INTERNATIONAL STANDARD

**ISO 18265**

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# Metallic materials — Conversion of hardness values

*Matériaux métalliques — Conversion des valeurs de dureté*

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# Foreword

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The committee responsible for this document is ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 3, *Hardness testing*.

This second edition cancels and replaces the first edition (ISO 18265:2003) which has been technically revised.

# Introduction

The hardness conversion values given in Table A.1 were obtained in interlaboratory tests by the *Verein Deutscher Eisenhüttenleute* (VDEh) (German Iron and Steel Institute) using verified and calibrated hardness testing machines. Statistically reliable information cannot be given on the uncertainty of these values because the test conditions were not reproducible, and the number of results used to calculate the mean hardness values is not known. The conversion values in this table are in accordance with the information presented in IC No. 3 (1980) and IC No. 4 (1982) of the European Coal and Steel Community, as well as in ISO 4964:1984 and ISO/TR 10108:1989.

Annexes C, D and E contain – in a revised format – the extensive results on the conversion of hardness values presented in TGL 43212/02 to 43212/04, standards published by the former East German standards body, the *Amt für Standardisierung, Meßwesen und Warenprüfung* (ASMW). The values presented in Annex B had also been determined by the ASMW, but were published in a report of the *Physikalisch-Technische Bundesanstalt* (PTB),[1] the German national institute for science and technology, not in a TGL standard.

The converted hardness values in the above-mentioned TGL standards were obtained in statistically reliable hardness and tensile tests. The hardness tests were performed using ASMW normal testing machines on plane-parallel, polished specimens of various materials in different heat treatment conditions. Tensile strength was tested on machines whose force measuring and extension measuring systems had been calibrated immediately before testing. The tensile test method used is equivalent to that specified in ISO 6892-1, and the calibration procedures conform with those specified in ISO 7500-1 and ISO 9513.

Annex G contains the results on the conversion of hardness values of two tool steels with the assistance of the *Verein Deutscher Eisenhüttenleute* (VDEh) which were obtained in the year 2007.

Users of this International Standard should take note of Clause 2, especially the concluding warning.

# Metallic materials — Conversion of hardness values

## 1 Scope

This International Standard specifies the principles of the conversion of hardness values to equivalent values in other hardness scales and to estimates of tensile strength. It gives general information on the use of the conversion tables.

The conversion tables in Annexes A to G apply to

— unalloyed and low alloy steels and cast steel,

— steels for quenching and tempering,

— steels for cold working,

— high speed steels,

— tool steels,

— hardmetals, and

— non-ferrous metals and alloys.

NOTE 1 The conversion tables in Annexes B to G are based on empirical results which were evaluated by means of regression analysis. Such analysis was not possible in the case of the values given in Annex A because a sufficient number of results was not available.

NOTE 2 Annex H gives information about the effects of changes of the test procedure in the standards specifying the hardness tests.

Converted values obtained using this International Standard are only directly applicable to the exact material tested. For all other materials, they provide an indicator only. In all cases, the converted values are not intended as replacements for values obtained by the correct standard method. In particular, tensile strength estimates are the least reliable converted values in this International Standard.

Sections of this International Standard are reprinted, with permission of ASTM International, from ASTM E140 *Standard Hardness Conversion Tables for Metals Relationship among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Harness, Knoop Hardness, and Scleroscope Hardness*.

## 2 Principles of conversion

Hardness testing is a form of materials testing that provides information on the mechanical properties of a material with limited destruction of the specimen and within a relatively short period of time. In practice, it is often desirable to use hardness results to draw conclusions on the tensile strength of the same material if tensile testing is too involved or the piece to be examined is not to be destroyed.

Since the means of loading in hardness testing is considerably different from that in tensile testing, it is not possible to derive a reliable functional relationship between these two characteristic values on the basis of a model. Nevertheless, hardness values and tensile strength values are positively correlated, and so it is possible to draw up empirical relationships for limited applications.

Often it is necessary to check a given hardness value against a value gained by a different test method. This is especially the case if only a certain method can be used due to the particular specimen or coating thickness, the size of the object to be tested, surface quality, or the availability of hardness testing machines.

Conversion of hardness values to tensile values makes it possible to carry out hardness measurement in place of the measurement of tensile strength taking into account that these tensile strength values must be seen as being the least reliable form of conversion. Likewise, with conversion between hardness scales, a hardness value can be replaced with a value obtained using the desired method.

Sometimes a conversion relationship is drawn on a single-case basis to gain information on properties other than hardness, most often to obtain a good estimate of tensile strength. Special relationships are sometimes drawn for hardness-to-hardness conversions. This may be done as long as the following conditions are fulfilled.

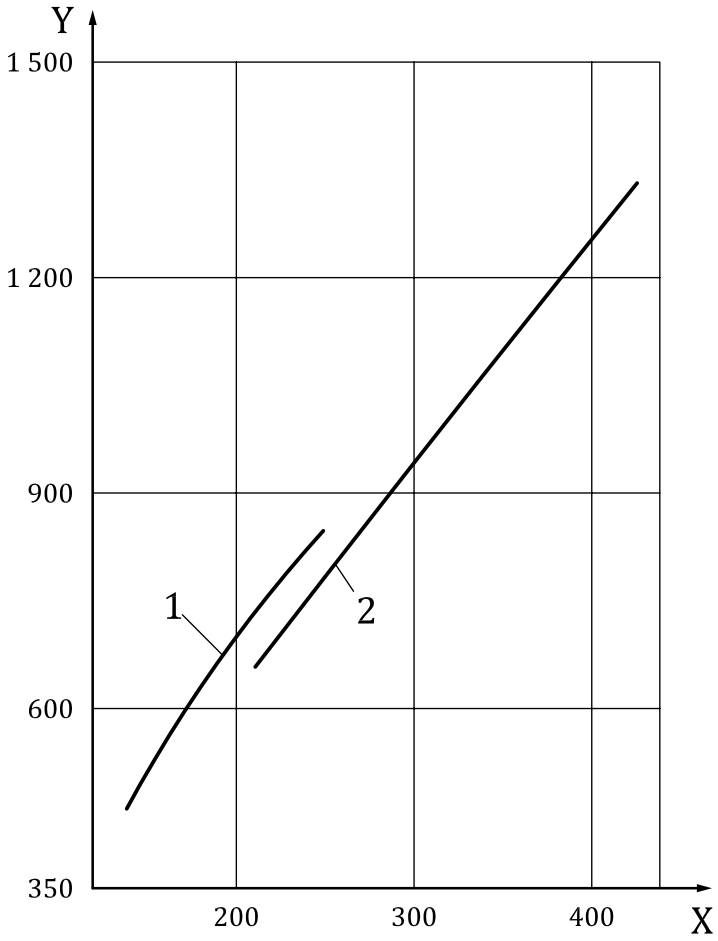
— The hardness test method used is only employed internally, and the results obtained will not be compared with those of other methods, or the details of the test procedure are defined precisely enough so that results can be reproduced by another laboratory or at another time.

— The conversion tables used shall have been derived from a sufficiently large number of parallel experiments using both scales and carried out on the material in question.

— Converted results are to be expressed in such a manner that it is clear which method was used to determine the original hardness value.

However, the conversion values in this International Standard are informative only. A measurement made according to the correct hardness (or tensile) standard for the scale being reported shall always take precedence over a hardness (or strength) value derived from a conversion table within this International Standard. Similarly, a value derived by conversion shall not provide sufficient grounds either for a complaint or for proof of meeting an acceptance criterion.

**WARNING — In practice, an attempt is often made to establish a strong relationship between the original and converted values without taking the characteristics of the material under test into consideration. As Figures 1 and 2 show, this is not possible. Therefore, users of this International Standard should ensure that all conditions for conversion are met (see also References [2] and [3]).**




**Key**

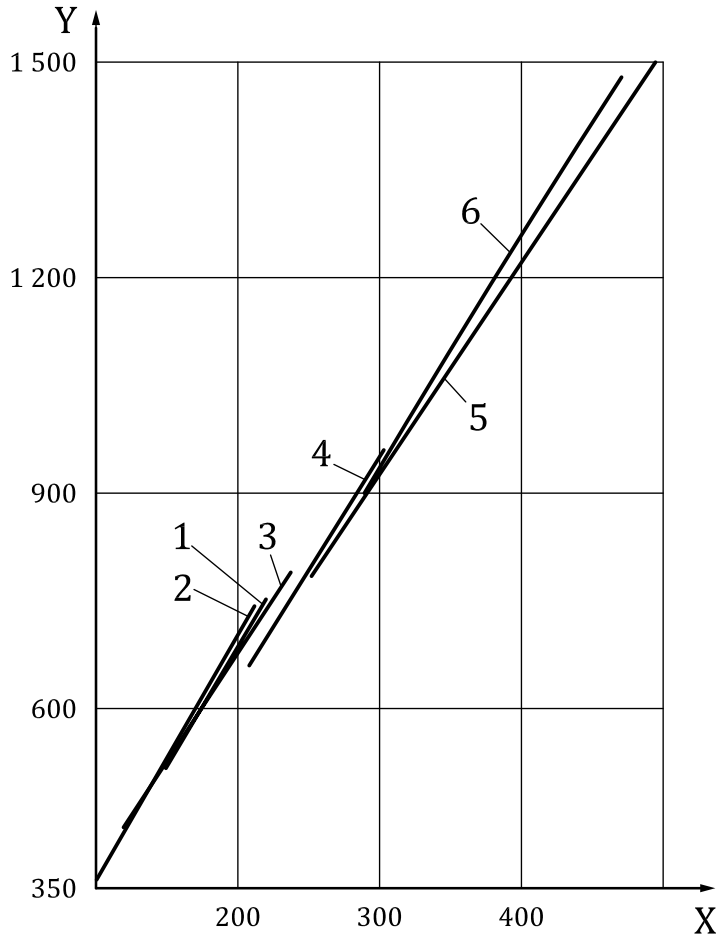
X Hardness HV 30

Y Tensile strength, $R_m$ in MPa

1 untreated, soft annealed, normalized

2 quenched and tempered

**Figure 1 — HV 30/$R_m$ curves for quenching and tempering steels in various heat treatment conditions**




**Key**

| | | | |
|---|---|---|---|
| X | Hardness HV30 | 3 | $R_e/R_m$=0,70 to 0,79 normal annealed |
| Y | Tensile strength, $R_m$ in MPa | 4 | $R_e/R_m$=0,70 to 0,79 heat treated |
| 1 | $R_e/R_m$=0,45 to 0,59 | 5 | $R_e/R_m$=0,80 to 0,89 |
| 2 | $R_e/R_m$=0,60 to 0,69 | 6 | $R_e/R_m$=0,90 to 0,99 |

**Figure 2 — Mean HV 30/$R_m$ curves for quenching and tempering steels with different $R_e/R_m$ ratios**

## 3 Application of conversion tables

### 3.1 General

Conversion from one hardness value to another or from a hardness value to a tensile strength value involves uncertainties which must be taken into account. Extensive investigations have shown that it is not possible to establish universally applicable conversion relationships between hardness values obtained by different methods, no matter how carefully the tests had been carried out. This lies in the fact that there is a complex relationship between the indentation behaviour of a material and its elastic and plastic deformation. For this reason, the given conversion relationship provides greater equivalency the more similarity there is between the elasticity of the tested material and that of the material used to establish the relationship. Likewise, a better equivalency can be expected for methods with similar indentation processes (i.e. where the differences in the force application-indentation procedures and the test parameters is minimal). Therefore, conversion from hardness values to tensile values must be seen as being the least reliable form of conversion.

NOTE In many cases, the yield strength or the 0,2 % proof strength provides information on the elastic behaviour of a material.

Measurement best practice shall be defined by the hardness test adopted.

It should be noted that each hardness determination is only applicable to the immediate area of the indentation. Where hardness varies, e.g. at an increasing distance from the surface, Brinell or Vickers hardness values, or even tensile strength values can deviate from the converted values solely as a result of the different rate of elongation within the area under consideration. Different geometry indentations are affected differently by these effects and so conversions from one hardness scale to another may no longer be consistent even in the same sample.

Hardness values shall only be converted when the prescribed test method cannot be used, for example because a suitable machine is not available, or if the required samples cannot be taken. A suitable test method can be selected with the aid of Figures 3 and 4.

Converted values shall not be used as the basis for proof of compliance (or not) to a specification or contract (any necessary exceptions therefore require specific agreement between the parties concerned).

If hardness or tensile strength values are determined by conversion in accordance with this International Standard, this shall be stated, as shall the hardness test method (ISO 6506-1, ISO 6507-1, ISO 6508-1) used.

The basis of conversion shall be the mean of at least three individual hardness values.

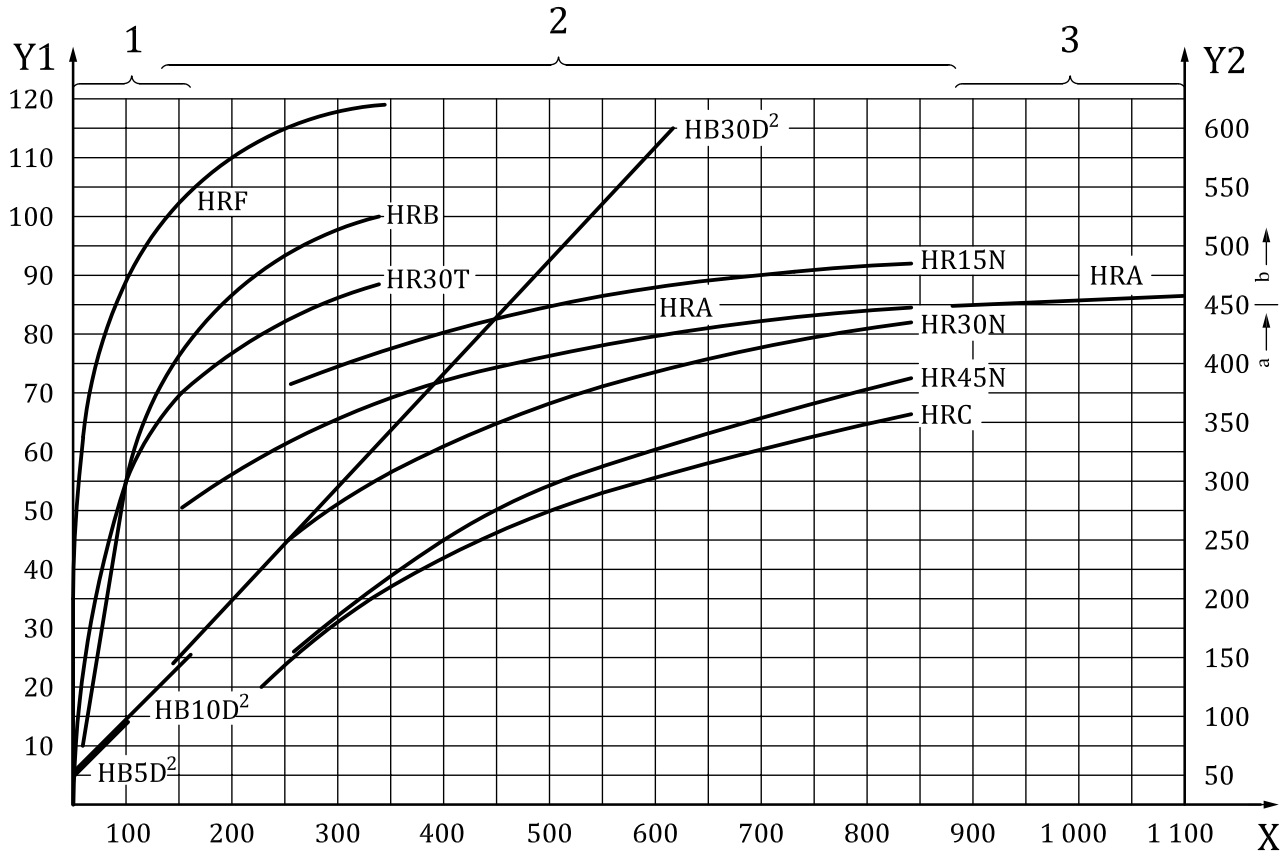
To ensure an acceptable uncertainty of measurement, the specimen surfaces shall be sufficiently smooth; depending on the hardness test method and the test force a suitable method of surface preparation has to be selected, e.g. machine-finishing (for macro hardness) up to polishing (for low-force and micro hardness).

The uncertainties of the values given in the conversion tables here comprise the confidence interval of the hardness conversion curves calculated by means of regression analysis, and the uncertainty of the hardness or tensile strength value to be converted. The confidence interval of the regression function is a parameter that cannot be influenced by the user and is calculated as a function of hardness.

