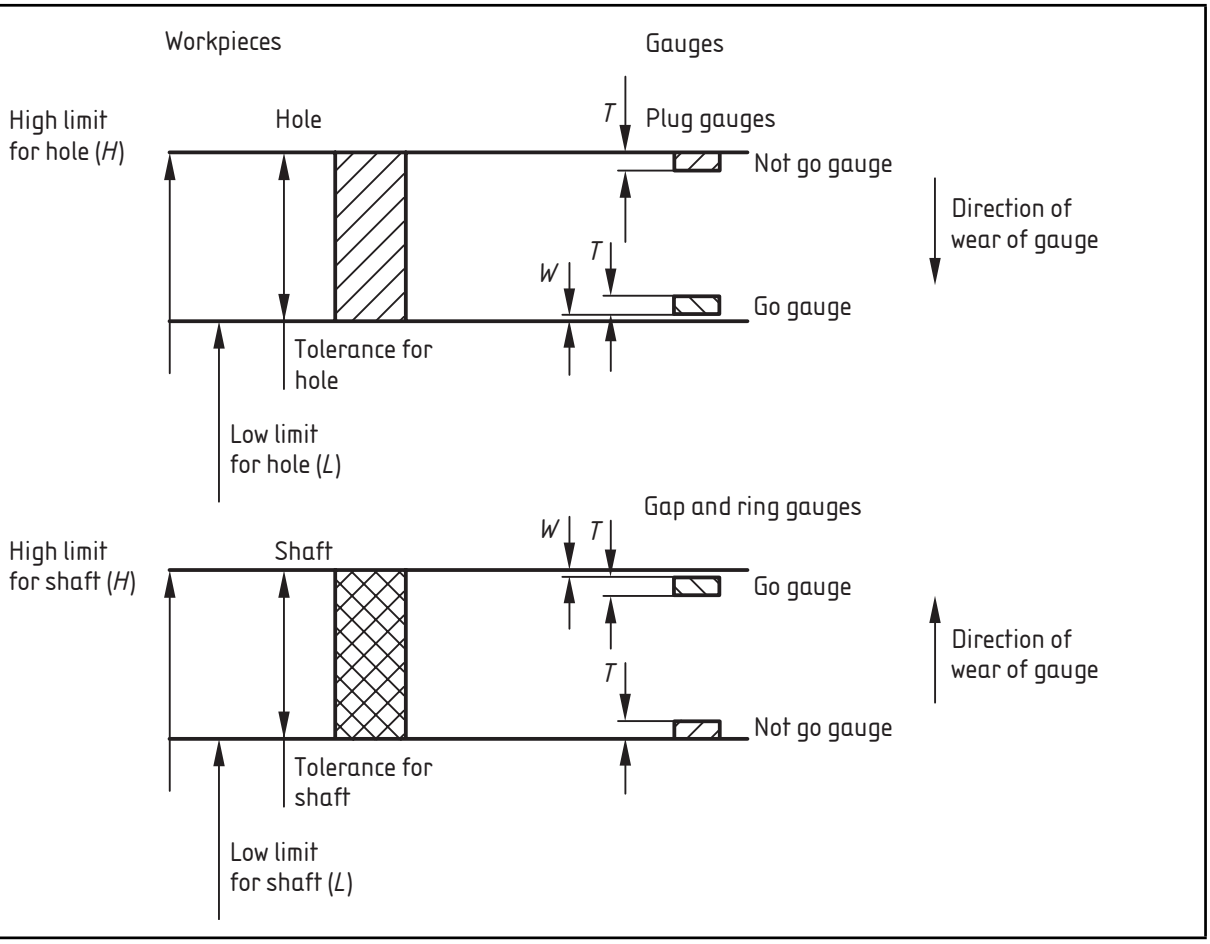


Table 2 **Minimum gauge tolerance appropriate to type and size of gauge**

Gauge size		**Type**	**Minimum tolerance appropriate to the type and size of gauge**
Above	**Up to and including**		
mm	mm		mm
—	25	Cylindrical plug	0.001
25	50		0.002
50	100		0.003
100	150		0.006
150	200		0.009
100	250	Cylindrically ended bar	0.009
250	500		0.016
375	750	Spherically ended rod and pin gauges	0.016
750	1 000		0.030
—	13	Ring and gap gauges	0.001
13	25		0.002
25	50		0.003
50	75		0.006
75	175		0.009
175	400		0.016
400	750		0.030

Annex A (informative) Examples of the use of Table 1

A.1 Example 1: Limits for hole

The limits for GO and NOT GO gauges for an internal diameter (hole) (see Figure A.1) are found as follows.

