UDC 669.14 : 620.178.152.2/.4 : 620.172

December 1976

Testing of Steel and Cast Steel

Conversion Table for Vickers Hardness, Brinell Hardness, Rockwell Hardness and Tensile Strength

DIN 50 150

Prüfung von Stahl und Stahlguss; Umwertungstabelle für Vickershärte, Brinellhärte, Rockwellhärte und Zugfestigkeit

For connection with EURONORM 8-55 issued by the European Community for Coal and Steel, see Explanations.

1 Purpose and range of application

The conversion table in this Standard applies

- to hardness values determined according to the following standards:

  DIN 50 103 Part 1 and Part 2 (Rockwell)
  DIN 50 133 Part 1 (Vickers) and
  DIN 50 351 (Brinell)
- to tensile strength values determined according to DIN 50 145 and
- to values of HRD hardness [1]) not standardized in German standards.

Subject to the restrictions mentioned later, this conversion table applies to unalloyed and low alloy steels and cast steel in the hot formed or heat-treated condition. In the case of high alloy and/or work-hardened steels, substantial deviations are likely in the conversion.

Conversion between hardness values or from hardness values to tensile strength values essentially involves inaccuracies which have to be taken into account. Extensive studies have shown that it is impossible to convert from one to another hardness values determined by different methods even when they have been determined with extreme care, on the basis of a relationship that is valid for all metallic materials or even merely for all grades of steel. This stems from the fact that the indentation behaviour of a material is determined by its stress-deformation behaviour in a very complex manner. A given conversion relationship will therefore provide better agreement, the closer is the stress-deformation behaviour of the material under test to that of the materials used for deriving the conversion relationship.

Note: In many cases, some information on the stress-deformation behaviour can be obtained from the elastic limit-tensile strength ratio.

2 Definitions

Reference should be made to the standards quoted in Section 1 for an explanation of the definitions, formulae and symbols relating to the various methods of hardness testing.

3 Conversion

3.1 General

The following Table correlates corresponding hardness values obtained by various methods and tensile strength values, obtained in extensive tests.

Conversion as defined in this Standard means giving, for any experimentally determined hardness value obtained by a particular method, the corresponding hardness value for another method or the corresponding tensile strength value as given in this Table.

Hardness conversion should only be carried out if it is not possible to use the prescribed test method, for example because no suitable testing machine is available or because the specimen is not suitable for testing with the testing machine or if it is not possible to take the specimens required for the prescribed method (e. g. tensile specimens) from the test piece.

Characteristics merely obtained indirectly by using this Standard may only be used as a basis for objections if there is an agreement to this effect in the supply contract.

If hardness or tensile strength values are determined by conversion to this Standard, the test method used for the measurement must be quoted and the fact that conversion has been carried out to this Standard.

In principle, it must be remembered that any hardness determination is valid only for the region of the indentation. Where hardness changes occur, e. g. with increasing distance from the surface, the results of Brinell and Vickers hardness measurements or even of the tensile test may deviate from the converted values simply as a result of differing amounts of stretching of the areas of the material measured.

The value used for conversion shall be the mean of at least three individual hardness values.

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[1]) International practice, e. g. ASTM E 18-74 (American Society for Testing and Materials)

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3.2 Conversion between hardness values

In considering the reliability of converted hardness values, it is necessary to take account both of the accuracy of the hardness test method used and the width of the conversion scatter band, as shown schematically in Fig. 1.

Curve a here represents the mean conversion relationship for steels as defined in this Standard. Curves b_1 and b_2 define the range either side of a obtained on the basis of the differing stress-deformation behaviour of these steels.

With ideal conversion, hardness value y_0 is obtained for x_0. Taking into account the scatter band b_1 to b_2 it is possible to obtain virtually any hardness value between y_{01} and y_{02}.

Beyond this, it is necessary to take account of the fact that even hardness value x_0 itself is still subject to the uncertainty involved in the measuring process used. This hardness can therefore vary between x_1 and x_2 so that the converted value can lie between y_{11} and y_{22}.

Note: In co-operative tests conducted by the VDEh a (graphically determined) scatter band of ±24 HV10 or ±23 HB was obtained from an evaluation of about 700 measured values for conversion between Vickers hardness HV10 and Brinell hardness HB.

3.3 Conversion between hardness values and tensile strength values

If conversion from one hardness value to another may involve a substantial dispersion and systematic variations, the dispersion obtained when converting between hardness values and tensile strength values is bound to be even greater. One reason for this is the considerable difference between the deformation behaviour during hardness measurements and that in the tensile test which, among other factors takes the form of different stress conditions and differing rates of strain. Another reason ist the major differences in the stress-deformation behaviour of different steels.

The tensile strength values given in the Table should therefore be regarded only as approximate values that can in no sense replace measured values determined in the tensile test.