The uncertainty associated with the hardness values to be converted is influenced by the repeatability of the testing machine, the quality of the specimen surface, the uniformity of the specimen's hardness, and the number of indentations used to determine hardness. It is thus dependent on the test conditions of the person doing the conversion. This conversion is to be carried out on the basis of the tables given in this International Standard for various groups of materials. These tables give hardness values for various scales and, in some cases, the relevant tensile strength.

When only comparing the values in these tables without actually carrying out hardness testing, the uncertainty of the converted value is reduced to the confidence interval of the calculated hardness conversion curve. When using the tables, it is not significant which value is taken as the measured value and which as the converted one.

The determination of the uncertainty of converted values, as well as the specification of a permissible level of uncertainty may be agreed, in which case the converted values are to be established on the basis of the mean of five individual values.



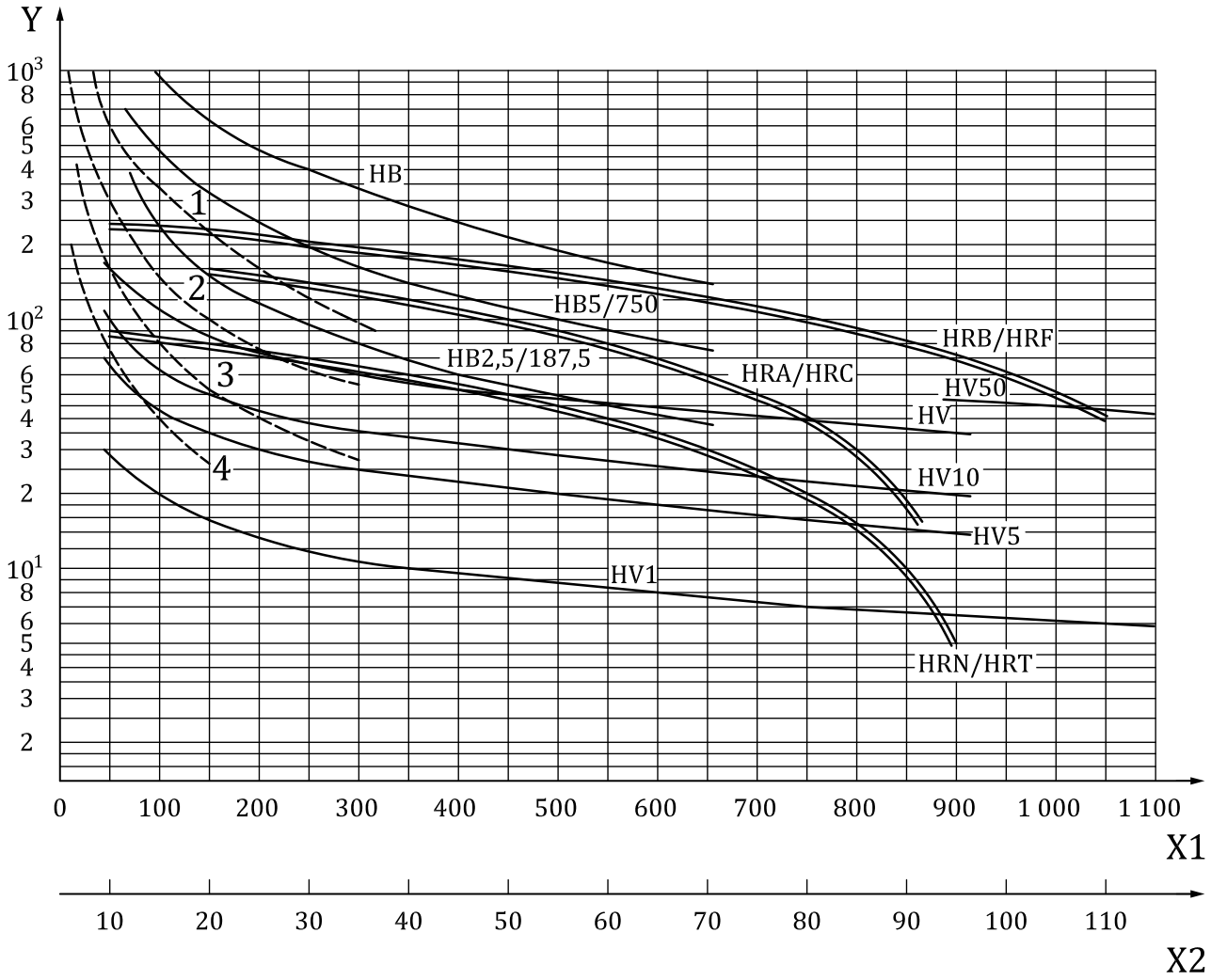

**Key**

| | | | |
|---|---|---|---|
| X | Vickers hardness HV30 | 1 | non-ferrous metal |
| $Y_1$ | Rockwell hardness | 2 | steel |
| $Y_2$ | Brinell hardness | 3 | hardmetal |
| a | Brinell hardness, determined with steel ball (HBS) | | |
| b | Brinell hardness, determined with hardmetal ball (HBW) | | |

This figure is intended only as an aid in selecting an alternative test method and is not to be used for conversion purposes.

NOTE The designation "HB5D$^2$" corresponds to the force-diameter ratio according to ISO 6506-1.

**Figure 3 — Various hardness scales compared to the Vickers scale**




**Key**

| | | | |
|---|---|---|---|
| $X_1$ | Brinell hardness HB/ Vickers hardness HV | 1 | HB10/1 000 |
| $X_2$ | Rockwell hardness, HR according to its different scales | 2 | HB10/500 and HB 5/250 |
| Y | Indentation, depth, µm | 3 | HB5/125 and HB 2,5/62,5 |
| | | 4 | HB2,5/62,5 |

**Figure 4 — Indentation depth as a function of hardness for various test methods**

## 3.2 Converting values

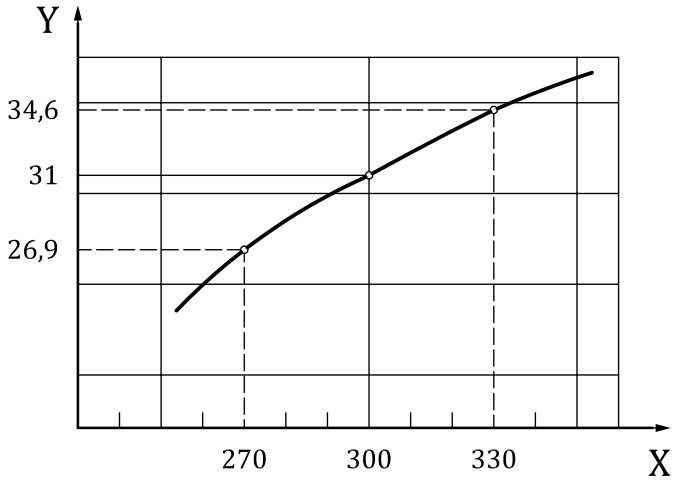
### 3.2.1 Limits of error

Depending on the measurement conditions in practice, measured value/converted value pairs (e.g. HV/HRC, HRC/HV, HRA/HRN, HB/$R_m$) can be taken from the tables in Annexes A to G. Essential criteria which should be taken into account when selecting a hardness test method are discussed in this clause.

The example below illustrates the conversion of values together with their limits of error using Table C.2.

| | |
|---|---|
| Given hardness value: | (300 ± 30) HV |
| Desired scale: | HRC |
| Converted values from table: | 270 HV ≙ 26,9 HRC |
| | 300 HV ≙ 31,0 HRC |
| | 330 HV ≙ 34,6 HRC |

The converted value, $31\,^{+3,6}_{-4,1}$ HRC, for the nominal value 300 HV no longer represents the mean of the upper and lower limits in HRC because of the nonlinear relationship between HV and HRC values (see Figure 5). The confidence interval of the hardness conversion curve may be disregarded for such estimations.




**Key**

X HV 30

Y HRC

**Figure 5 — Shift of the nominal value when converting hardness values**

### 3.2.2 Uncertainty

The uncertainty of a converted value should be taken from the curves associated with the conversion table used, as shown in the figures in Annexes B to E for various types of material.

The families of curves given in the annexes represent the uncertainty, $u$, for a probability level of 95 % as a function of the hardness value $\bar{H}_K$ for various reproducibility limits, $R$. ($\bar{H}_K$ is the corrected arithmetic mean of five individual values.) The curves have been arranged so that interpolation between neighboring curves is possible. The reproducibility, $R$, is to be calculated on the basis of five measurements as shown in 3.4.2 for various hardness test methods.

The uncertainty curves only take account of the effects of the random errors of the measured value on the converted value. However, they do not take account of the systematic error of the testing machine used, as this can lead to exceedingly high errors in the converted result, even if the systematic error lies within the permissible range specified for the machine; this is explained in 3.4. For this reason, hardness testing machines are to be verified, using calibrated blocks, at least within the time interval specified in the relevant standards. The systematic error determined in this manner is to be compensated by correcting the measured mean hardness value. This is especially important in the case of Rockwell

hardness testing. Figure 6 illustrates the determination of the uncertainty, $u$, of a converted hardness value (dashed line) according to the example below.

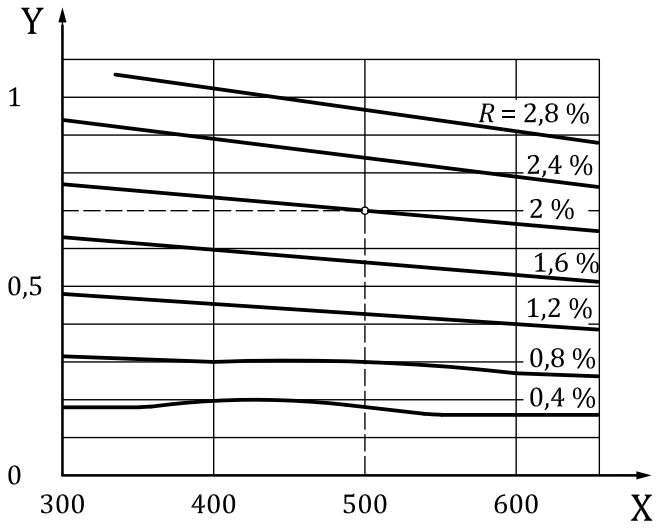
EXAMPLE

— Measured, corrected mean hardness $\bar{H}_K$ 500 HV

— Converted value as in Annex C 49,5 HRC

— Calculated reproducibility limit, $R$ 2,0 %

— Uncertainty of converted value, $u$ ± 0,7 HRC




**Key**

X $\bar{H}_K$ in HV 30

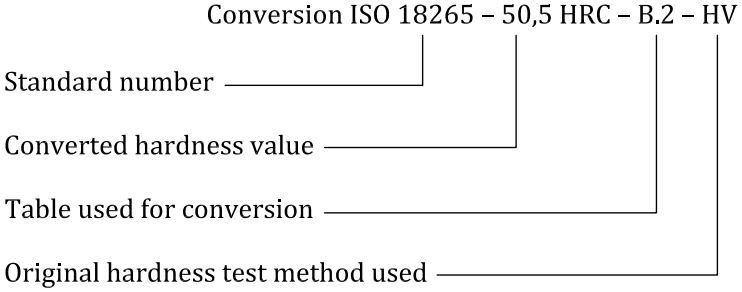
Y $u$ in HRC

**Figure 6 — Determining uncertainty of a converted hardness value (example)**

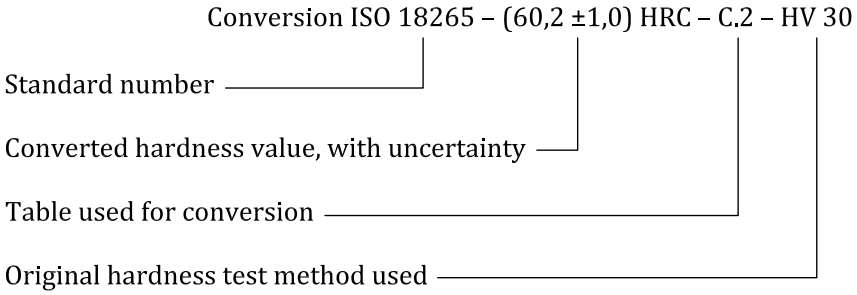
## 3.3 Designation of conversion results

Conversion results shall be reported in a manner that clearly indicates which method was used to determine the original hardness value. In addition, the relevant annex to this International Standard or the table used shall be given.

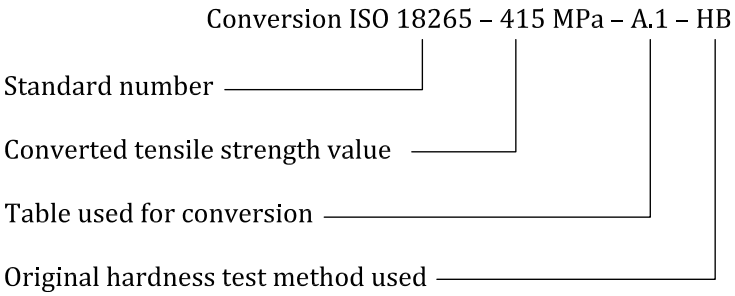
EXAMPLE 1



EXAMPLE 2 If it is agreed that the uncertainty of the converted value is to be given, this is included in the result as follows:




EXAMPLE 3 Conversions into tensile strength values are expressed as follows:




## 3.4 Notes on use of conversion tables

### 3.4.1 Selection of alternative hardness test methods

**3.4.1.1** In Figure 3, hardness scales for non-ferrous metals, hardmetals and selected steels are compared. The relationship of each scale to the Vickers scale is illustrated, and by comparison with Rockwell and Brinell scales (y-axes), information is gained as to the hardness ranges covered by each method. This figure is intended solely as an aid to selection and is not to be used for conversion purposes.

**3.4.1.2** Figure 4 shows indentation depths as a function of hardness for various test methods. This should facilitate selection of a suitable test method on the basis of specimen or coating thickness.

**3.4.1.3** Another criterion for selecting an alternative hardness test method is the uncertainty of the conversion results. Since this can vary greatly, the uncertainty curves given in this International Standard should also be used to determine which combination of methods is optimal for the application in question.

### 3.4.2 Calculating the reproducibility limit, *R*

The reproducibility limit, *R*, expressed as a percentage, is to be calculated for the different hardness test methods as shown in Equations (1) to (3).

For HRB and HRF testing:

$$R = \frac{H_{\max} - H_{\min}}{130 - \bar{H}} \times 100 \quad (1)$$

For HRC, HRA, HRD, HRN and HRT testing:

$$R = \frac{H_{\max} - H_{\min}}{100 - \bar{H}} \times 100 \quad (2)$$

where

$H_{\max}$, $H_{\min}$ are the highest and lowest measured hardness values;

$\bar{H}$ is the mean of measured hardness values.

For HV, Vickers microhardness, and HB testing:

$$R = \frac{d_{\max} - d_{\min}}{\bar{d}} \times 100 \quad (3)$$

where

$d_{\max}$, $d_{\min}$ are the largest and smallest measured indentation diagonals (Vickers) or the largest and smallest diameters (Brinell);

$\bar{d}$ is the mean of measured diagonals or diameters.

### 3.4.3 Effect of the systematic error

The effect of systematic errors of hardness values on conversion results is illustrated in the following example.

EXAMPLE According to Table E.2, a hardness value of 87,8 HRA corresponds to a converted value of 1 180 HV 50. In this hardness range, the limits of error of the testing machines (see ISO 6508-2 and ISO 6507-2) are ±1,5 HRA and ±23,6 HV 50, respectively (i.e. ±2 % of the hardness value). A systematic error of a Rockwell testing machine of +1,4 HRA lies within the permissible limits of error, although this still would lead to a deviation of 130 HV 50 for the converted value if no correction is made before conversion. Deviations of this magnitude occur particularly when converting from Rockwell to Vickers or Brinell values.

# Annex A
(informative)

# Conversion table for unalloyed, low alloy steels and cast steel

**WARNING — Hardness conversions are no substitute for direct measurements. These tables should be used with caution and only in accordance with the principles of conversions, see Clause 2.**

The values in this table are considered to be estimates for indication only. The hardness values lie outside the defined conditions of the relevant hardness test standard. The tensile strength values were not obtained under reproducible conditions and it is now impossible to determine the uncertainty of the data.

## A.1 Hardness-to-hardness conversion

When considering the confidence level of converted hardness values, the uncertainty of the hardness test method as well as the width of the conversion scatterband must be taken into account, as shown in Figure A.1. Curve $a$ characterizes the mean conversion relationship upon which the values given in this Annex are based. Curves $b_1$ and $b_2$ delineate the areas on either side of $a$ which take into consideration the different elasticities of the steels tested. In an ideal conversion, the hardness value $x_0$ becomes $y_0$. Taking account of the scatterband between $b_1$ and $b_2$, practically every hardness value between $y_{01}$ and $y_{02}$ is obtainable. It should be borne in mind that, because the hardness value $x_0$ is associated with the uncertainty of the relevant test method, the actual hardness can fluctuate between $x_1$ and $x_2$ and thus the converted value will lie between $y_{11}$ and $y_{22}$.