The workpiece tolerance is 0.200 mm.

a) From column 4 of Table 1, the limits for the GO gauge are:

+ 0.021 mm

+ 0.012 mm

Therefore, the size of the GO gauge is:

$$\boxed{C1}\ L^{+0.021\ \text{mm}}_{+0.012\ \text{mm}} = {}^{75.021\ \text{mm}}_{75.012\ \text{mm}}\ \boxed{C1}$$

b) From column 5 of Table 1, the limits for the NOT GO gauge are:

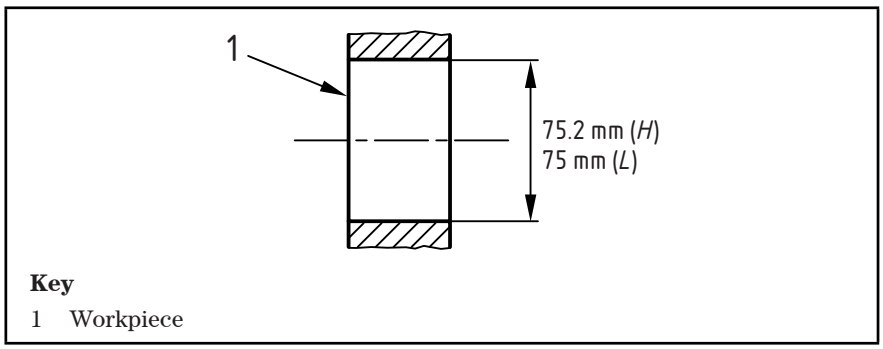
0 mm

−0.009 mm.

Therefore, the size of the NOT GO gauge is:

$$\boxed{C1}\ H^{0\ \text{mm}}_{-0.009\ \text{mm}} = {}^{75.200\ \text{mm}}_{75.191\ \text{mm}}\ \boxed{C1}$$

Figure A.1 **Limits for hole**



Key
1 Workpiece

A.2 Example 2: Limits for shaft

The limits for GO and NOT GO gauges for a shaft (see Figure A.2) are found as follows.

The workpiece tolerance is 0.040 mm.

a) From column 6 of Table 1, the limits for the GO gauge are:

−0.002 mm

−0.005 mm

Therefore, the size of the GO gauge is:

$$\boxed{C1}\ H^{-0.002\ \text{mm}}_{-0.005\ \text{mm}} = {}^{44.928\ \text{mm}}_{44.925\ \text{mm}}\ \boxed{C1}$$

b) From column 7 of Table 1, the limits for the NOT GO gauge are:

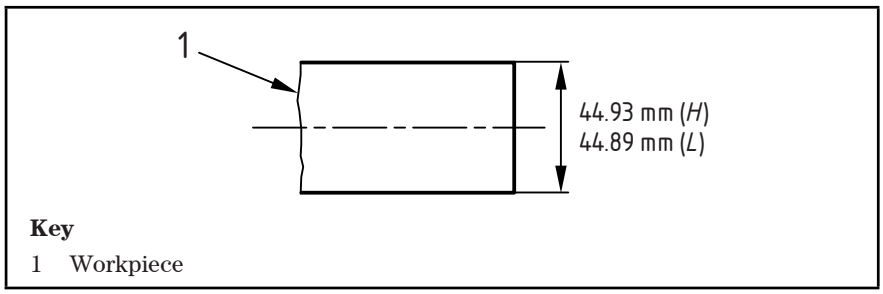
+ 0.003 mm

0

Therefore, the size of the NOT GO gauge is:

$$\boxed{C1}\ L^{+0.003\ \text{mm}}_{0\ \text{mm}} = {}^{44.893\ \text{mm}}_{44.890\ \text{mm}}\ \boxed{C1}$$

Figure A.2 **Limits for shaft**



Annex B (informative) Principles of inspection using plain limit gauges

B.1 Limits

The workpiece limits of size within the prescribed length of assembly are considered to be as follows.

a) *Holes.* The diameter of a perfect cylinder just contacting the high points of the workpiece is to be not less than the workpiece lower limit. The maximum diameter at any position in the hole does not exceed the workpiece upper limit.

b) *Shafts.* The diameter of a perfect cylinder just circumscribing the shaft is to be not more than the workpiece upper limit. The minimum diameter at any position on the shaft is to be not less than the workpiece lower limit.