Note: In co-operative tests carried out by the VDEh a (graphically determined) scatter band of ±25 HV10 for hardness or ±85 N/mm² for tensile strength was obtained from an evaluation of about 700 measured values for conversion between Vickers hardness HV10 and tensile strength. At the same time it was found that, with particular groups of steels, there was a possibility of systematic variations from the mean value line. Thus, with the pearlitic steel group in the range between 300 HV and 500 HV10 for example, values of tensile strength were obtained which were on average some 100 N/mm² above the tensile strength values obtained from this Table.

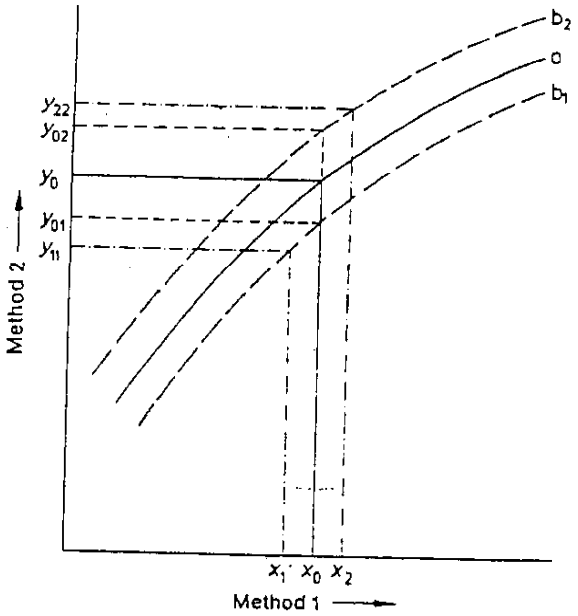


Figure 1. Schematic representation of scatter bands for hardness conversion

Tensile strength	Vickers hardness	Brinell hardness [2]	Rockwell hardness							
N/mm^2	($F \geq 98$ N)	$\left(0.102 \frac{F}{D^2} \cdot 30 \frac{N}{mm^2}\right)$	HRB	HRF	HRC	HRA	HRD [1]	HR 15N	HR 30N	HR 45N
255	80	76,0								
270	85	80,7	41,0							
285	90	85,5	48,0	82,6						
305	95	90,2	52,0							
320	100	95,0	56,2	87,0						
335	105	99,8								
350	110	105	62,3	90,5						
370	115	109								
385	120	114	66,7	93,6						
400	125	119								
415	130	124	71,2	96,4						
430	135	128								
450	140	133	75,0	99,0						
465	145	138								
480	150	143	78,7	101,4						
495	155	147								
510	160	152	81,7	103,6						
530	165	156								
545	170	162	85,0	105,5						
560	175	166								
575	180	171	87,1	107,2						
595	185	176								
610	190	181	89,5	108,7						
625	195	185								
640	200	190	91,5	110,1						
660	205	195	92,5							
675	210	199	93,5	111,3						
690	215	204	94,0							
705	220	209	95,0	112,4						
720	225	214	96,0							
740	230	219	96,7	113,4						
755	235	223								
770	240	228	98,1	114,3	20,3	60,7	40,3	69,6	41,7	19,9
785	245	233			21,3	61,2	41,1	70,1	42,5	21,1
800	250	238	99,5	115,1	22,2	61,6	41,7	70,6	43,4	22,2
820	255	242			23,1	62,0	42,2	71,1	44,2	23,2
835	260	247	(101)		24,0	62,4	43,1	71,6	45,0	24,3
850	265	252			24,8	62,7	43,7	72,1	45,7	25,2
865	270	257	(102)		25,6	63,1	44,3	72,6	46,4	26,2
880	275	261			26,4	63,5	44,9	73,0	47,2	27,1
900	280	266	(104)		27,1	63,8	45,3	73,4	47,8	27,9
915	285	271			27,8	64,2	46,0	73,8	48,4	28,7
930	290	276	(105)		28,5	64,5	46,5	74,2	49,0	29,5
950	295	280			29,2	64,8	47,1	74,6	49,7	30,4
965	300	285			29,8	65,2	47,5	74,9	50,2	31,1
995	310	295			31,0	65,8	48,4	75,6	51,3	32,5
1030	320	304			32,2	66,4	49,4	76,2	52,3	33,9
1060	330	314			33,3	67,0	50,2	76,8	53,6	35,2
1095	340	323			34,4	67,6	51,1	77,4	54,4	36,5
1125	350	333			35,5	68,1	51,9	78,0	55,4	37,8

The figures in brackets are hardness values that lie outside the range of definition of the standardized hardness test methods but which in practice are frequently used as approximate values.