NOTE In the interlaboratory tests carried out by the VDEh (see the Introduction), the evaluation of about 700 results for the conversion between HV10 values and HB values produced (graphically depicted) scatterband widths of ±24 HV10 and ±23 HB, respectively. Regression analysis was not performed.

## A.2 Hardness-to-tensile-strength conversion

While hardness-to-hardness conversion involves considerable scatter and systematic errors, conversion of hardness to tensile strength values produces even greater scattering. One reason for this is that a great uncertainty can be affected by microstructural changes (e.g. resulting from heat treatment or cold working) within even the same type of steel.

The tensile strength values given in Table A.1 are therefore only approximate values which cannot take the place of the results of tensile testing.

NOTE 1 In the interlaboratory tests carried out by the VDEh (see Introduction), the evaluation of about 700 results for the conversion from HV10 values to tensile strength values produced (graphically depicted) scatterband widths of ± 25 HV10 and ± 85 N/mm$^2$, respectively. It was also shown that systematic deviations from the mean were possible for particular steel groups. For instance, for pearlitic steels within the hardness range of 300 HV10 to 500 HV10, it was found that the converted tensile values were, on the average, about 100 MPa higher than those listed in Table A.1. Regression analysis was not performed.

NOTE 2 Since high-strength structural steels are now being tested at an increasing rate, the tensile strengths in Table A.1 were extended up to 2 180 MPa. The tensile strength values in this table are based on results of extensive interlaboratory tests by the VDEh in the hardness range up to about 420 HV10, and on the results from Reference [4] which are gradually approached by the values in the range above 420 HV10.

**Table A.1 — Conversion of hardness-to-hardness or hardness-to-tensile-strength values for unalloyed and low alloy steels and cast steel**

碳钢、低合金钢和铸钢的硬度-硬度、硬度-抗拉强度换算值

| Tensile strength | Vickers hardness | Brinell hardness | Rockwell hardness | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| MPa | HV10 | HB [a] | HRB | HRF | HRC | HRA | HRD | HR15N | HR30N | HR45N |
| 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 | | | | | | | |

[a] Brinell hardness values up to 450 HB were determined using a steel ball indenter, those above this value were determined with a hardmetal ball.

NOTE 1 Values in parentheses are those lying outside the defined range of the standard test method but which may used as estimates.

NOTE 2 The value of the tension test are not based on method A (10.3 Testing rate based on close-loop control at the rate of the extension) in ISO 6892-1:2009

**Table A.1** *(continued)*

| Tensile strength | Vickers hardness | Brinell hardness | Rockwell hardness | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| MPa | HV10 | HB [a] | HRB | HRF | HRC | HRA | HRD | HR15N | HR30N | HR45N |
| 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 |
| 1 030 | 320 | 304 | | | 32,2 | 66,4 | 49,4 | 76,2 | 52,3 | 33,9 |
| 1 060 | 330 | 314 | | | 33,3 | 67,0 | 50,2 | 76,8 | 53,6 | 35,2 |
| 1 095 | 340 | 323 | | | 34,4 | 67,6 | 51,1 | 77,4 | 54,4 | 36,5 |
| 1 125 | 350 | 333 | | | 35,5 | 68,1 | 51,9 | 78,0 | 55,4 | 37,8 |
| 1 155 | 360 | 342 | | | 36,6 | 68,7 | 52,8 | 78,6 | 56,4 | 39,1 |
| 1 190 | 370 | 352 | | | 37,7 | 69,2 | 53,6 | 79,2 | 57,4 | 40,4 |
| 1 220 | 380 | 361 | | | 38,8 | 69,8 | 54,4 | 79,8 | 58,4 | 41,7 |
| 1 255 | 390 | 371 | | | 39,8 | 70,3 | 55,3 | 80,3 | 59,3 | 42,9 |
| 1 290 | 400 | 380 | | | 40,8 | 70,8 | 56,0 | 80,8 | 60,2 | 44,1 |
| 1 320 | 410 | 390 | | | 41,8 | 71,4 | 56,8 | 81,4 | 61,1 | 45,3 |
| 1 350 | 420 | 399 | | | 42,7 | 71,8 | 57,5 | 81,8 | 61,9 | 46,4 |
| 1 385 | 430 | 409 | | | 43,6 | 72,3 | 58,2 | 82,3 | 62,7 | 47,4 |
| 1 420 | 440 | 418 | | | 44,5 | 72,8 | 58,8 | 82,8 | 63,5 | 48,4 |
| 1 455 | 450 | 428 | | | 45,3 | 73,3 | 59,4 | 83,2 | 64,3 | 49,4 |

[a] Brinell hardness values up to 450 HB were determined using a steel ball indenter, those above this value were determined with a hardmetal ball.

NOTE 1 Values in parentheses are those lying outside the defined range of the standard test method but which may used as estimates.

NOTE 2 The value of the tension test are not based on method A (10.3 Testing rate based on close-loop control at the rate of the extension) in ISO 6892-1:2009

**Table A.1** *(continued)*

| Tensile strength | Vickers hardness | Brinell hardness | Rockwell hardness | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| MPa | HV10 | HB [a] | HRB | HRF | HRC | HRA | HRD | HR15N | HR30N | HR45N |
| 1 485 | 460 | 437 | | | 46,1 | 73,6 | 60,1 | 83,6 | 64,9 | 50,4 |
| 1 520 | 470 | 447 | | | 46,9 | 74,1 | 60,7 | 83,9 | 65,7 | 51,3 |
| 1 555 | 480 | 456 | | | 47,7 | 74,5 | 61,3 | 84,3 | 66,4 | 52,2 |
| 1 595 | 490 | 466 | | | 48,4 | 74,9 | 61,6 | 84,7 | 67,1 | 53,1 |
| 1 630 | 500 | 475 | | | 49,1 | 75,3 | 62,2 | 85,0 | 67,7 | 53,9 |
| 1 665 | 510 | 485 | | | 49,8 | 75,7 | 62,9 | 85,4 | 68,3 | 54,7 |
| 1 700 | 520 | 494 | | | 50,5 | 76,1 | 63,5 | 85,7 | 69,0 | 55,6 |
| 1 740 | 530 | 504 | | | 51,1 | 76,4 | 63,9 | 86,0 | 69,5 | 56,2 |
| 1 775 | 540 | 513 | | | 51,7 | 76,7 | 64,4 | 86,3 | 70,0 | 57,0 |
| 1 810 | 550 | 523 | | | 52,3 | 77,0 | 64,8 | 86,6 | 70,5 | 57,8 |
| 1 845 | 560 | 532 | | | 53,0 | 77,4 | 65,4 | 86,9 | 71,2 | 58,6 |
| 1 880 | 570 | 542 | | | 53,6 | 77,8 | 65,8 | 87,2 | 71,7 | 59,3 |
| 1 920 | 580 | 551 | | | 54,1 | 78,0 | 66,2 | 87,5 | 72,1 | 59,9 |
| 1 955 | 590 | 561 | | | 54,7 | 78,4 | 66,7 | 87,8 | 72,7 | 60,5 |
| 1 995 | 600 | 570 | | | 55,2 | 78,6 | 67,0 | 88,0 | 73,2 | 61,2 |
| 2 030 | 610 | 580 | | | 55,7 | 78,9 | 67,5 | 88,2 | 73,7 | 61,7 |
| 2 070 | 620 | 589 | | | 56,3 | 79,2 | 67,9 | 88,5 | 74,2 | 62,4 |
| 2 105 | 630 | 599 | | | 56,8 | 79,5 | 68,3 | 88,8 | 74,6 | 63,0 |
| 2 145 | 640 | 608 | | | 57,3 | 79,8 | 68,7 | 89,0 | 75,1 | 63,5 |
| 2 180 | 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 |

[a] Brinell hardness values up to 450 HB were determined using a steel ball indenter, those above this value were determined with a hardmetal ball.

NOTE 1 Values in parentheses are those lying outside the defined range of the standard test method but which may used as estimates.

NOTE 2 The value of the tension test are not based on method A (10.3 Testing rate based on close-loop control at the rate of the extension) in ISO 6892-1:2009

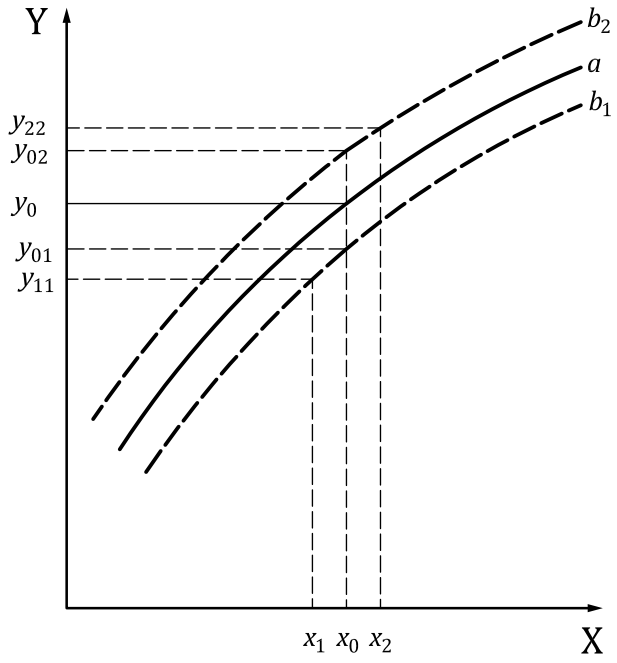
**Table A.1** *(continued)*

| Tensile strength | Vickers hardness | Brinell hardness | Rockwell hardness | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| MPa | HV10 | HB [a] | HRB | HRF | HRC | HRA | HRD | HR15N | HR30N | HR45N |
| | 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 |

[a] Brinell hardness values up to 450 HB were determined using a steel ball indenter, those above this value were determined with a hardmetal ball.

NOTE 1 Values in parentheses are those lying outside the defined range of the standard test method but which may used as estimates.

NOTE 2 The value of the tension test are not based on method A (10.3 Testing rate based on close-loop control at the rate of the extension) in ISO 6892-1:2009




**Key**

X determined hardness value

Y converted value

**CAUTION — There may be very large scatter bands in the conversions of different kinds of cast steel.**

**Figure A.1 — Scatter band for hardness-to-hardness conversion (schematic)**

# Annex B
(informative)

# Conversion tables for steels for quenching and tempering

**WARNING — Hardness conversions are no substitute for direct measurements. These tables should be used with caution and only in accordance with the principles of conversions, see Clause 2.**

The values and curves presented in this Annex are based on a report of the *Physikalisch-Technische Bundesanstalt* (PTB),[1] the German national institute for science and technology, and are reproduced with their permission (see also the Introduction for further information).

The values in these conversion tables are based on the results of testing carried out on steels as in TGL 6547 that have been quenched and tempered. The steel grades that were tested are listed in Table B.1, which also provides an overview of the former designations used in the TGL standard along with the corresponding designations as in EN 10083-1. Tables B.2 to B.4 give conversion values for the steels in various heat treatment conditions, while Tables B.5 to B.7 give an overview of the uncertainty curves presented in Figures B.1 to B.68 which are to be used in conjunction with the conversion tables.

NOTE A useful reference book is [24]. It provides information for the comparison of different national and international steel designations with regard to their compositions.

**Table B.1 — Quenching and tempering steels tested**

| Steel grade (as in TGL 6547) | Steel grade (as in EN 10083-1) | |
|---|---|---|
| | Material no. | Name |
| C25 | 1.1158 | C25E |
| C35 | 1.1180 | C35R |
| CK45 | 1.1191 | C45E |
| CK55[a] | 1.1203 | C55E |
| C60 | 1.1223 | C60R |
| CK67 [b] | [c] | [c] |
| 24CrMoV5.5 [a] | [c] | [c] |
| 30CrMoV9 | 1.7707 | 30CrMoV9 [d] |
| 30Mn5 | 1.1165 | 30Mn5 [d] |
| 34Cr4 | 1.7033 | 34Cr4 |
| 37MnSi5 | 1.5122 | 37MnSi5 [d] |
| 38CrSi6 | 1.7038 | 37CrS4 |
| 40Cr4 | 1.7035 | 41Cr4 |
| 42CrMo4 | 1.7225 | 42CrMo4 |
| 42MnV7 | 1.5223 | 42MnV7 [d] |
| 50CrV4 | 1.8159 | 51CrV4 |
| 50MnSi4 | 1.5131 | 50MnSi4 [d] |
| 60CrMo4 [a] | 1.7228 | 50CrMo4 |

[a] Not included in TGL 6547.

[b] As in TGL 7975.

[c] Not included in EN 10083-1 and in DIN 17200.

[d] According to DIN 17200:1987-03 (withdrawn, replaced by EN 10083-1) but not included in EN 10083-1.

**Table B.2 — Conversion of hardness-to-hardness and hardness-to-tensile-strength values for quenching and tempering steels in the quenched tempered conditions**

调质钢（调质状态）的硬度-硬度、硬度-抗拉强度换算值

| HV | HBW | HRC | HRA | HR45N | HR30N | HR15N | HRB | HRF | HR45T | HR30T | HR15T | $R_m$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 210 | 205 | 15,3 | 57,2 | 13,4 | 36,1 | 65,2 | 94,8 | 110,4 | 65,4 | 76,8 | 89,2 | 651 |
| 220 | 215 | 17,4 | 58,4 | 15,9 | 38,1 | 66,5 | 96,7 | 111,4 | 67,6 | 78,5 | 90,0 | 683 |
| 230 | 225 | 19,3 | 59,6 | 18,2 | 40,4 | 67,8 | 98,4 | 112,4 | 69,6 | 80,0 | 90,8 | 716 |
| 240 | 235 | 21,2 | 60,6 | 20,4 | 41,8 | 68,9 | 100,0 | 113,3 | 71,4 | 81,4 | 91,4 | 748 |
| 250 | 245 | 22,9 | 61,6 | 22,5 | 43,4 | 70,0 | 101,4 | 114,1 | 73,0 | 82,5 | 92,0 | 781 |
| | | | | | | | | | | | | |
| 260 | 255 | 24,6 | 62,5 | 24,4 | 45,0 | 71,0 | 102,7 | 114,9 | 74,4 | 83,6 | 92,5 | 813 |
| 270 | 266 | 26,2 | 63,4 | 26,3 | 46,5 | 72,0 | 103,9 | 115,6 | 75,7 | 84,5 | 90,0 | 845 |
| 280 | 276 | 27,7 | 64,3 | 28,1 | 47,9 | 72,9 | 105,0 | 116,2 | 76,9 | 85,4 | 90,8 | 877 |
| 290 | 286 | 29,1 | 65,0 | 29,8 | 49,3 | 73,7 | 106,0 | 116,8 | 77,9 | 86,1 | 91,4 | 909 |
| 300 | 296 | 30,5 | 65,8 | 31,4 | 50,5 | 74,5 | 106,9 | 117,3 | 78,9 | 86,8 | 92,0 | 940 |
| | | | | | | | | | | | | |
| 310 | 306 | 31,8 | 66,5 | 32,9 | 51,8 | 75,3 | 107,7 | 117,8 | 79,7 | 87,4 | 94,3 | 972 |
| 320 | 316 | 33,1 | 67,2 | 34,4 | 52,9 | 76,0 | 108,5 | 118,3 | 80,5 | 88,0 | 94,6 | 1 003 |
| 330 | 326 | 34,3 | 67,8 | 35,8 | 54,0 | 76,7 | 109,2 | 118,8 | 81,2 | 88,4 | 94,8 | 1 035 |
| 340 | 336 | 35,4 | 68,5 | 37,2 | 55,1 | 77,3 | 109,9 | 119,2 | 81,9 | 88,9 | 95,0 | 1 070 |
| 350 | 345 | 36,5 | 69,1 | 38,4 | 56,1 | 78,0 | 110,5 | 119,6 | 82,5 | 89,3 | 95,2 | 1 097 |
| | | | | | | | | | | | | |
| 360 | 355 | 37,6 | 69,6 | 39,7 | 57,1 | 78,6 | 111,1 | 119,9 | 83,0 | 89,6 | 95,4 | 1 128 |
| 370 | 365 | 38,6 | 70,2 | 40,9 | 58,0 | 79,1 | 111,7 | 120,3 | 83,5 | 89,9 | 95,5 | 1 159 |
| 380 | 375 | 39,6 | 70,7 | 42,0 | 58,9 | 79,7 | 112,2 | 120,6 | 84,0 | 90,2 | 95,6 | 1 189 |
| 390 | 385 | 40,6 | 71,2 | 43,2 | 59,8 | 80,2 | 112,7 | 120,9 | 84,4 | 90,5 | 95,7 | 1 220 |
| 400 | 395 | 41,5 | 71,7 | 44,2 | 60,6 | 80,7 | 113,1 | 121,2 | 84,8 | 90,7 | 95,8 | 1 250 |
| | | | | | | | | | | | | |
| 410 | 405 | 42,4 | 72,2 | 45,3 | 61,4 | 81,2 | 113,6 | 121,5 | 85,1 | 90,9 | 95,9 | 1 281 |
| 420 | 414 | 43,2 | 72,6 | 46,3 | 62,2 | 81,6 | | | | | | 1 311 |
| 430 | 424 | 44,1 | 73,0 | 47,2 | 63,0 | 82,1 | | | | | | 1 341 |
| 440 | 434 | 44,9 | 73,5 | 48,2 | 63,7 | 82,5 | | | | | | 1 371 |
| 450 | 444 | 45,7 | 73,9 | 49,1 | 64,4 | 82,9 | | | | | | 1 401 |
| | | | | | | | | | | | | |
| 460 | 453 | 46,4 | 74,3 | 50,0 | 65,1 | 83,3 | | | | | | 1 430 |
| 470 | 463 | 47,2 | 74,6 | 50,8 | 65,8 | 83,7 | | | | | | 1 460 |
| 480 | 473 | 47,9 | 75,0 | 51,7 | 66,4 | 84,1 | | | | | | |
| 490 | 482 | 48,6 | 75,4 | 52,5 | 67,0 | 84,4 | | | | | | |
| 500 | 492 | 49,2 | 75,7 | 53,2 | 67,6 | 84,8 | | | | | | |
| | | | | | | | | | | | | |
| 510 | 501 | 49,9 | 76,0 | 54,0 | 68,2 | 85,1 | | | | | | |
| 520 | 511 | 50,5 | 76,4 | 54,8 | 68,8 | 85,4 | | | | | | |

NOTE 1 The values of the tension tests are <u>not</u> based on method A (10.3 Testing rate based on close-loop control at the rate of the extension) in ISO 6892-1:2009.