These considerations mean that if the workpiece is everywhere at its maximum material limit, it should be perfectly round and straight.

Unless specific tolerances on circularity of section and straightness are specified, departures of the workpiece from cylindrical form can reach the diametral tolerance only if the workpiece size is at the least material limit. Examples of extreme errors in form are shown in Figure B.1 and Figure B.2.

B.2 Application of limit gauges to workpieces

NOTE The relationship of the limits for gauges to the workpiece limits is given in Figure 1.

B.2.1 The maximum material limit of a workpiece, i.e. the upper limit for a shaft or the lower limit for a hole, should be checked with a full form GO gauge that should be of the same length as the intended assembly of workpieces, shafts and holes concerned. The workpiece has to pass into or over the gauge.

B.2.2 The least material limit of a workpiece, i.e. the lower limit for a shaft or the upper limit for a hole, should be checked with a NOT GO gauge designed to contact the workpiece at two diametrically opposite points. The workpiece is not to pass into or over the gauge at any diametral position around and along the workpiece length.

B.2.3 The system of checking described in **B.2.1** and **B.2.2** is known as the Taylor Principle. For practical reasons the following departures from the strict application of the Taylor Principle are recognized.

a) *Gauging at the maximum material limit*

1) The length of a GO cylindrical plug or ring gauge may be less than the length of engagement of the mating workpieces if it is known that, with the manufacturing process used, the error of straightness of the hole or shaft is so small that it does not affect the character of fit of the assembled workpieces. This departure from the ideal facilitates the use of standard gauge blanks.

2) A GO cylindrical plug gauge might be too heavy for gauging a large hole. It is permissible to use instead a segmental cylindrical bar or spherical gauge if it is known that with the manufacturing process used, the error of roundness or straightness of the hole is so small that it does not affect the character of fit of the assembled workpieces.

3) A GO cylindrical ring gauge is often inconvenient for gauging shafts and may be replaced by a gap gauge if it is known that, with the manufacturing process used, the errors of roundness (especially lobing) and of straightness of the shaft are so small that they do not affect the character of fit of the assembled workpieces. The straightness of long shafts that have a small diameter should be checked separately.

b) *Gauging at the least material limit*

1) Point contacts are subject to rapid wear and in most cases may be replaced, where appropriate, by small plain cylindrical or spherical surfaces.

2) For gauging very small holes, a two-point checking device is difficult to design and manufacture. NOT GO plug gauges of full cylindrical form might have to be used but the user has to be aware that there is a possibility of accepting workpieces having a diameter outside the NOT GO limit.

3) Non-rigid workpieces can be deformed to an oval by a two-point mechanical contact device operating under a finite contact force. If it is not possible to reduce the contact force almost to zero, then it is necessary to use NOT GO ring or plug gauges of full cylindrical form.

Thin-walled workpieces may be out-of-round due to internal stresses or heat treatment. In these cases the NOT GO limit means that the circumference of the cylinder corresponding to that limit is not to be transgressed. Therefore, NOT GO gauges of full cylindrical form have to be applied with a force that is sufficient to convert the elastic deformation into circularity but does not expand or compress the wall of the workpiece.

B.2.4 The sizes of gauges cannot be made exactly to the appropriate workpiece limit; they have to be made to specified tolerances.

Figure B.1 **Possible extreme errors of form allowed by the effects of the limits of workpiece size: holes**

