British Standard

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TABLES FOR COMPARISON OF HARDNESS SCALES

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BRITISH STANDARDS INSTITUTION
Incorporated by Royal Charter

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 13th March, 1967.

The Institution desires to call attention to the fact that this British Standard does not purport to include all the necessary provisions of a contract.

In order to keep abreast of progress in the industries concerned, British Standards are subject to periodical review. Suggestions for improvements will be recorded and in due course brought to the notice of the committees charged with the revision of the standards to which they refer.

A complete list of British Standards, numbering over 9,000, fully indexed and with a note of the contents of each, will be found in the BSI Catalogue which may be purchased from BSI Sales Department. The Catalogue may be consulted in many public libraries and similar institutions.

This standard makes reference to the following British Standards:

BS 240. Method for Brinell hardness test.
BS 427. Method for Vickers hardness test.
BS 891. Method for Rockwell hardness test.

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 references relate to the work on this standard:
Committee references MEE/37 and MEE/37/9
Draft for comment D65/12287

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CO-OPERATING ORGANIZATIONS

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

Associated Offices Technical Committee
Association of Consulting Engineers
Association of Mining Electrical and Mechanical Engineers
Board of Trade
British Chemical Plant Manufacturers' Association
British Compressed Air Society
*British Electrical and Allied Manufacturers' Association
British Gear Manufacturers' Association
British Internal Combustion Engine Manufacturers' Association
*British Iron and Steel Federation
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Crown Agents for Oversea Governments and Administrations
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Institution of Gas Engineers
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Institution of Mechanical Engineers
Institution of Mechanical Engineers (Automobile Division)
*Institution of Production Engineers
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Ministry of Public Building and Works
*Ministry of Technology—National Engineering Laboratory
Ministry of Transport
National Coal Board
*National Physical Laboratory (Ministry of Technology)
Radio Industry Council
Royal Institute of British Architects

The Government departments and scientific and industrial organizations, 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.

Alloy Steels Association
Aluminium Federation
British Cast Iron Research Association
British Non-ferrous Metals Federation
British Non-ferrous Metals Research Association
Copper Development Association
Gauge and Tool Makers' Association
Institute of Metals
Institute of Sheet Metal Engineering
Institute of Welding
Institution of Engineering Inspection
Ministry of Aviation
Ministry of Technology—Building Research Station
Ministry of Technology—Forest Products Laboratory
Post Office
Society of Motor Manufacturers and Traders Ltd.
Individual Manufacturers of Testing Machines

BRITISH STANDARD TABLES FOR COMPARISON OF HARDNESS SCALES

FOREWORD

The most widely employed standard methods for measuring the hardness of metals are the Brinell, Vickers and Rockwell tests as described in BS 240*, BS 427† and BS 891‡ respectively, and there are individual preferences regarding the use of these tests. There are, however, instances when the same material is tested in different works or laboratories by different methods or when the hardness of a material is quoted according to one method of test but can only be verified by another.

To meet a general need for some means of correlating the various hardness scales, BS 860 was first published in 1939. During recent years, however, there have been detailed investigations into the factors which affect the accuracy with which hardness tests can be performed and this in turn has led to a comprehensive revision of the British Standard methods for hardness testing. The improved accuracy with which such tests can now be carried out has indicated certain discrepancies in the earlier edition of BS 860 and it has accordingly been decided that the standard should be revised to take into account the latest published information on hardness conversions and the results available from practical tests on various materials.

In this edition of the standard it has been considered more expedient to provide separate tables for each material. This will facilitate the inclusion of hardness conversion values for other metals based on comparative tests on similar materials having similar mechanical properties as the need arises.

In Tables 1, 2, 3 and 4 the Vickers scale is taken as the basis of reference as this scale is applicable to all metals. Pending acceptance by ISO, Table 4 has been included as an Appendix to provide general guidance. (See Note 1 to Table 4).

This standard is issued solely to indicate the order of the relationship between the three methods of hardness measurement. It should not be used as a standard for the conversion of hardness values given on one scale in any British Standard to those of another scale.

TABLES

1. INTRODUCTION

1.1 The tables given in this standard are for the most part based on experimental work carried out on specially prepared hardness test blocks using

* BS 240, ' Method for Brinell hardness test '.
† BS 427, ' Method for Vickers hardness test '.
‡ BS 891, ' Method for Rockwell hardness test

standardizing machines having a high degree of accuracy. It has accordingly been decided to include only those scales for which standardizing machines are available in this country, and for this reason certain scales, e.g. HRA are excluded.

1.2 The experimental data has shown that, for practical purposes, certain simplifications can be made in deriving hardness comparisons for different materials. For example, within the ranges covered by the tables it has been found that the conversion from Vickers to Brinell hardness numbers for aluminium and its alloys, copper, brass and steel may be represented by the relationship HB = 0·95 HV. Similarly, for the same materials the conversion from Vickers to the Rockwell B Scale can be represented by a single curve.

1.3 It should be noted that the experimental results used for deriving the tables showed some scatter about the mean line which was finally adopted. This scatter was however less than that which would normally be expected in general routine industrial hardness measurements (see also 3.3).