NOTE 2 If only HV is given without a number, then most probably HV30 is meant.

**Table B.2** *(continued)*

| HV | HBW | HRC | HRA | HR45N | HR30N | HR15N | HRB | HRF | HR45T | HR30T | HR15T | $R_m$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 530 | 520 | 51,2 | 76,7 | 55,5 | 69,3 | 85,8 | | | | | | |
| 540 | 530 | 51,8 | 77,0 | 56,2 | 69,9 | 86,1 | | | | | | |
| 550 | 539 | 52,4 | 77,3 | 56,8 | 70,4 | 86,4 | | | | | | |
| | | | | | | | | | | | | |
| 560 | 549 | 52,9 | 77,6 | 57,5 | 70,9 | 86,6 | | | | | | |
| 570 | 558 | 53,5 | 77,9 | 58,2 | 71,4 | 86,9 | | | | | | |
| 580 | 568 | 54,0 | 78,2 | 58,8 | 71,9 | 87,2 | | | | | | |
| 590 | 577 | 54,6 | 78,4 | 59,4 | 72,4 | 87,5 | | | | | | |
| 600 | 586 | 55,1 | 78,7 | 60,0 | 72,8 | 87,7 | | | | | | |
| 610 | 596 | 55,6 | 78,9 | 60,6 | 73,3 | 88,0 | | | | | | |
| 620 | 605 | 56,1 | 79,2 | 61,2 | 73,7 | 88,2 | | | | | | |
| 630 | 614 | 56,6 | 79,4 | 61,7 | 74,2 | 88,5 | | | | | | |
| 640 | 623 | 57,1 | 79,7 | 62,3 | 74,6 | 88,7 | | | | | | |
| 650 | 632 | 57,5 | 79,9 | 62,8 | 75,0 | 88,9 | | | | | | |

NOTE 1 The values of the tension tests are not based on method A (10.3 Testing rate based on close-loop control at the rate of the extension) in ISO 6892-1:2009.

NOTE 2 If only HV is given without a number, then most probably HV30 is meant.

**Table B.3 — Conversion of hardness-to-hardness or hardness-to-tensile-strength values for quenching and tempering steels in the untreated, soft annealed or normalized conditions**

调质钢（未处理、退火或正火状态）的硬度-硬度、硬度-抗拉强度换算值

| HV | HBW | HRC | HRA | HR45N | HR30N | HR15N | HRB | HRF | HR45T | HR30T | HR15T | $R_m$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 140 | | | | | | | | | | | | 460 |
| 150 | 152 | – | 48,4 | – | 21,5 | 56,6 | 81,0 | 102,5 | 51,6 | 68,4 | 85,1 | 503 |
| 160 | 162 | 1,0 | 50,2 | – | 24,4 | 58,3 | 83,9 | 104,1 | 54,8 | 70,5 | 86,2 | 544 |
| 170 | 173 | 4,0 | 51,9 | 0,8 | 27,1 | 60,0 | 86,6 | 105,6 | 57,7 | 72,4 | 87,2 | 585 |
| 180 | 183 | 6,8 | 53,4 | 4,0 | 29,5 | 61,5 | 89,0 | 106,9 | 60,2 | 74,1 | 88,0 | 624 |
| 190 | 193 | 9,4 | 54,8 | 7,0 | 31,8 | 62,9 | 91,2 | 108,1 | 62,5 | 75,6 | 88,8 | 661 |
| | | | | | | | | | | | | |
| 200 | 203 | 11,9 | 56,2 | 9,9 | 34,0 | 64,3 | 93,2 | 109,2 | 64,6 | 77,0 | 89,4 | 697 |
| 210 | 214 | 14,2 | 57,4 | 12,6 | 36,1 | 65,6 | 95,0 | 110,3 | 66,4 | 78,3 | 90,0 | 732 |
| 220 | 223 | 16,4 | 58,6 | 15,1 | 38,1 | 66,8 | 96,7 | 111,2 | 68,2 | 79,5 | 90,6 | 765 |
| 230 | 233 | 18,5 | 59,7 | 17,6 | 39,9 | 67,9 | 98,3 | 112,2 | 69,7 | 80,6 | 91,1 | 796 |
| 240 | 243 | 20,5 | 60,7 | 19,9 | 41,7 | 69,0 | 99,8 | 113,0 | 71,2 | 81,6 | 91,6 | 826 |
| | | | | | | | | | | | | |
| 250 | 252 | 22,4 | 61,7 | 22,1 | 43,3 | 70,0 | 101,2 | 113,8 | 72,5 | 82,6 | 92,0 | |
| 260 | 262 | 24,3 | 62,6 | 24,1 | 44,9 | 71,0 | 102,5 | 114,6 | 73,7 | 83,5 | 92,4 | |
| 270 | 271 | 26,0 | 63,5 | 26,2 | 46,4 | 72,0 | 103,7 | 115,3 | 74,9 | 84,3 | 92,7 | |
| 280 | 280 | 27,7 | 64,3 | 28,1 | 47,9 | 72,9 | 104,9 | 116,0 | 75,9 | 85,1 | 93,0 | |
| 290 | 289 | 29,2 | 65,1 | 29,9 | 49,2 | 73,7 | 106,0 | 116,6 | 76,9 | 85,8 | 93,3 | |
| | | | | | | | | | | | | |
| 300 | 298 | 30,8 | 65,8 | 31,6 | 50,6 | 74,6 | 107,0 | 117,2 | 77,9 | 86,5 | 93,6 | |
| 310 | 307 | 32,2 | 66,6 | 33,6 | 51,8 | 75,4 | 108,0 | 117,8 | 78,8 | 87,1 | 93,9 | |
| 320 | 316 | 33,6 | 67,2 | 35,0 | 53,0 | 76,1 | 108,9 | 118,4 | 79,6 | 87,8 | 94,1 | |

NOTE 1 The values of the tension tests are not based on method A (10.3 Testing rate based on close-loop control at the rate of the extension) in ISO 6892-1:2009.

NOTE 2 If only HV is given without a number, then most probably HV30 is meant.

**Table B.4 — Conversion of hardness-to-hardness values for quenching and tempering steels in the quenched condition**

调质钢（淬火状态）的硬度-硬度换算值

| HV | HBW | HRC | HRA | HR45N | HR30N | HR15N |
|---|---|---|---|---|---|---|
| | | | | | | |
| 580 | 572 | 54,0 | 78,1 | 59,5 | 71,4 | 87,2 |
| 590 | 576 | 54,4 | 78,4 | 59,6 | 71,9 | 87,4 |
| | | | | | | |
| 600 | 580 | 54,8 | 78,6 | 59,9 | 72,3 | 87,6 |
| 610 | 585 | 55,2 | 78,8 | 60,2 | 72,8 | 87,8 |
| 620 | 591 | 55,6 | 79,1 | 60,5 | 73,2 | 88,0 |
| 630 | 597 | 56,1 | 79,3 | 60,9 | 73,6 | 88,2 |
| 640 | 604 | 56,5 | 79,6 | 61,4 | 74,1 | 88,4 |
| | | | | | | |
| 650 | 611 | 56,9 | 79,8 | 61,8 | 74,5 | 88,7 |
| 660 | 619 | 57,4 | 80,1 | 62,4 | 75,0 | 88,9 |
| 670 | 627 | 57,8 | 80,3 | 63,0 | 75,4 | 89,1 |
| 680 | 636 | 58,3 | 80,6 | 63,6 | 75,8 | 89,4 |
| 690 | 646 | 58,7 | 80,9 | 64,2 | 76,2 | 89,6 |
| | | | | | | |
| 700 | 656 | 59,2 | 81,1 | 64,9 | 76,7 | 89,8 |
| 710 | 666 | 59,7 | 81,4 | 65,6 | 77,1 | 90,1 |
| 720 | 677 | 60,1 | 81,7 | 66,4 | 77,5 | 90,3 |

NOTE If only HV is given without a number, then most probably HV30 is meant.

**Table B.5 — Uncertainty curves to be used for conversion as in Table B.2**

| To obtain uncertainty $u$, in | of conversion from/to | use |
|---|---|---|
| HB | HV/HB | Figure B.1 |
| HV | HB/HV | Figure B.2 |
| HRC | HV/HRC | Figure B.3 |
| HV | HRC/HV | Figure B.4 |
| HRA | HV/HRA | Figure B.5 |
| HV | HRA/HV | Figure B.6 |
| HR45N | HV/HR45N | Figure B.7 |
| HV | HR45N/HV | Figure B.10 |
| HR30N | HV/HR30N | Figure B.8 |
| HV | HR30N/HV | Figure B.11 |
| HR15N | HV/HR15N | Figure B.9 |
| HV | HR15N/HV | Figure B.12 |
| HRB | HV/HRB | Figure B.13 |
| HV | HRB/HV | Figure B.14 |
| HRF | HV/HRF | Figure B.15 |
| HV | HRF/HV | Figure B.16 |
| HR45T | HV/HR45T | Figure B.17 |

NOTE If only HV is given without a number, then most probably HV30 is meant.

**Table B.5** *(continued)*

| To obtain uncertainty $u$, in | of conversion from/to | use |
|---|---|---|
| HV | HR45T/HV | Figure B.18 |
| HR30T | HV/HR30T | Figure B.19 |
| HV | HR30T/HV | Figure B.20 |
| HR15T | HV/HR15T | Figure B.21 |
| HV | HR15T/HV | Figure B.22 |
| HRC | HRA/HRC | Figure B.23 |
| HRC | HR30N/HRC | Figure B.24 |
| HRB | HRF/HRB | Figure B.25 |
| HRB | HR30T/HRB | Figure B.26 |
| MPa | HV/$R_m$ | Figure B.63 |
| MPa | HB/$R_m$ | Figure B.64 |
| MPa | HRC/$R_m$ | Figure B.65 |
| NOTE If only HV is given without a number, then most probably HV30 is meant. | | |

**Table B.6 — Uncertainty curves to be used for conversion as in Table B.3**

| To obtain uncertainty $u$, in | of conversion from/to | use |
|---|---|---|
| HB | HV/HB | Figure B.27 |
| HV | HB/HV | Figure B.28 |
| HRC | HV/HRC | Figure B.29 |
| HV | HRC/HV | Figure B.30 |
| HRA | HV/HRA | Figure B.31 |
| HV | HRA/HV | Figure B.32 |
| HR45N | HV/HR45N | Figure B.33 |
| HV | HR45N/HV | Figure B.34 |
| HR30N | HV/HR30N | Figure B.35 |
| HV | HR30N/HV | Figure B.36 |
| HR15N | HV/HR15N | Figure B.37 |
| HV | HR15N/HV | Figure B.38 |
| HRB | HV/HRB | Figure B.39 |
| HV | HRB/HV | Figure B.40 |
| HRF | HV/HRF | Figure B.41 |
| HV | HRF/HV | Figure B.42 |
| HR45T | HV/HR45T | Figure B.43 |
| HV | HR45T/HV | Figure B.44 |
| HR30T | HV/HR30T | Figure B.45 |
| HV | HR30T/HV | Figure B.46 |
| HR15T | HV/HR15T | Figure B.47 |
| HV | HR15T/HV | Figure B.48 |
| HRC | HR30N/HRC | Figure B.49 |
| HRB | HR30T/HRB | Figure B.50 |
| MPa | HV/$R_m$ | Figure B.66 |
| MPa | HB/$R_m$ | Figure B.67 |
| MPa | HRC/$R_m$ | Figure B.68 |
| NOTE If only HV is given without a number, then most probably HV30 is meant. | | |

**Table B.7 — Uncertainty curves to be used for conversion as in Table B.4**

| To obtain uncertainty *u*, in | of conversion from/to | use |
|---|---|---|
| HB | HV/HB | Figure B.51 |
| HV | HB/HV | Figure B.52 |
| HRC | HV/HRC | Figure B.53 |
| HV | HRC/HV | Figure B.54 |
| HRA | HV/HRA | Figure B.55 |
| HV | HRA/HV | Figure B.56 |
| HR45N | HV/HR45N | Figure B.57 |
| HV | HR45N/HV | Figure B.58 |
| HR30N | HV/HR30N | Figure B.59 |
| HV | HR30N/HV | Figure B.60 |
| HR15N | HV/HR15N | Figure B.61 |
| HV | HR15N/HV | Figure B.62 |
| NOTE If only HV is given without a number, then most probably HV30 is meant. | | |