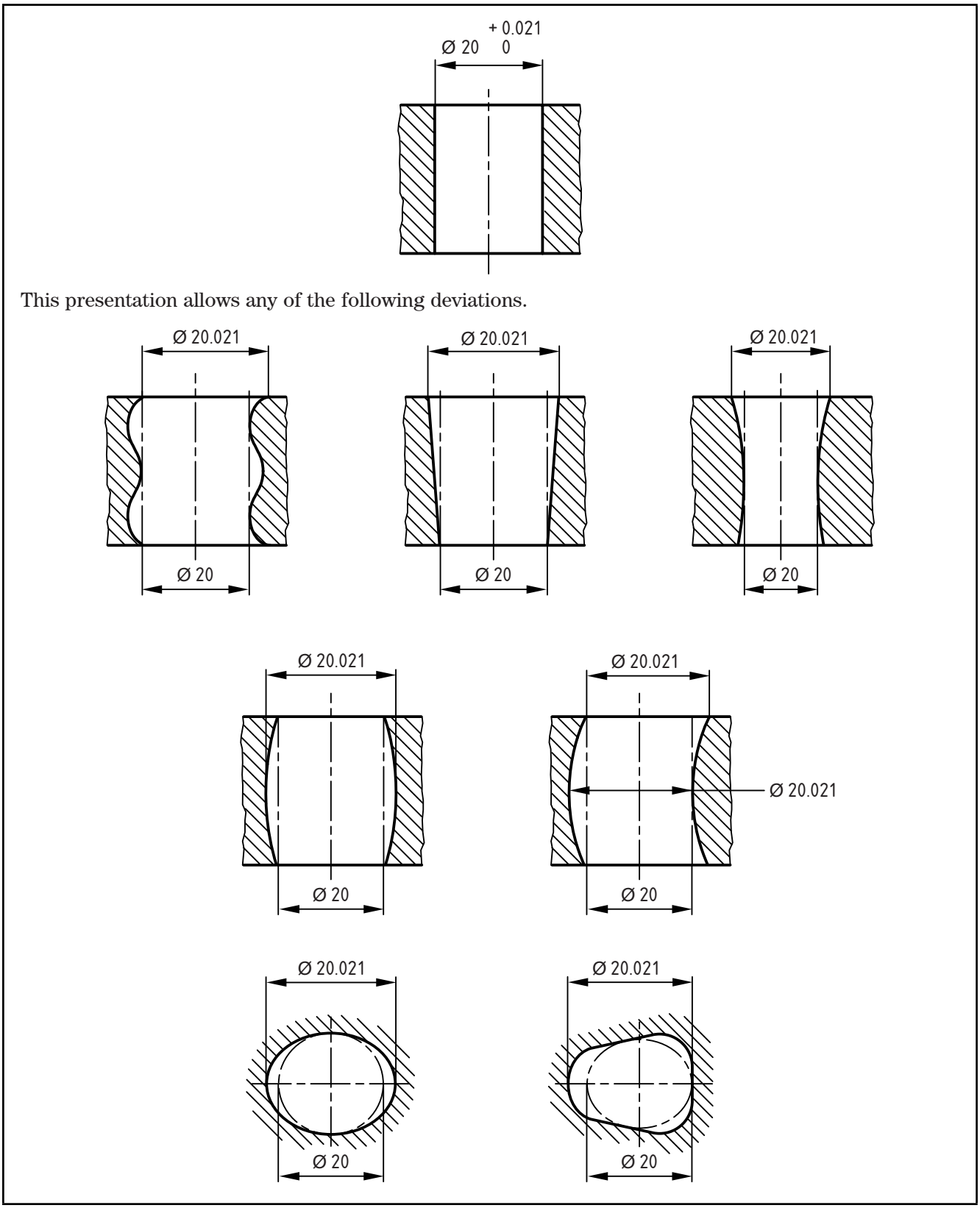