[1] See page 1

[2] Calculated from: HB = 0.95 · HV

Tensile strength	Vickers hardness	Brinell hardness [2]	Rockwell hardness							
N/mm^2	($F \geq 98$ N)	$\left(0{,}102 \frac{F}{D^2} = 30 \frac{N}{mm^2}\right)$	HRB	HRF	HRC	HRA	HRD [1]	HR 15 N	HR 30 N	HR 45 N
1155	360	342			36,6	68,7	52,8	78,6	56,4	39,1
1190	370	352			37,7	69,2	53,6	79,2	57,4	40,4
1220	380	361			38,8	69,8	54,4	79,8	58,4	41,7
1255	390	371			39,8	70,3	55,3	80,3	59,3	42,9
1290	400	380			40,8	70,8	56,0	80,8	60,2	44,1
1320	410	390			41,8	71,4	56,8	81,4	61,1	45,3
1350	420	399			42,7	71,8	57,5	81,8	61,9	46,4
1385	430	409			43,6	72,3	58,2	82,3	62,7	47,4
1420	440	418			44,5	72,8	58,8	82,8	63,5	48,4
1455	450	428			45,3	73,3	59,4	83,2	64,3	49,4
1485	460	437			46,1	73,6	60,1	83,6	64,9	50,4
1520	470	447			46,9	74,1	60,7	83,9	65,7	51,3
1555	480	(456)			47,7	74,5	61,3	84,3	66,4	52,2
1595	490	(466)			48,4	74,9	61,6	84,7	67,1	53,1
1630	500	(475)			49,1	75,3	62,2	85,0	67,7	53,9
1665	510	(485)			49,8	75,7	62,9	85,4	68,3	54,7
1700	520	(494)			50,5	76,1	63,5	85,7	69,0	55,6
1740	530	(504)			51,1	76,4	63,9	86,0	69,5	56,2
1775	540	(513)			51,7	76,7	64,4	86,3	70,0	57,0
1810	550	(523)			52,3	77,0	64,8	86,6	70,5	57,8
1845	560	(532)			53,0	77,4	65,4	86,9	71,2	58,6
1880	570	(542)			53,6	77,8	65,8	87,2	71,7	59,3
1920	580	(551)			54,1	78,0	66,2	87,5	72,1	59,9
1955	590	(561)			54,7	78,4	66,7	87,8	72,7	60,5
1995	600	(570)			55,2	78,6	67,0	88,0	73,2	61,2
2030	610	(580)			55,7	78,9	67,5	88,2	73,7	61,7
2070	620	(589)			56,3	79,2	67,9	88,5	74,2	62,4
2105	630	(599)			56,8	79,5	68,3	88,8	74,6	63,0
2145	640	(608)			57,3	79,8	68,7	89,0	75,1	63,5
2180	650	(618)			57,8	80,0	69,0	89,2	75,5	64,1
	660				58,3	80,3	69,4	89,5	75,9	64,7
	670				58,8	80,6	69,8	89,7	76,4	65,3
	680				59,2	80,8	70,1	89,8	76,8	65,7
	690				59,7	81,1	70,5	90,1	77,2	66,2
	700				60,1	81,3	70,8	90,3	77,6	66,7
	720				61,0	81,8	71,5	90,7	78,4	67,7
	740				61,8	82,2	72,1	91,0	79,1	68,6
	760				62,5	82,6	72,6	91,2	79,7	69,4
	780				63,3	83,0	73,3	91,5	80,4	70,2
	800				64,0	83,4	73,8	91,8	81,1	71,0
	820				64,7	83,8	74,3	92,1	81,7	71,8
	840				65,3	84,1	74,8	92,3	82,2	72,2
	860				65,9	84,4	75,3	92,5	82,7	73,1
	880				66,4	84,7	75,7	92,7	83,1	73,6
	900				67,0	85,0	76,1	92,9	83,6	74,2
	920				67,5	85,3	76,5	93,0	84,0	74,8
	940				68,0	85,6	76,9	93,2	84,4	75,4

The figures in brackets are hardness values that lie outside the range of definition of the standardized hardness test methods but which in practice are frequently used as approximate values. Apart from this, the Brinell hardness values in brackets apply only if the measurement is made with a carbide ball

[1]) See page 1

[2]) Calculated from: HB = 0.95 · HV

Explanations

This Standard has been prepared by Advisory Committee A 2 a "Hardness testing" of the Fachnormenausschuss Materialprüfung (Technical Committee for Materials Testing).

It takes account of engineering developments since the corresponding Preliminary Standard appeared in May 1957. The changes compared with the Preliminary Standard and the essential reasons for these are given below.