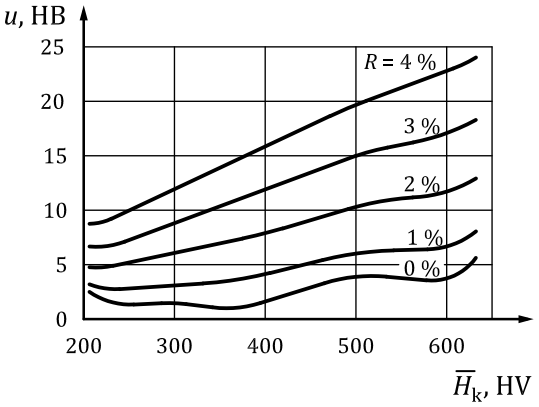



**Figure B.1**

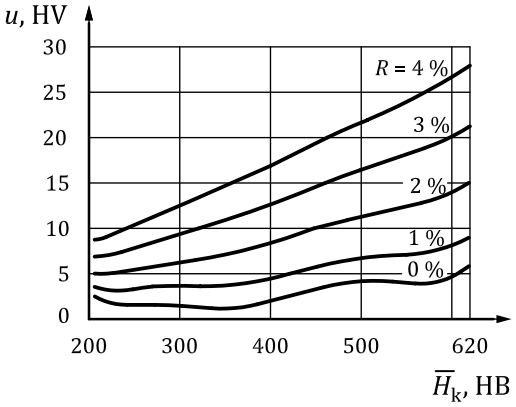



**Figure B.2**

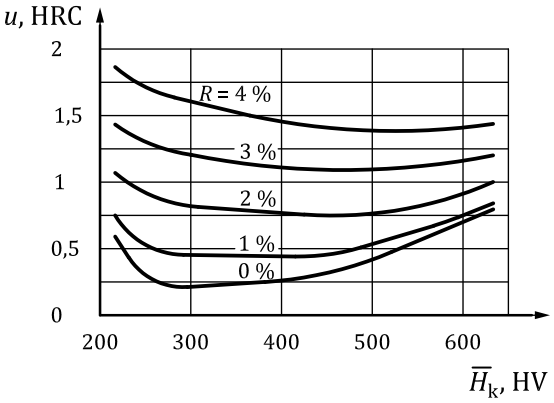



**Figure B.3**

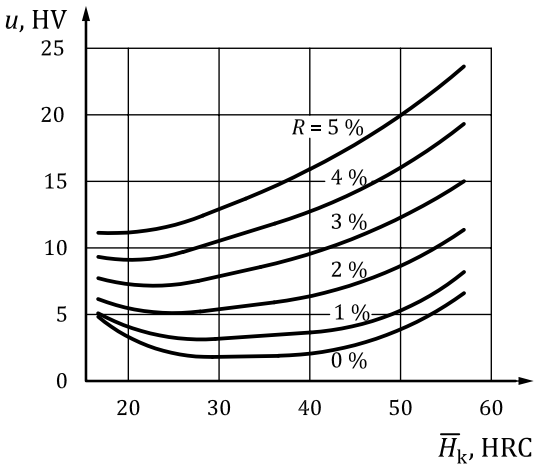



**Figure B.4**

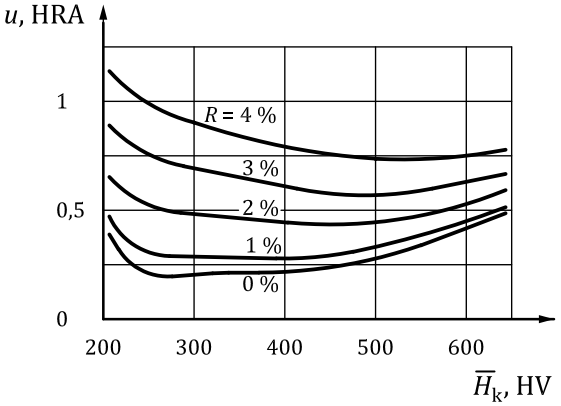



**Figure B.5**

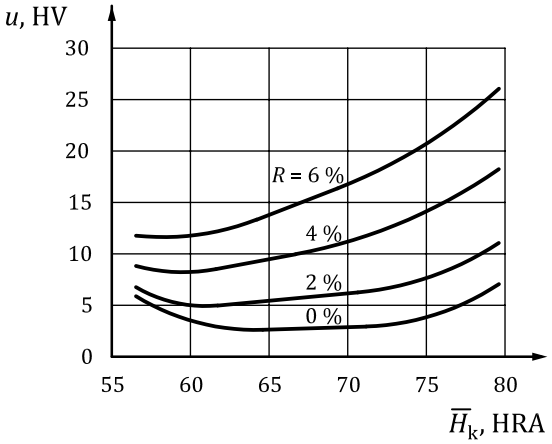



**Figure B.6**

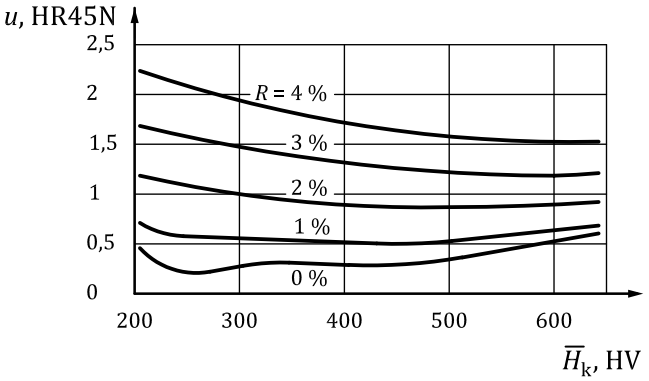



**Figure B.7**

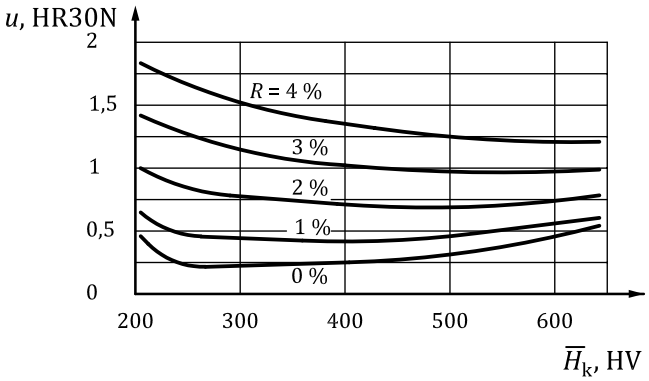



**Figure B.8**

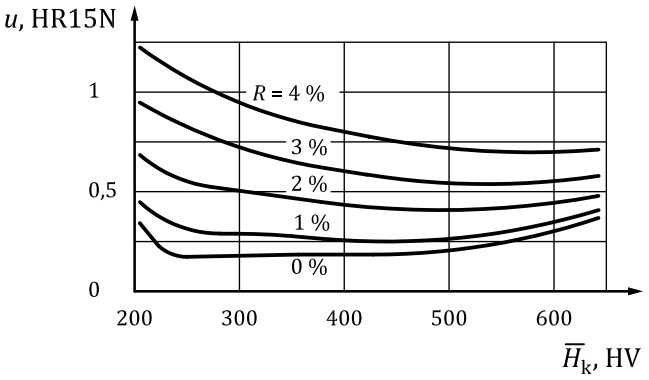



**Figure B.9**

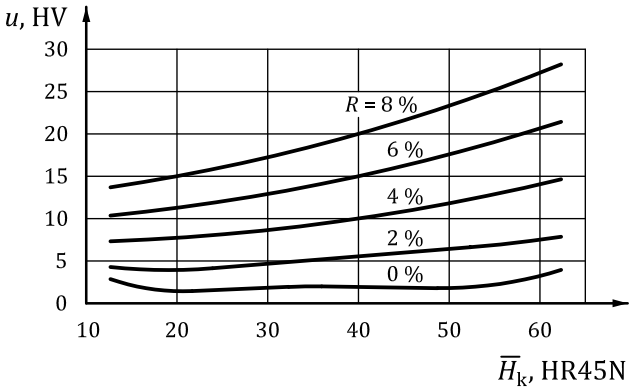



**Figure B.10**

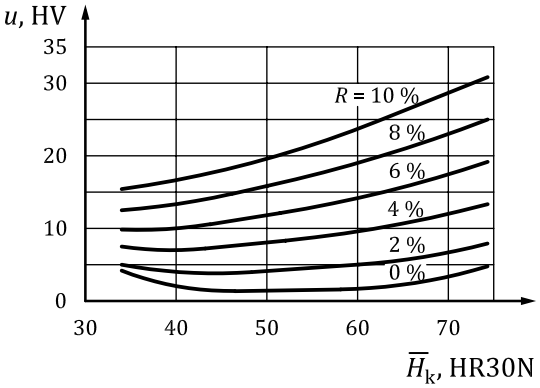



**Figure B.11**

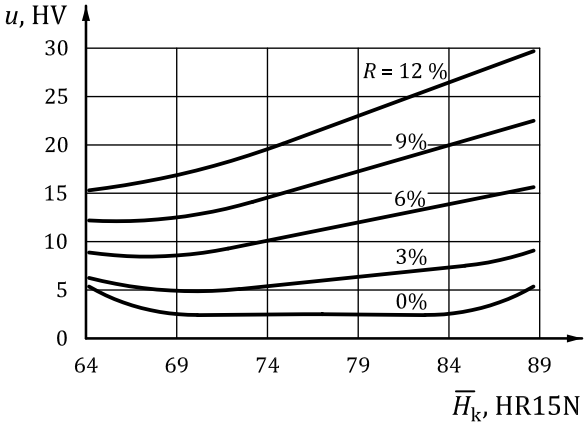



**Figure B.12**

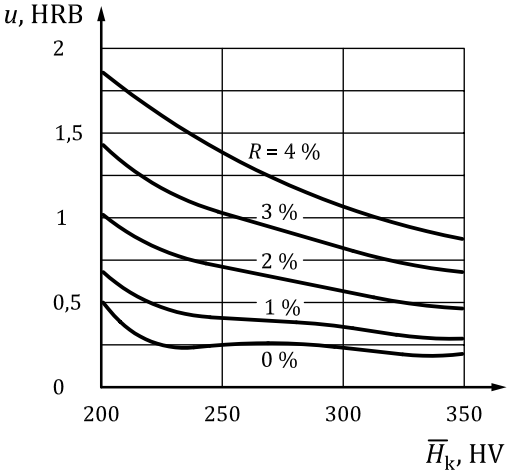



**Figure B.13**

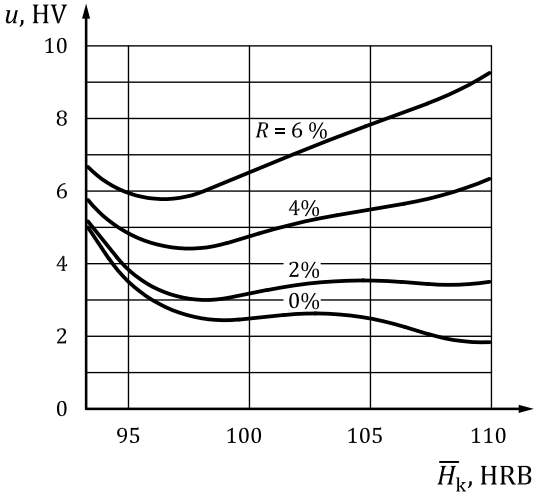



**Figure B.14**

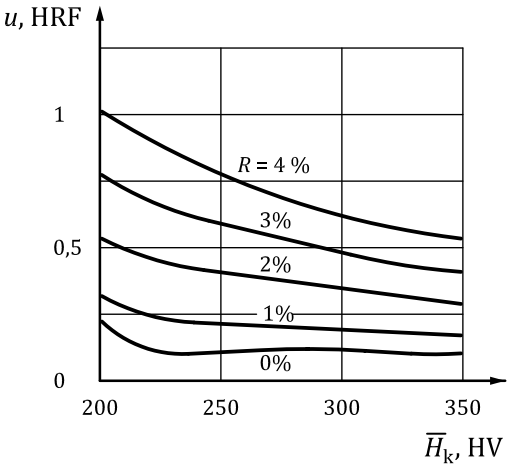



**Figure B.15**

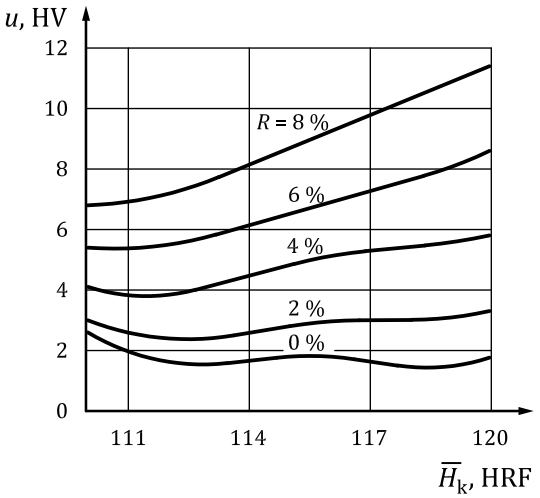



**Figure B.16**

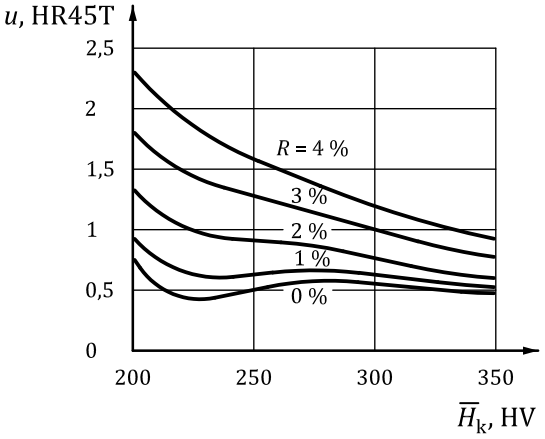



**Figure B.17**

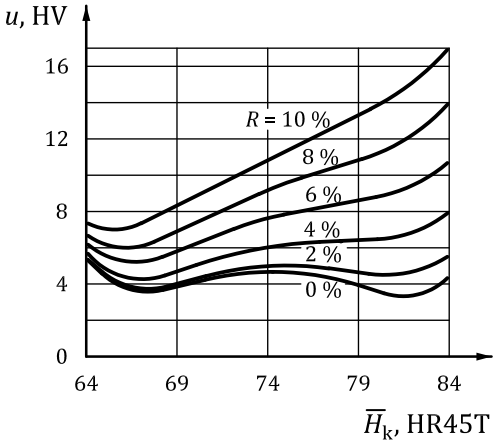



**Figure B.18**

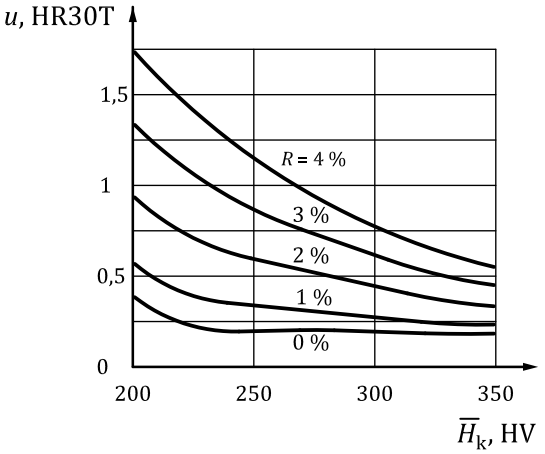



**Figure B.19**

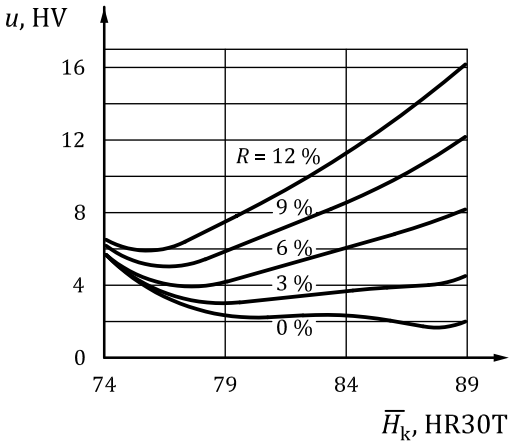



**Figure B.20**

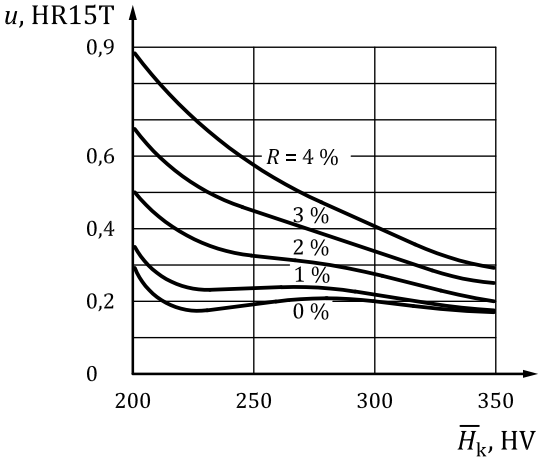



**Figure B.21**

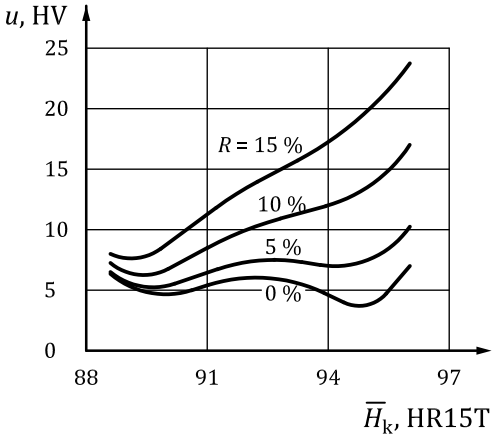



**Figure B.22**

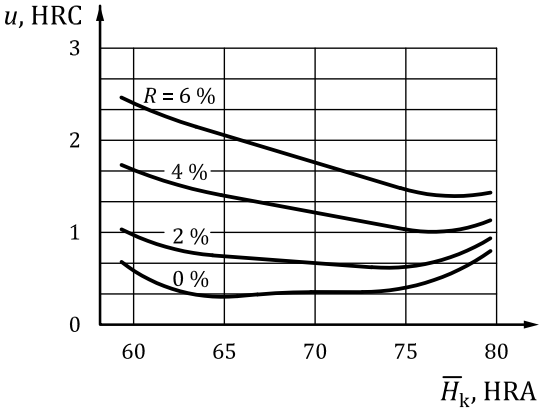



**Figure B.23**

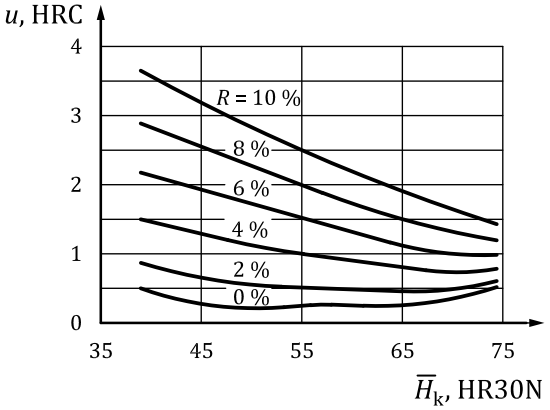
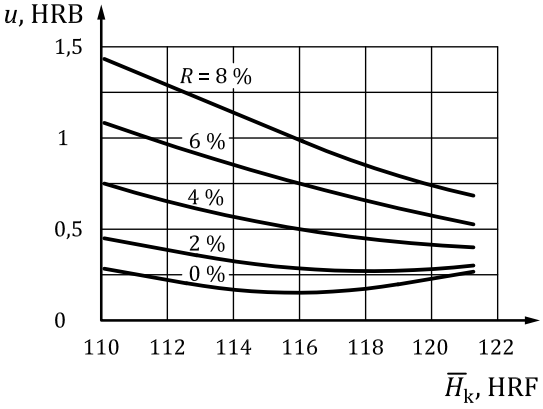