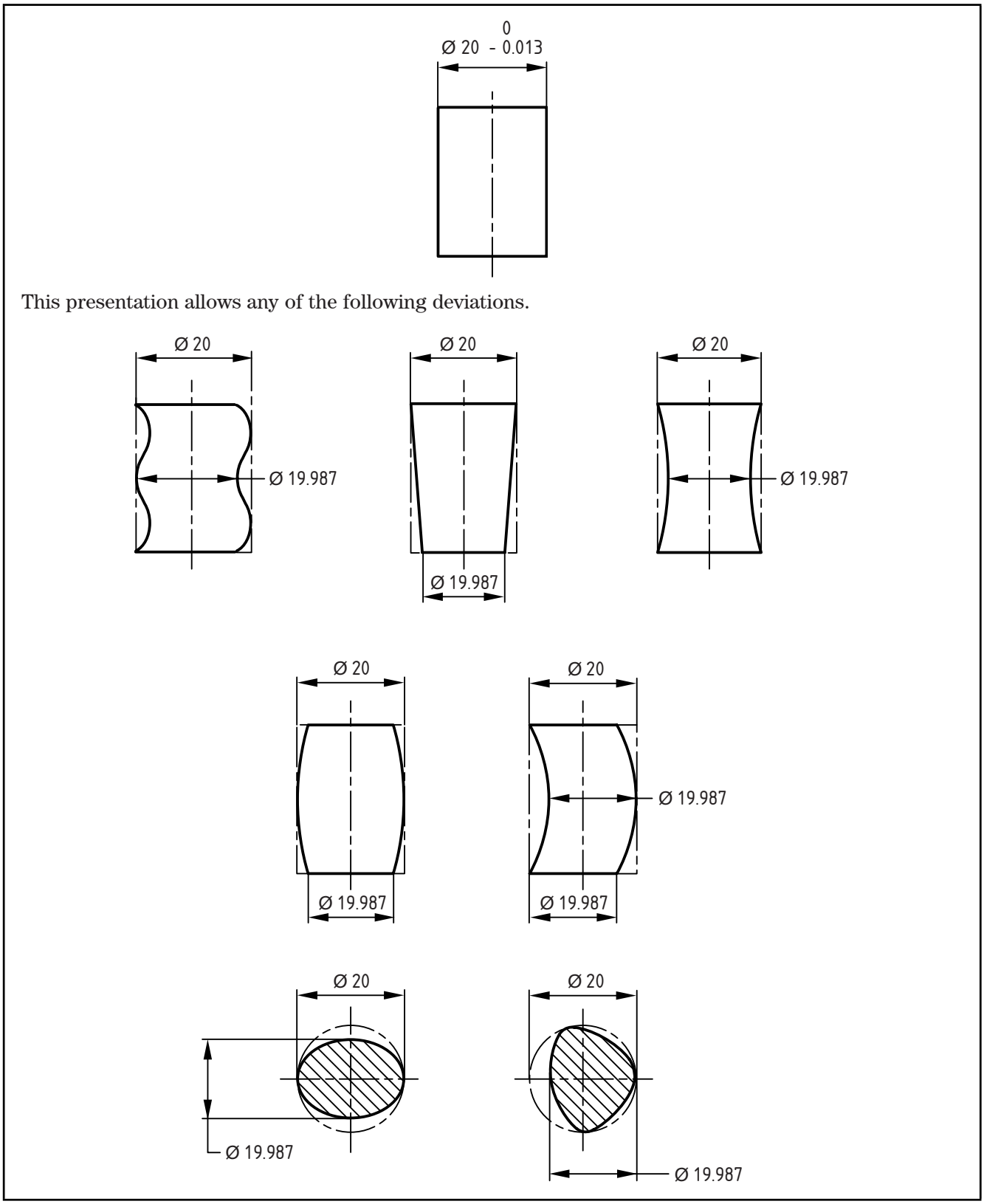