2. DERIVATION OF CONVERSIONS

2.1 Conversion from Vickers to Brinell. The values for this conversion have been computed from a curve HB = 0·95 HV fitted to experimental results obtained on aluminium alloy, copper, brass and steel test blocks. In the Brinell test, the appropriate F/D^2 ratio (5 or 10 for aluminium, 10 for brass and 30 for steel) was used. The aluminium alloy and brass blocks were calibrated employing a load of 10 kgf in the Vickers scale, and 1 mm and 2 mm diameter ball indenters in the Brinell scale. The values on the steel blocks were obtained employing the preferred load of 30 kgf in the Vickers scale, and both 5 mm and 10 mm diameter ball indenters in the Brinell scale.

2.2 Conversion from Vickers to Rockwell B scale. The values for this conversion have been computed from a curve $\text{HRB} = 135 - \frac{8250}{\text{HV}}$ fitted to experimental results obtained on aluminium alloy, brass and steel test blocks calibrated in the Rockwell B scale, and in the Vickers scale employing a load of 10 kgf.

2.3 Conversion from Vickers to Rockwell C scale. The values for this conversion, which applies to steel only, have been computed from a curve fitted to experimental results on test blocks calibrated in the Rockwell C scale, and in the Vickers scale employing loads of both 30 kgf and 10 kgf.

3. USE OF TABLES

3.1 To facilitate interpolation, the converted values have been given to a precision not normally obtainable in practice (see also 3.3). For practical use,

the converted values should be rounded to a value commensurate with the accuracy of commercial machines as given in BS 240*, BS 427† and BS 891‡.

3.2 As there are known to be a number of factors which may influence the accuracy of a hardness test, it must be appreciated that hardness values obtained from conversions based on these tables will be less accurate than the hardness value being converted. Moreover, departures from the test conditions, e.g. load, size of indenter, testing procedure, used in deriving these tables may affect the accuracy of the hardness conversions.

3.3 It cannot be too strongly emphasized that the conversions given in the tables have been derived by the use of standardizing machines. The hardness values obtained by the use of commercial machines complying in every respect with the appropriate British Standards (BS 240, BS 427 and BS 891*) may differ from those given by a standardizing machine by as much as ± 3% in the Brinell scale, ± 2% in the Vickers scale, ± 2 units in the Rockwell B scale and ± 1·5 units in the Rockwell C scale. In addition it must be emphasized that samples prepared by commercial methods may give somewhat different conversions from those obtained with specially prepared test blocks.

3.4 For materials other than those covered by the following tables, it is recommended that hardness conversions should be avoided unless a reliable basis for conversion has been established by direct tests on the material concerned.

* BS 240, ' Method for Brinell hardness test '.
† BS 427, ' Method for Vickers hardness test '.
‡ BS 891, ' Method for Rockwell hardness test '.

TABLE 1. CONVERSIONS FOR ALUMINIUM AND ITS ALLOYS

HV 10	HB ($\frac{F}{D^2}$ = 5 or 10)	HRB
210	199·5	95·7
205	194·8	94·8
200	190·0	93·8
195	185·3	92·7
190	180·5	91·6
185	175·8	90·4
180	171·0	89·2
175	166·3	87·9
170	161·5	86·5
165	156·8	85·0
160	152·0	83·4
155	147·3	81·8
150	142·5	80·0
145	137·8	78·1
140	133·0	76·1
135	128·3	73·9
130	123·5	71·5
125	118·8	69·0
120	114·0	66·3
115	109·3	63·3
110	104·5	60·0
105	99·8	56·4
100	95·0	52·5

HV 10	HB ($\frac{F}{D^2}$ = 5 or 10)	HRB
98	93·1	50·8
96	91·2	49·1
94	89·3	47·2
92	87·4	45·3
90	85·5	43·3
88	83·6	41·3
86	81·7	39·1
84	79·8	36·8
82	77·9	34·4
80	76·0	31·9
78	74·1	—
76	72·2	—
74	70·3	—
72	68·4	—
70	66·5	—
68	64·6	—
66	62·7	—
64	60·8	—
62	58·9	—
60	57·0	—

HV 10	HB ($\frac{F}{D^2}$ = 5 or 10)	HRB
58	55·1	—
56	53·2	—
54	51·3	—
52	49·4	—
50	47·5	—
48	45·6	—
46	43·7	—
44	41·8	—
42	39·9	—
40	38·0	—
38	36·1	—
36	34·2	—
34	32·3	—
32	30·4	—
30	28·5	—
28	26·6	—
26	24·7	—
24	22·8	—
22	20·9	—
20	19·0	—
18	17·1	—