**Figure B.24**

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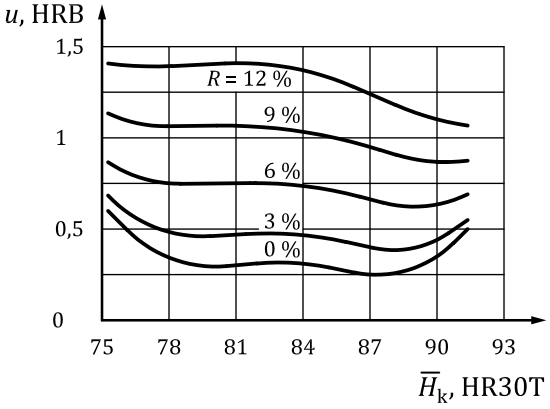



**Figure B.26**

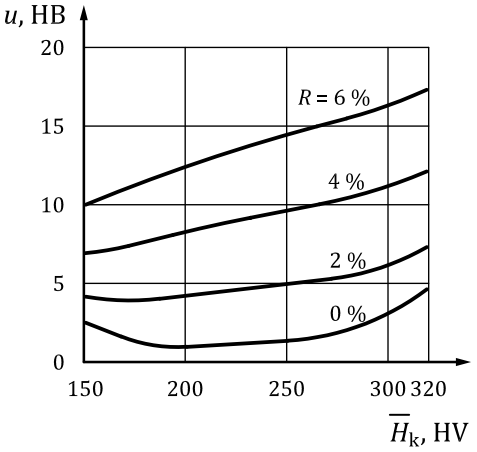



**Figure B.27**

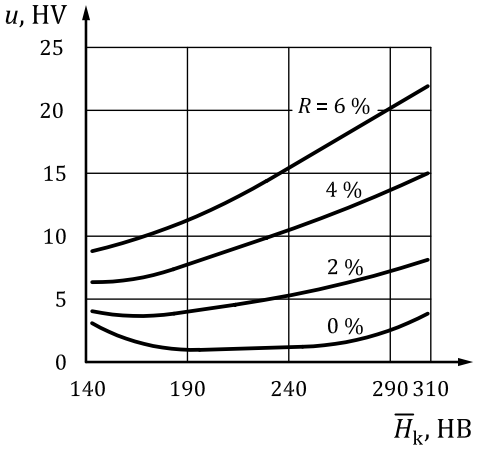



**Figure B.28**

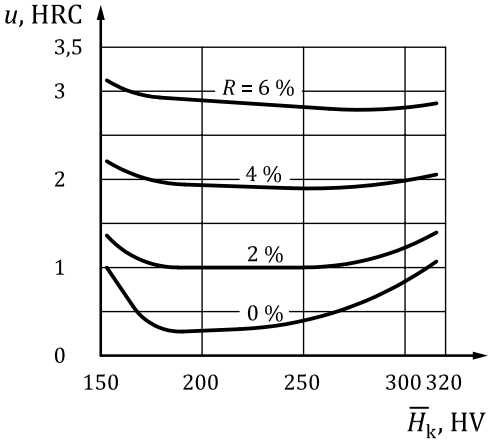



**Figure B.29**

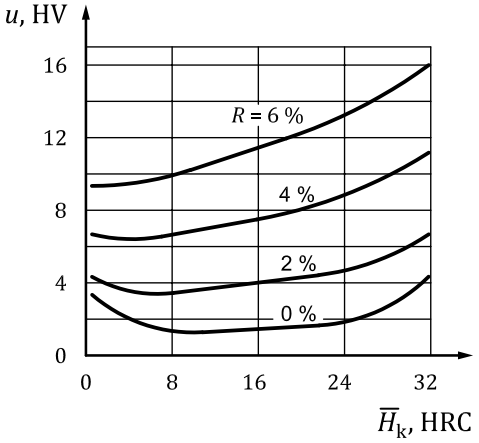



**Figure B.30**

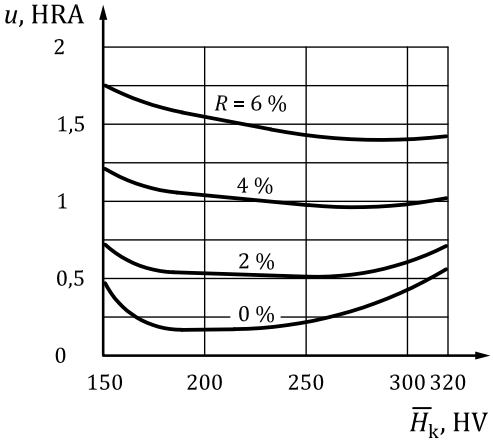



**Figure B.31**

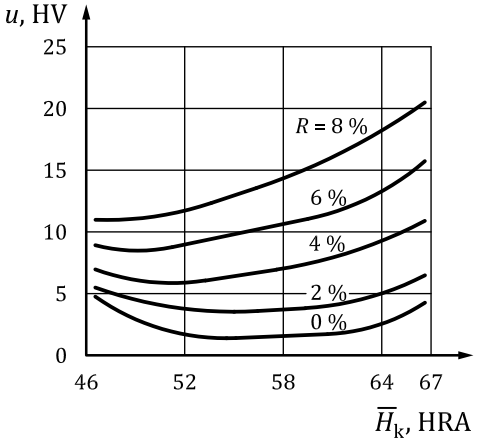



**Figure B.32**

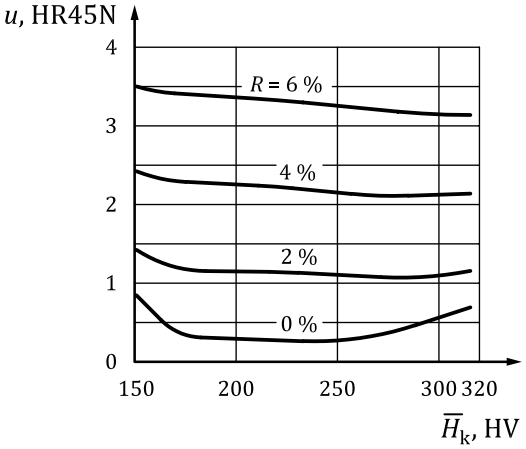



**Figure B.33**

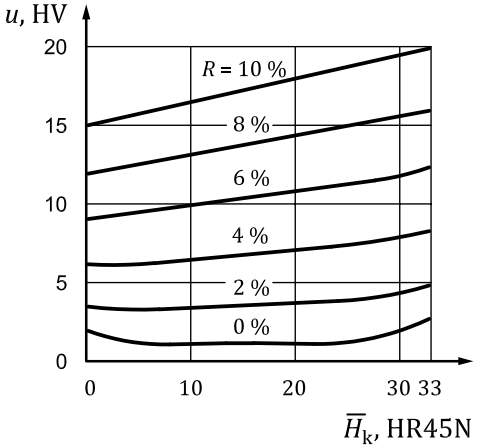



**Figure B.34**

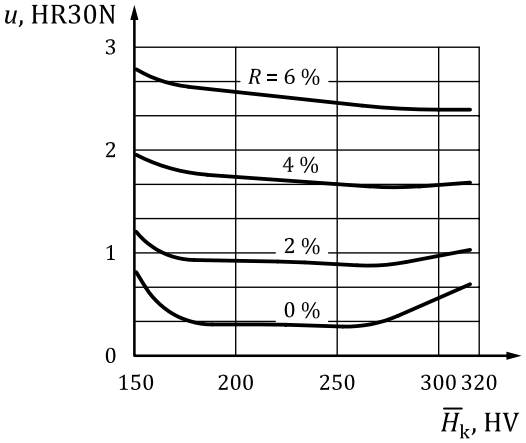



**Figure B.35**

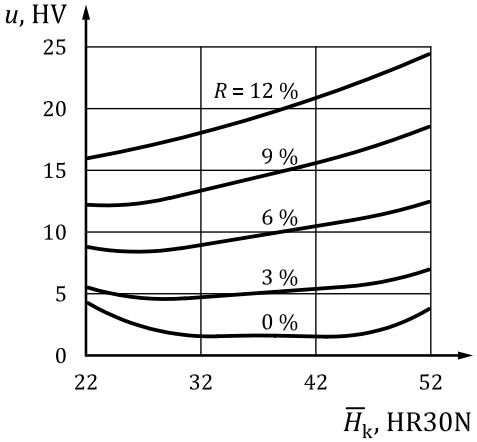



**Figure B.36**

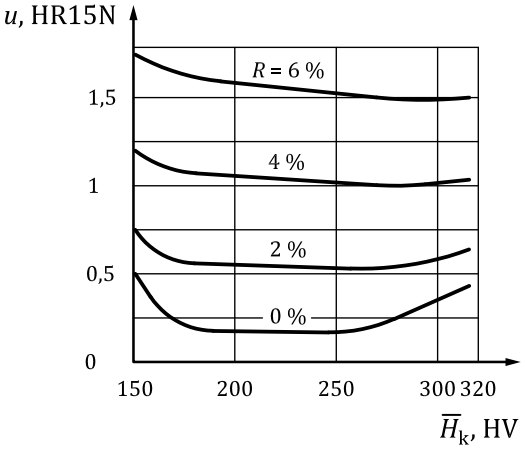



**Figure B.37**

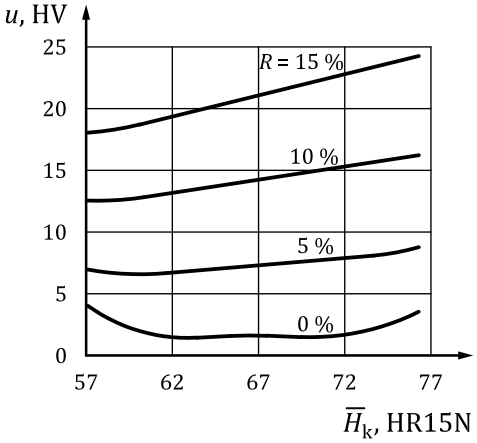



**Figure B.38**

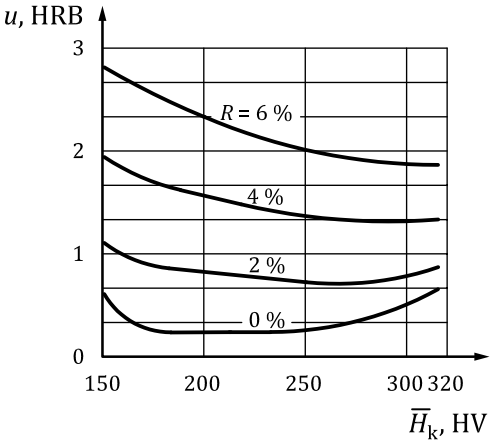



**Figure B.39**

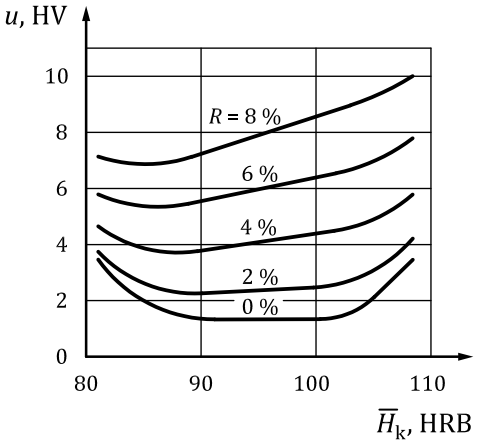



**Figure B.40**

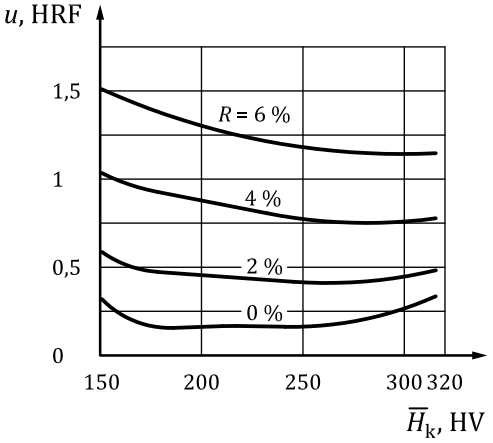



**Figure B.41**

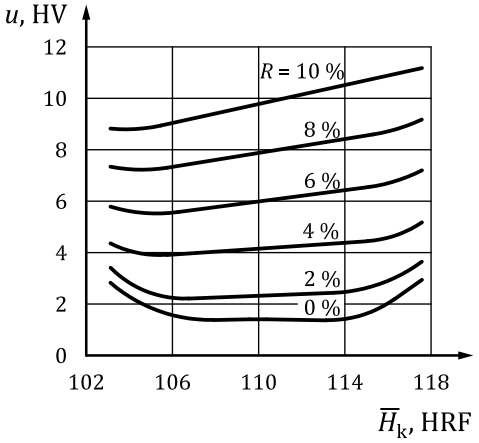



**Figure B.42**

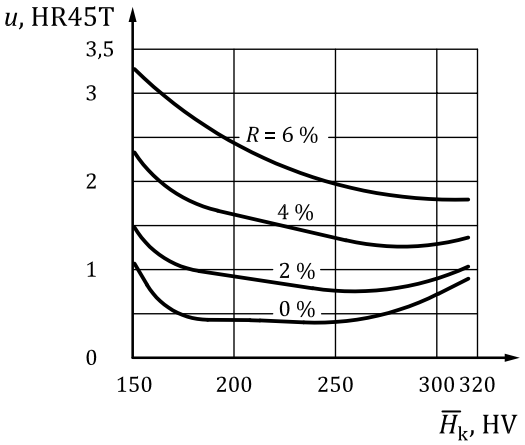



**Figure B.43**

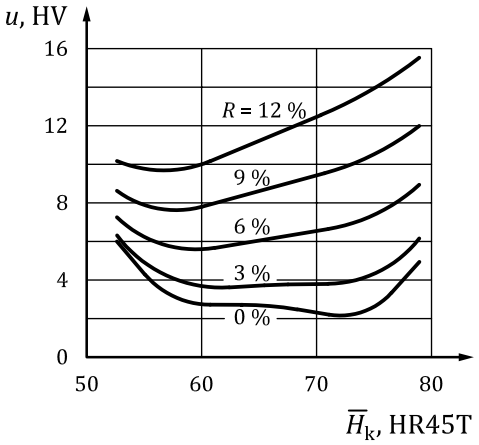



**Figure B.44**

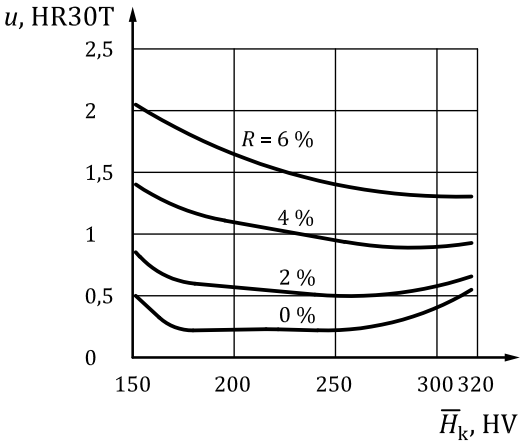



**Figure B.45**

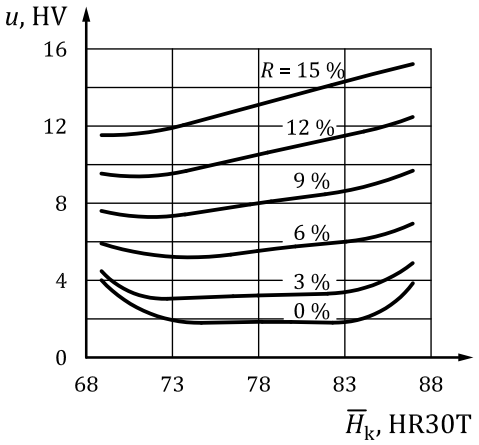



**Figure B.46**

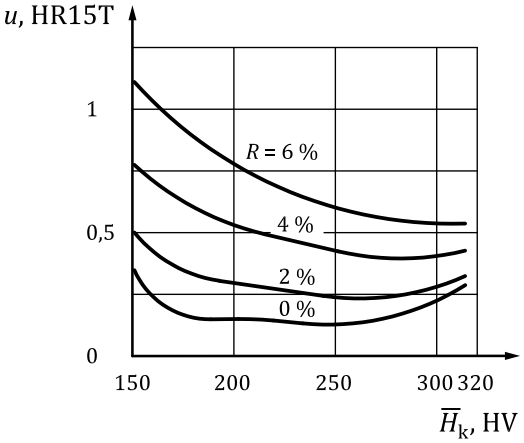



**Figure B.47**

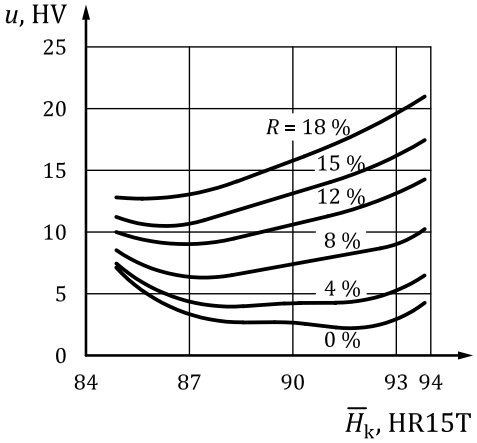



**Figure B.48**

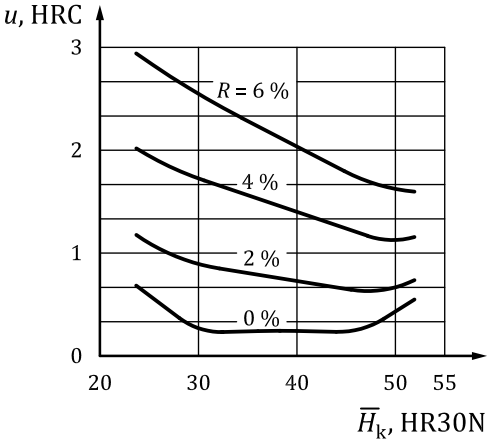



**Figure B.49**

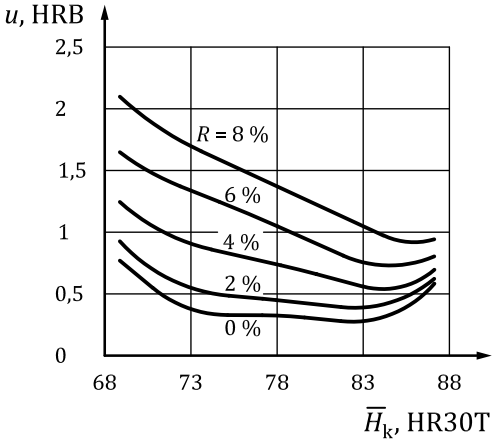



**Figure B.50**

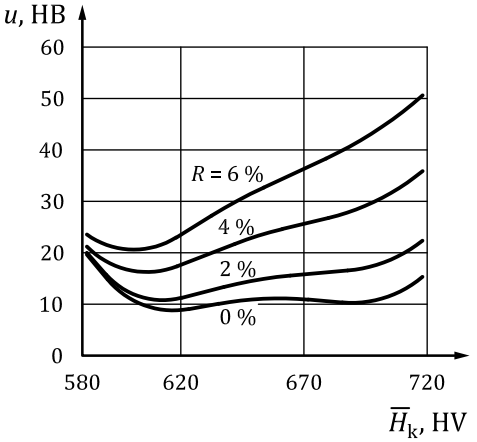



**Figure B.51**

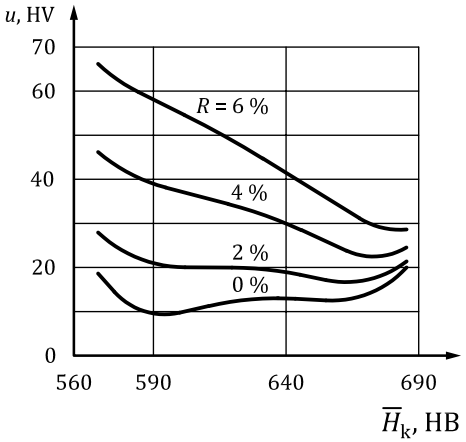



**Figure B.52**

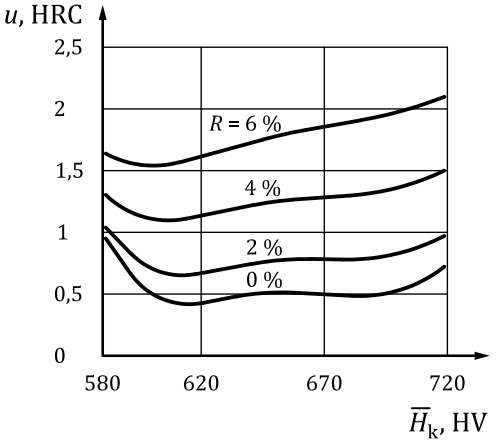