Figure B.2 **Possible extreme errors of form allowed by the effects of the limits of workpiece size: shafts**



Annex C (informative) Values for gauges in imperial units

C.1 General

Table C.1 and Table C.2 show gauge limits for workpiece tolerances in imperial units. The values shown correspond with manufacturing practice; they are approximate but not exact equivalents of the metric values specified in Table 1.

C.2 Gauge limits

Limits for gauges are supplied according to workpiece tolerances in ranges between 0.000 35 in and 0.125 in.

Table C.1 **Gauge size limits at 20 °C for ranges of workpiece tolerance in imperial units**

1	2	3	4	5	6	7
Workpiece tolerance [A]	**Tolerance, *T*, for GO and for NOT GO gauges**	**Wear allowance, *W*, for GO gauges only**	**Plug type gauges** [B]		**Ring or gap gauges** [C], [D]	
			GO	**NOT GO**	**GO**	**NOT GO**
in	in	in	in	in	in	in
0.000 35 [D] ⩽ 0.000 7	0.000 05	0.000 05	$L^{+0.000\,1}_{+0.000\,05}$	$H^{0}_{-0.000\,05}$	$H^{-0.000\,05}_{-0.000\,1}$	$L^{+0.000\,05}_{0}$
> 0.000 7 ⩽ 0.001 25	0.000 1	0.000 05	$L^{+0.000\,15}_{+0.000\,05}$	[c1] $H^{0}_{-0.000\,1}$ [c1]	$H^{-0.000\,05}_{-0.000\,15}$	$L^{+0.000\,1}_{0}$
> 0.00125 ⩽ 0.002 3	0.000 1	0.000 1	$L^{+0.000\,2}_{+0.000\,1}$	[c1] $H^{0}_{-0.000\,1}$ [c1]	$H^{-0.000\,1}_{-0.000\,2}$	$L^{+0.000\,1}_{0}$
> 0.002 3 ⩽ 0.004 0	0.000 15	0.000 15	$L^{+0.000\,3}_{+0.000\,15}$	$H^{0}_{-0.000\,15}$	$H^{-0.000\,15}_{-0.000\,3}$	$L^{+0.000\,15}_{0}$
> 0.004 0 ⩽ 0.007 0	0.000 25	0.000 3	$L^{+0.000\,55}_{+0.000\,3}$	$H^{0}_{-0.000\,25}$	$H^{-0.000\,3}_{-0.000\,55}$	$L^{+0.000\,25}_{0}$
> 0.007 0 ⩽ 0.012 5	0.000 35	0.000 5	$L^{+0.000\,85}_{+0.000\,5}$	$H^{0}_{-0.000\,35}$	$H^{-0.000\,5}_{-0.000\,85}$	$L^{+0.000\,35}_{0}$
> 0.012 5 ⩽ 0.023	0.000 55	0.001 0	[c1] $L^{+0.001\,55}_{+0.001\,0}$ [c1]	$H^{0}_{-0.000\,55}$	[c1] $H^{-0.001\,0}_{-0.001\,55}$ [c1]	$L^{+0.000\,55}_{0}$
> 0.023 ⩽ 0.040	0.001 0	0.001 9	$L^{+0.002\,9}_{+0.001\,9}$	$H^{0}_{-0.001\,0}$	$H^{-0.001\,9}_{-0.002\,9}$	$L^{+0.001\,0}_{0}$
> 0.040 ⩽ 0.070	0.001 6	0.003 2	$L^{+0.004\,8}_{+0.003\,2}$	$H^{0}_{-0.0016}$	$H^{-0.003\,2}_{-0.004\,8}$	$L^{+0.001\,6}_{0}$
> 0.070 ⩽ 0.125	0.002 0	0.006 1	$L^{+0.008\,1}_{+0.006\,1}$	$H^{0}_{-0.002\,0}$	$H^{-0.006\,1}_{-0.008\,1}$	$L^{+0.002\,0}_{0}$

NOTE Gauge wear and wear allowance. Provision is made for the wear of GO gauges by the introduction of a wear allowance (W) between the tolerance zone for the gauge and the maximum material limit for the workpiece. Wear allowance is not applied to the NOT GO gauge.

Gauge users have to watch for the effect of wear upon sizes of their gauges. Regular examination and measurement of gauges in use is essential so that a gauge, and in particular a GO gauge, which has worn outside its limit is detected and withdrawn from service to avoid accepting workpieces exceeding the maximum material limit.

A) Difference between high (*H*) limit and low (*L*) limit shaft or hole.

B) Limits expressed with respect to *H* minus *L* for the workpiece (hole). Errors of size and form of the gauge are to be contained within these limits.

C) Limits expressed with respect to *H* minus *L* for the workpiece (shaft). Errors of size and form of the gauge are to be contained within these limits.

D) Workpieces with a tolerance less than 0.003 5 in should be measured directly, or by means other than the gauges described in this standard.

Table C.2 **Minimum gauge tolerance appropriate to type and size of gauge (imperial units)**

Gauge size		Type	Minimum tolerance appropriate to the type and size of gauge
Above	**Up to and including**		
in	in		in
—	1	Cylindrical plug	0.000 05
[C1⟩ 1	2		0.000 1 ⟨C1]
[C1⟩ 2	4		0.000 1 ⟨C1]
4	6		0.000 15
6	8		0.000 35
4	10	Cylindrically ended bar	0.000 35
10	20		0.000 65
15	30	Spherically ended rod and pin gauges	0.000 65
30	40		0.001 2
—	0.5	Ring and gap gauges	0.000 05
[C1⟩ 0.5	1		0.000 1 ⟨C1]
[C1⟩ 1	2		0.000 1 ⟨C1]
2	3		0.000 25
3	7		0.000 35
7	16		0.000 65
16	30		0.001 2

Bibliography

BS 1044-1, *Specification for gauge blanks – Part 1: Plug, ring and calliper gauges*

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