The hardness values for scales HRA, HRD, HRF, HR 15 N, HR 30 N, and HR 45 N have been newly adopted. The need for this arose from the standardization of these scales which has taken place in the meantime (DIN 50 103 Part 1 and Part 2). Rockwell hardness scale HRD, which is not standardized in Germany, has been adopted in this successor issue because it also is widely used. The numerical values given for the methods in this Table are in agreement with ASTM E 140-1972. The hardness values for scales HRB and HRC in the Table have also been taken from ASTM E 140-1972. This resulted in only minor differences compared with the previous conversion for HRC (Preliminary Standard DIN 50 150, May 1957 issue), and at the same time provided better agreement with test values in the case of HRD.

It was not possible to include hardness values for scales HR 15 T, HR 30 T and HR 45 T because adequate test results are not yet available. It is intended however to include these in the next revision of this Standard. For this reason, it is requested that any documents providing information on this should be submitted to the Fachnormenausschuss Materialprüfung (Technical Committee for Materials Testing).

The following applies to conversion between Vickers hardness and Brinell hardness:

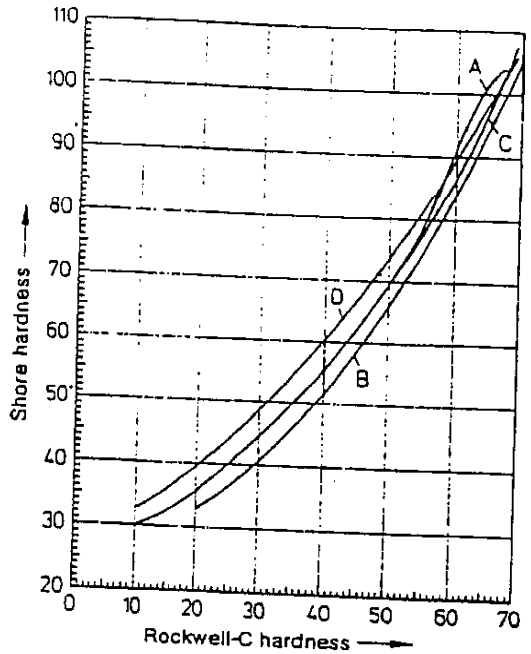
In the Preliminary Standard DIN 50 150, May 1957 issue, the numerical values for HV and HB were identical up to 350. Numerous tests and extensive analyses of hardness measurements on standardized test blocks have however shown that even for very low hardness values systematic differences occur between the results obtained with these two methods. A better representation of the measured values over the whole hardness range however is obtained by the relationship HB = 0.95 · HV. This has resulted in slight differences compared with the Preliminary Standard, particularly in the range below 350.

In accordance with some requests for changes in the corresponding draft standard, the previous practice of having separate conversion tables for converting from one hardness value to another and for conversion between hardness and tensile test values, in which particular hardness test methods were given preference for the conversion between hardness values and tensile test values (in Preliminary Standard DIN 50 150, May 1957 issue: Brinell hardness; in draft standard DIN 50 150, July 1975 issue: Vickers hardness), has been abandoned. In this Standard all the numerical values are collated in one table.

Since even high tensile structural steels are increasingly being tested, the range for tensile strength in the Table has been extended up to 2180 N/mm². The tensile strength values given are based on extensive co-operative tests conducted by VDEh, which were carried out in the lower range up to about 420 HV 10 and on test results by F. Hahn [3], to which the values in the range above 420 HV 10 gradually approximate.

The information on the mean uncertainty of measurement has not been taken over into the successor issue since it does not belong in a conversion standard but in the standard for the testing machines. In the present Standard, there ought properly to have been information on the conversion uncertainty, but at the present time there are still not enough measurement results available. Apart from this, at the present time it seems questionable whether the mean measurement uncertainty can be characterized by simple coefficients independently of the properties of the testing machines used.

As in the Preliminary Standard, May 1957 issue, in this version also no conversion of the rebound hardness (e. g. Shore hardness) has been adopted because no standard has yet been prepared for the rebound hardness. In addition, results obtained with rebound hardness testing machines from different manufacturers cannot readily be compared. Preliminary HRC-Shore hardness conversion curves are given in Figure 2 [4].



A: Model D (only for rolling)
B: Model D
C: Model C
D: Model A and B
} of The Shore Instrumental Comp. New York

of Karl Frank GmbH, Weinheim-Birkenau

Figure 2. HRC-Shore hardness conversion diagram

A corresponding table, limited however to conversion of hardness values, is at the present time recommended in ISO/TC 17.

The table in EURONORM 8-55 corresponds in content to the tables in the now obsolete May 1957 issue of DIN 50 150.

[3] F. Hahn: "Die Prüfung der Festigkeit harter Stähle im Zugversuch" (Testing the strength of hard steels in the tensile test) Thesis, Technical University of Berlin 1968

[4] See also: Schmitz, H., and Schlüter, W., "Versuche zur Vereinheitlichung der Rückprallhärteprüfung" (Tests for standardization of rebound hardness testing) Stahl und Eisen 75 (1955) pp. 411-416.