**Figure B.53**

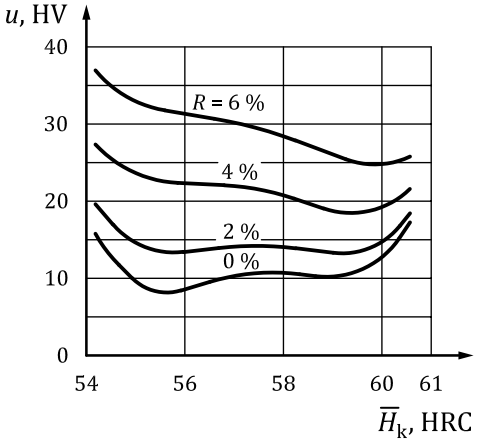



**Figure B.54**

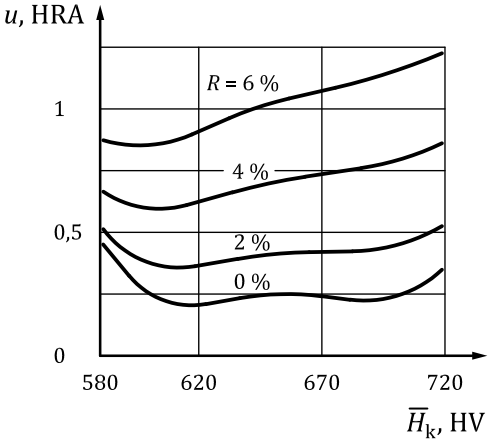



**Figure B.55**

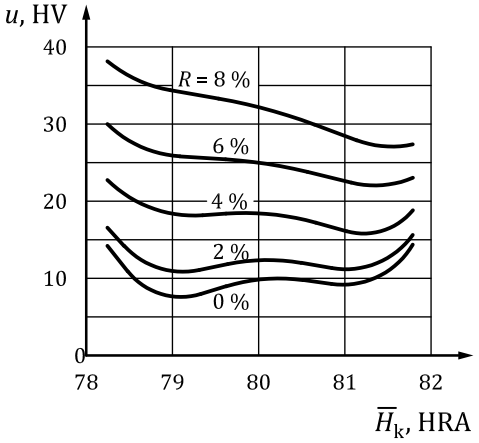



**Figure B.56**

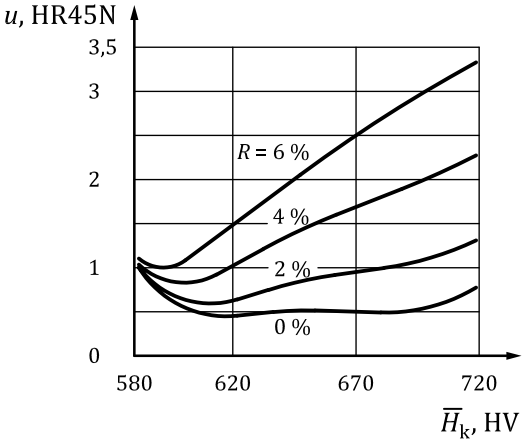



**Figure B.57**

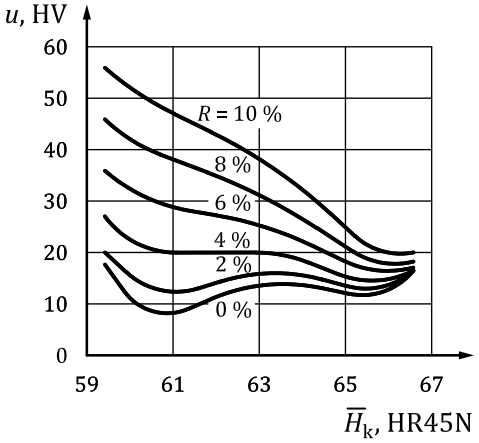



**Figure B.58**

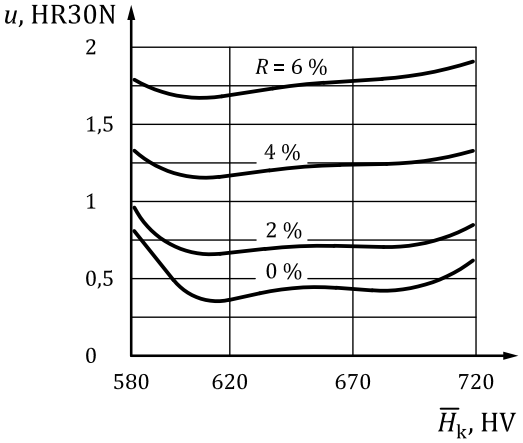



**Figure B.59**

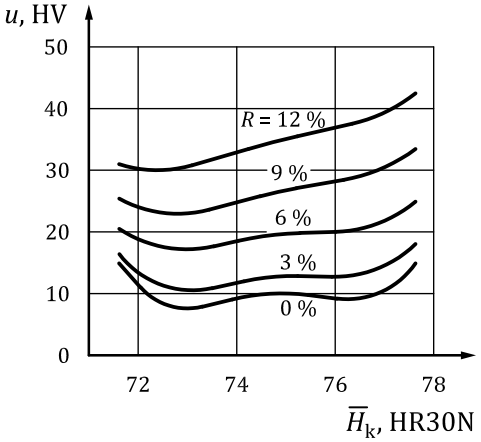



**Figure B.60**

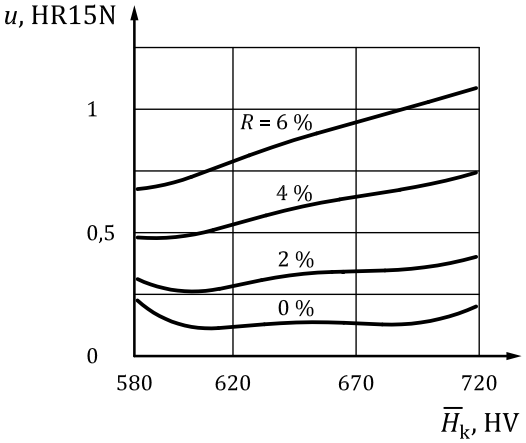



**Figure B.61**

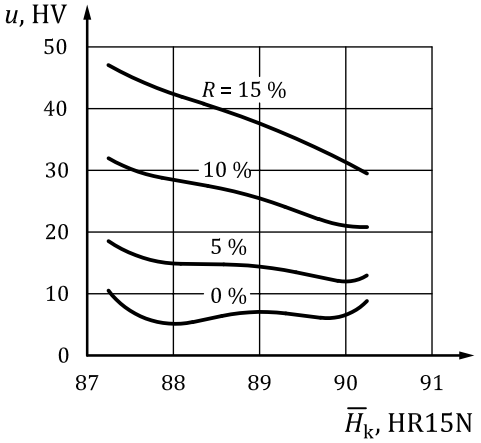



**Figure B.62**

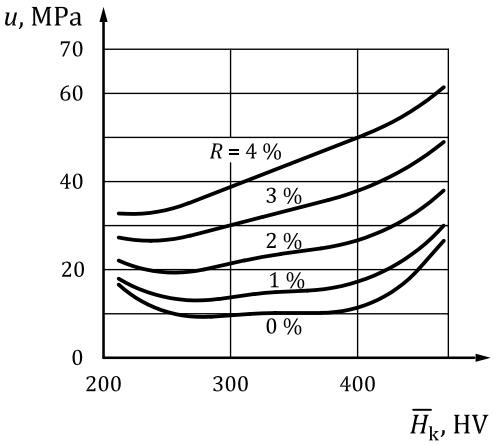



**Figure B.63**

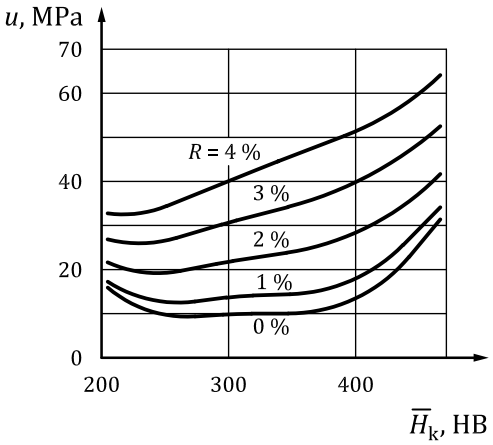



**Figure B.64**

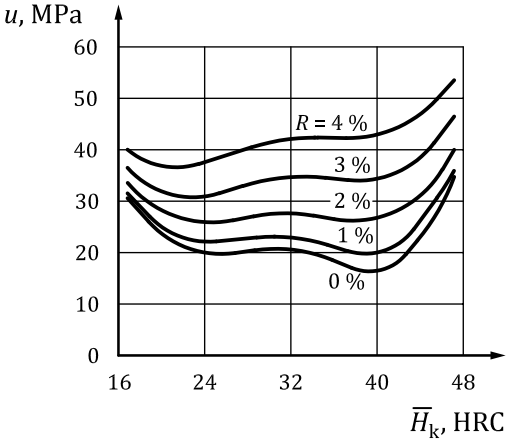



**Figure B.65**

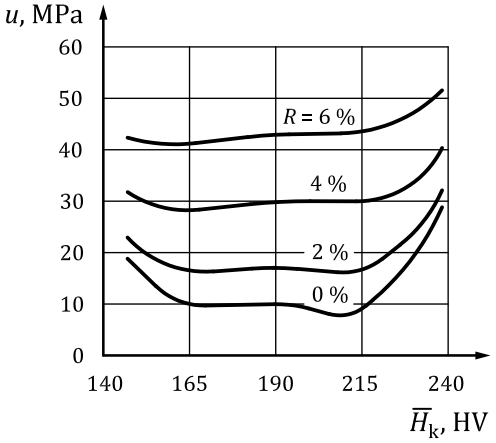



**Figure B.66**

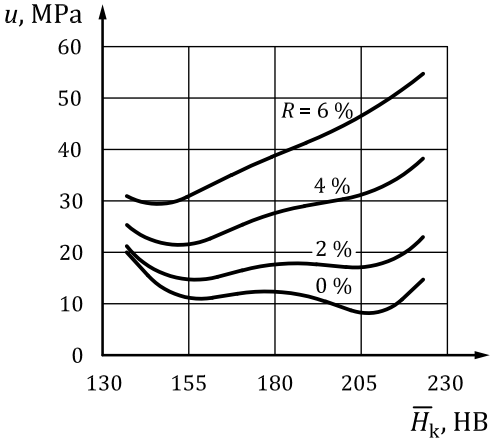



**Figure B.67**

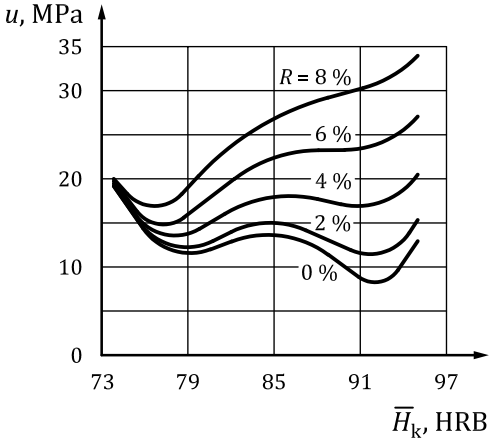



**Figure B.68**

# Annex C
(informative)

# Conversion tables for steels for cold working

**WARNING — Hardness conversions are no substitute for direct measurements. These tables should be used with caution and only in accordance with the principles of conversions, see Clause 2.**

This Annex presents conversion values for steels for cold working that have been quenched and tempered. These values are based on results of testing carried out on steels as specified in TGL 4393. The steel grades that were tested are listed in Table C.1, which also provides an overview of the former designations used in the TGL standard along with the corresponding designations as in ISO 4957. Table C.2 lists the conversion values, while Table C.3 gives an overview of the uncertainty curves presented in Figures C.1 to C.28 which are to be used in conjunction with the conversion tables.