TABLE 2. CONVERSIONS FOR COPPER AND BRASS

HV 10	HB ($\frac{F}{D^2} = 10$)	HRB
210	199·5	95·7
205	194·8	94·8
200	190·0	93·8
195	185·3	92·7
190	180·5	91·6
185	175·8	90·4
180	171·0	89·2
175	166·3	87·9
170	161·5	86·5
165	156·8	85·0
160	152·0	83·4
155	147·3	81·8
150	142·5	80·0
145	137·8	78·1
140	133·0	76·1
135	128·3	73·9
130	123·5	71·5
125	118·8	69·0
120	114·0	66·3
115	109·3	63·3
110	104·5	60·0
105	99·8	56·4
100	95·0	52·5

HV 10	HB ($\frac{F}{D^2} = 10$)	HRB
98	93·1	50·8
96	91·2	49·1
94	89·3	47·2
92	87·4	45·3
90	85·5	43·3
88	83·6	41·3
86	81·7	39·1
84	79·8	36·8
82	77·9	34·4
80	76·0	31·9
78	74·1	—
76	72·2	—
74	70·3	—
72	68·4	—
70	66·5	—
68	64·6	—
66	62·7	—
64	60·8	—
62	58·9	—
60	57·0	—
58	55·1	—
56	53·2	—
54	51·3	—
52	49·4	—
50	47·5	—
48	45·6	—
46	43·7	—
44	41·8	—
42	39·9	—
40	38·0	—
38	36·1	—
36	34·2	—
34	32·3	—

TABLE 3. CONVERSIONS FOR STEEL

NOTE. These conversions may not apply to austenitic steels, particularly in the cold-worked condition.

HV 10 and 30	HB ($\frac{F}{D^2} = 30$)	HRB	HV 10 and 30	HB ($\frac{F}{D^2} = 30$)	HRB
470	446·5	—	235	223·3	99·9
460	437·0	—	230	218·5	99·1
450	427·5	—	225	213·8	98·3
440	418·0	—	220	209·0	97·5
430	408·5	—	215	204·3	96·6
420	399·0	—	210	199·5	95·7
410	389·5	—	205	194·8	94·8
400	380·0	—	200	190·0	93·8
390	370·5	—	195	185·3	92·7
380	361·0	—	190	180·5	91·6
370	351·5	—	185	175·8	90·4
360	342·0	—	180	171·0	89·2
350	332·5	—	175	166·3	87·9
340	323·0	—	170	161·5	86·5
330	313·5	—	165	156·8	85·0
320	304·0	—	160	152·0	83·4
310	294·5	—	155	147·3	81·8
300	285·0	—	150	142·5	80·0
290	275·5	—	145	137·8	78·1
280	266·0	—	140	133·0	76·1
270	256·5	—	135	128·3	73·9
260	247·0	—	130	123·5	71·5
250	237·5	—	125	118·8	69·0
245	232·8	—	120	114·0	66·3
240	228·0	—	115	109·3	63·3
			110	104·5	60·0
			105	99·8	56·4

APPENDIX A

TABLE 4. CONVERSIONS FOR STEEL (HV to HRC)

NOTE 1. The conversions given in Table 4 represent the result of the latest research and are recognized as being more accurate. They have been submitted to the International Organization for Standardization to form the basis of an ISO Recommendation but, pending acceptance by ISO, they are included as an appendix to provide general guidance.

NOTE 2. These conversions may not apply to austenitic steels, particularly in the cold-worked condition.

HV 10 and 30	HRC	HV 10 and 30	HRC	HV 10 and 30	HRC
900	67·7	670	58·9	440	45·1
890	67·3	660	58·5	430	44·3
880	67·0	650	58·0	420	43·5
870	66·6	640	57·6	410	42·6
860	66·3	630	57·1	400	41·7
850	65·9	620	56·7	390	40·8
840	65·5	610	56·2	380	39·8
830	65·2	600	55·7	370	38·8
820	64·8	590	55·3	360	37·8
810	64·4	580	54·8	350	36·8
800	64·0	570	54·3	340	35·7
790	63·7	560	53·7	330	34·5
780	63·3	550	53·1	320	33·4
770	62·9	540	52·4	310	32·2
760	62·5	530	51·8	300	30·9
750	62·1	520	51·1	290	29·6
740	61·7	510	50·4	280	28·2
730	61·3	500	49·7	270	26·7
720	60·9	490	49·0	260	25·1
710	60·5	480	48·2	250	23·5
700	60·1	470	47·5	245	22·7
690	59·7	460	46·7	240	21·8
680	59·3	450	45·9	235	20·9
				230	20·0

BRITISH STANDARDS INSTITUTION

The British Standards Institution was founded in 1901 and incorporated by Royal Charter in 1929.

The principal objects of the Institution as set out in the charter are to co-ordinate the efforts of producers and users for the improvement, standardization and simplification of engineering and industrial materials; to simplify production and distribution; to eliminate the waste of time and material involved in the production of an unnecessary variety of patterns and sizes of articles for one and the same purpose; to set up standards of quality and dimensions, and to promote the general adoption of British Standards.

In carrying out its work the Institution endeavours to ensure adequate representation of all viewpoints. Before embarking on any project it must be satisfied that there is a strong body of opinion in favour of proceeding and that there is a recognized need to be met.

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Membership of the Institution is open to British subjects, companies, technical and trade associations, and local and public authorities.