NOTE A useful reference book is [24]. It provides information for the comparison of different national and international steel designations with regard to their compositions.

**Table C.1 — Cold working steels tested**

| Steel grade (as in TGL 4393) | Steel grade (as in ISO 4957) | |
|---|---|---|
| | Material no. | Name |
| 85CrMo7.2 | 1.2304 | 85CrMo7 |
| UR85CrMo7.2 | 1.2304 | 85CrMo7 |
| 90MnV8 | 1.2842 | 90MnCrV8 |
| 101Cr6 | 1.3514 | 101Cr6LW |
| UR101Cr6 | 1.3505 [a] | 100Cr6 |
| 125CrSi5 | 1.2109 | 125CrSi5 |
| X125WMo6.5 | 1.3344 [a] | S6-5-3 |
| 210Cr46 | 1.2080 | X210Cr12 |
| 210CrW46 | 1.2436 | X210CrW12 |
| [a] Chemical composition roughly equivalent to that specified in TGL 4393. | | |

## Table C.2 — Conversion of hardness-to-hardness values for cold working steels

冷加工钢的硬度-硬度换算值

| HV | HV 5 | HB [a] | HRC | HRA | HR45N | HR30N | HR15N | HRB | HRF | HR45T | HR30T | HR15T |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 210 | 212 | 205 | – | – | – | – | – | 95,6 | (110,7) | 66,9 | 78,0 | 90,2 |
| 220 | 222 | 215 | (18,8) | 59,4 | (16,4) | (38,8) | (67,0) | 97,2 | (111,6) | 68,6 | 79,1 | 90,7 |
| 230 | 232 | 225 | 20,6 | 60,3 | (18,7) | (40,5) | (68,2) | 98,6 [b] | (112,5) | 70,2 | 80,1 | 91,2 |
| 240 | 242 | 235 | 22,2 | 61,2 [b] | 20,9 | 42,2 | (69,3) | 100,0 [b] | (113,3) | 71,6 | 81,0 | 91,7 |
| 250 | 252 | 245 | 23,9 | 62,1 [b] | 23,0 | 43,8 [b] | 70,3 | (101,4) | (114,0) | (72,9) | 81,9 | 92,1 |
| | | | | | | | | | | | | |
| 260 | 262 | 255 | 25,4 | 62,8 | 24,9 | 45,3 | 71,3 | (102,6) | (114,7) | (74,1) | (82,7) | 92,5 |
| 270 | 272 | 265 | 26,9 | 63,6 | 26,8 | 46,8 | 72,2 | (103,7) | (115,3) | (75,2) | (83,5) | 92,9 |
| 280 | 282 | 275 | 28,3 | 64,4 | 28,6 | 48,2 | 73,1 | (104,7) | (115,9) | (76,3) | (84,2) | (93,3) |
| 290 | 293 | 285 | 29,7 [b] | 65,1 | 30,2 | 49,5 | 73,9 | (105,6) | (116,4) | (77,3) | (84,8) | (93,6) |
| 300 | 303 | 295 | 31,0 | 65,8 | 31,9 | 50,7 | 74,7 | (106,5) | (116,9) | (78,2) | (85,5) | (93,9) |
| | | | | | | | | | | | | |
| 310 | 313 | 304 | 32,3 | 66,4 | 33,4 | 51,9 | 75,4 | (107,3) | (117,4) | (79,1) | (86,0) | (94,2) |
| 320 | 323 | 314 | 33,5 | 67,1 | 34,9 | 53,0 | 76,1 | (108,1) | (117,8) | (79,9) | (86,6) | (94,5) |
| 330 | 333 | 324 | 34,6 | 67,7 | 36,3 | 54,1 | 76,8 | (108,8) | (118,2) | (80,6) | (87,1) | (94,8) |
| 340 | 343 | 334 | 35,8 | 68,3 | 37,6 | 55,2 | 77,4 | (109,5) | (118,6) | (81,4) | (87,6) | (95,0) |
| 350 | 353 | 344 | 36,8 | 68,8 | 39,0 | 56,2 | 78,0 | – | – | – | – | – |
| | | | | | | | | | | | | |
| 360 | 363 | 354 | 37,9 | 69,4 | 40,2 | 57,2 | 78,6 | | | | | |
| 370 | 373 | 363 | 38,9 | 69,9 | 41,4 | 58,1 | 79,2 | | | | | |
| 380 | 383 | 373 | 39,9 | 70,4 | 42,6 | 59,0 | 79,7 | | | | | |
| 390 | 393 | 383 | 40,8 | 71,0 | 43,7 | 59,9 | 80,2 | | | | | |
| 400 | 404 | 392 | 41,7 | 71,4 | 44,8 | 60,7 | 80,7 | | | | | |
| | | | | | | | | | | | | |
| 410 | 414 | 402 | 42,6 | 71,9 | 45,8 | 61,5 | 81,2 | | | | | |
| 420 | 424 | 412 | 43,5 | 72,4 | 46,9 | 62,3 | 81,6 | | | | | |
| 430 | 434 | 422 | 44,3 | 72,8 | 47,8 | 63,1 | 82,1 | | | | | |
| 440 | 444 | 431 | 45,1 | 73,3 | 48,8 | 63,8 | 82,5 | | | | | |
| 450 | 454 | 441 | 45,9 | 73,7 | 49,7 | 64,5 | 82,9 | | | | | |
| | | | | | | | | | | | | |
| 460 | 464 | 450 | 46,7 | 74,1 | 50,5 | 65,2 | 83,3 | | | | | |
| 470 | 474 | 460 | 47,4 | 74,5 | 51,4 | 65,8 | 83,7 | | | | | |
| 480 | 484 | 469 | 48,2 | 74,9 | 52,2 | 66,5 | 84,0 | | | | | |
| 490 | 494 | 479 | 48,9 | 75,3 | 53,1 | 67,1 | 84,4 | | | | | |
| 500 | 505 | 488 | 49,5 | 75,6 | 53,9 | 67,7 | 84,7 | | | | | |
| | | | | | | | | | | | | |
| 510 | 515 | 498 | 50,2 | 76,0 | 54,6 | 68,3 | 85,1 | | | | | |
| 520 | 525 | 507 | 50,9 | 76,4 | 55,4 | 68,9 | 85,4 | | | | | |

[a] Brinell hardness values up to 450 HB were determined using a steel ball indenter, those above this value were determined with a hardmetal ball.

[b] Recalculated in 2012 by interpolation.

NOTE 1 Values in parentheses are those lying outside the defined range of the standard test method but which may used as estimates.

NOTE 2 If only HV is given without a number, then most probably HV30 is meant.

**Table C.2** *(continued)*

| HV | HV 5 | HB [a] | HRC | HRA | HR45N | HR30N | HR15N | HRB | HRF | HR45T | HR30T | HR15T |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 530 | 535 | 517 | 51,6 | 76,7 | 56,2 | 69,5 | 85,7 | | | | | |
| 540 | 545 | 526 | 52,1 | 77,0 | 56,8 | 70,0 | 86,0 | | | | | |
| 550 | 555 | 535 | 52,7 | 77,4 | 57,6 | 70,6 | 83,3 | | | | | |
| | | | | | | | | | | | | |
| 560 | 565 | 545 | 53,3 | 77,7 | 58,2 | 71,1 | 86,6 | | | | | |
| 570 | 575 | 554 | 53,9 | 78,0 | 58,9 | 71,6 | 86,9 | | | | | |
| 580 | 585 | 563 | 54,5 | 78,3 | 59,6 | 72,1 | 87,1 | | | | | |
| 590 | 595 | 572 | 55,0 | 78,6 | 60,2 | 72,6 | 87,4 | | | | | |
| 600 | 606 | 582 | 55,6 | 78,9 | 60,8 | 73,0 | 87,7 | | | | | |
| | | | | | | | | | | | | |
| 610 | 616 | 591 | 56,1 | 79,2 | 61,4 | 73,5 | 87,9 | | | | | |
| 620 | 626 | 600 | 56,6 | 79,5 | 62,0 | 74,0 | 88,2 | | | | | |
| 630 | 636 | - | 57,1 | 79,8 | 62,6 | 74,4 | 88,4 | | | | | |
| 640 | 646 | - | 57,6 | 80,0 | 63,2 | 74,8 | 88,6 | | | | | |
| 650 | 656 | - | 58,1 | 80,3 | 63,7 | 75,3 | 88,8 | | | | | |
| | | | | | | | | | | | | |
| 660 | 666 | | 58,6 | 80,6 | 64,3 | 75,7 | 89,1 | | | | | |
| 670 | 676 | | 59,0 | 80,8 | 64,8 | 76,1 | 89,3 | | | | | |
| 680 | 686 | | 59,5 | 81,0 | 65,3 | 76,5 | 89,5 | | | | | |
| 690 | 697 | | 59,9 | 81,3 | 65,8 | 76,9 | 89,7 | | | | | |
| 700 | 707 | | 60,4 | 81,5 | 66,3 | 77,3 | 89,9 | | | | | |
| | | | | | | | | | | | | |
| 710 | 717 | | 60,8 | 81,8 | 66,8 | 77,7 | 90,1 | | | | | |
| 720 | 727 | | 61,2 | 82,0 | 67,3 | 78,0 | 90,3 | | | | | |
| 730 | 737 | | 61,6 | 82,2 | 67,8 | 78,4 | 90,5 | | | | | |
| 740 | 747 | | 62,0 | 82,5 | 68,2 | 78,8 | 90,7 | | | | | |
| 750 | 757 | | 62,4 | 82,7 | 68,7 | 79,1 | 90,8 | | | | | |
| | | | | | | | | | | | | |
| 760 | 767 | | 62,8 | 82,9 | 69,1 | 79,4 | 91,0 | | | | | |
| 770 | 777 | | 63,2 | 83,1 | 69,6 | 79,8 | 91,2 | | | | | |
| 780 | 788 | | 63,6 | 83,3 | 70,0 | 80,1 | 91,4 | | | | | |
| 790 | 798 | | 64,0 | 83,5 | 70,4 | 80,4 | 91,5 | | | | | |
| 800 | 808 | | 64,4 | 83,7 | 70,8 | 80,8 | 91,7 | | | | | |
| | | | | | | | | | | | | |
| 810 | 818 | | 64,7 | 83,9 | 71,3 | 81,1 | 91,9 | | | | | |
| 820 | 828 | | 65,1 | 84,1 | 71,7 | 81,4 | 92,0 | | | | | |
| 830 | 838 | | 65,4 | 84,3 | 72,1 | 81,7 | 92,2 | | | | | |
| 840 | 848 | | 65,8 | 84,5 | 72,4 | 82,0 | 92,3 | | | | | |

[a] Brinell hardness values up to 450 HB were determined using a steel ball indenter, those above this value were determined with a hardmetal ball.

[b] Recalculated in 2012 by interpolation.

NOTE 1 Values in parentheses are those lying outside the defined range of the standard test method but which may used as estimates.

NOTE 2 If only HV is given without a number, then most probably HV30 is meant.

**Table C.3 — Uncertainty curves to be used for conversion as in Table C.2**

| To obtain uncertainty $u$, in | of conversion from/to | use |
|---|---|---|
| HV 10; HV 5 | HV/HV 10, HV/HV 5 | Figure C.1 |
| HV | HV 10/HV, HV 5/ HV | Figure C.2 |
| HB | HV/HB | Figure C.3 |
| HV | HB/HV | Figure C.4 |
| HRC | HV/HRC | Figure C.5 |
| HV | HRC/HV | Figure C.6 |
| HRA | HV/HRA | Figure C.7 |
| HV | HRA/HV | Figure C.8 |
| HR45N | HV/HR45N | Figure C.9 |
| HV | HR45N/HV | Figure C.10 |
| HR30N | HV/HR30N | Figure C.11 |
| HV | HR30N/HV | Figure C.12 |
| HR15N | HV/HR15N | Figure C.13 |
| HV | HR15N/HV | Figure C.14 |
| HRB | HV/HRB | Figure C.15 |
| HV | HRB/HV | Figure C.16 |
| HRF | HV/HRF | Figure C.17 |
| HV | HRF/HV | Figure C.18 |
| HR45T | HV/HR45T | Figure C.19 |
| HV | HR45T/HV | Figure C.20 |
| HR30T | HV/HR30T | Figure C.21 |
| HV | HR30T/HV | Figure C.22 |
| HR15T | HV/HR15T | Figure C.23 |
| HV | HR15T/HV | Figure C.24 |
| HRB | HRF/HRB | Figure C.25 |
| HRB | HR30T/HRB | Figure C.26 |
| HRC | HR30N/HRC | Figure C.27 |
| HRC | HRA/HRC | Figure C.28 |
| NOTE If only HV is given without a number, then most probably HV30 is meant. | | |

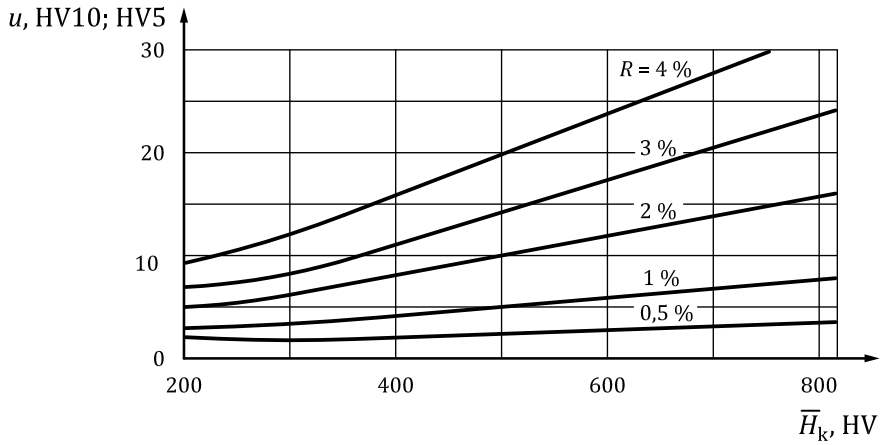



**Figure C.1**

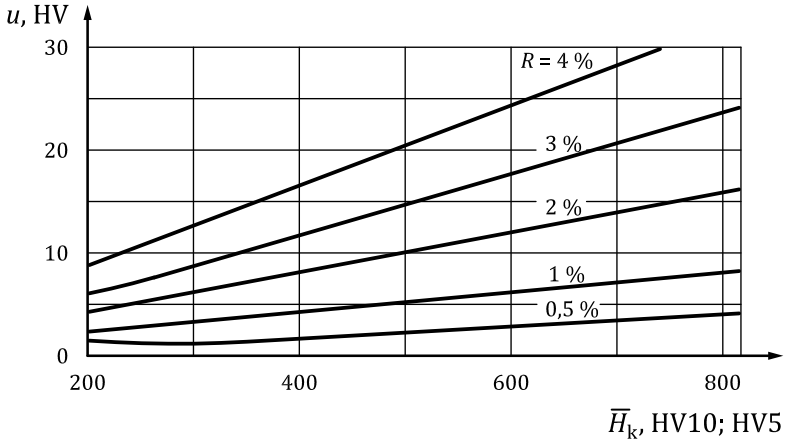



**Figure C.2**

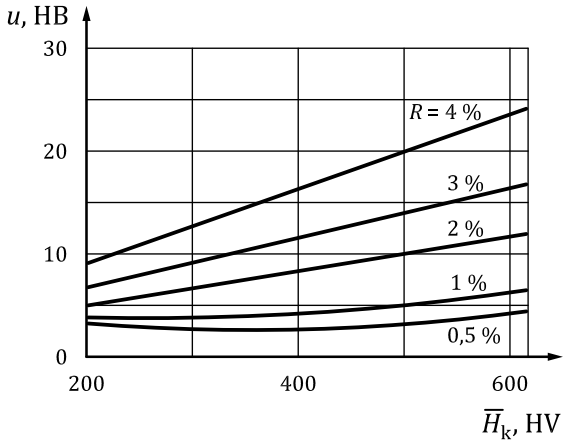



**Figure C.3**

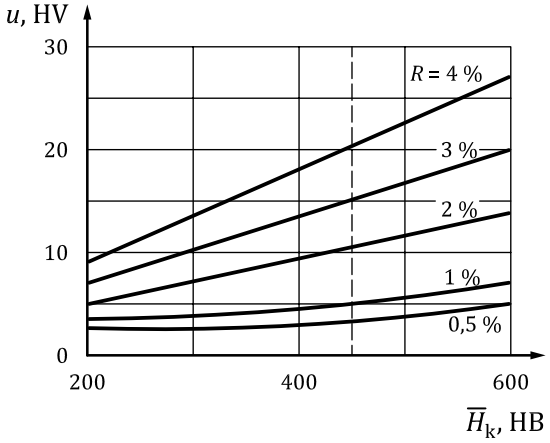



**Figure C.4**

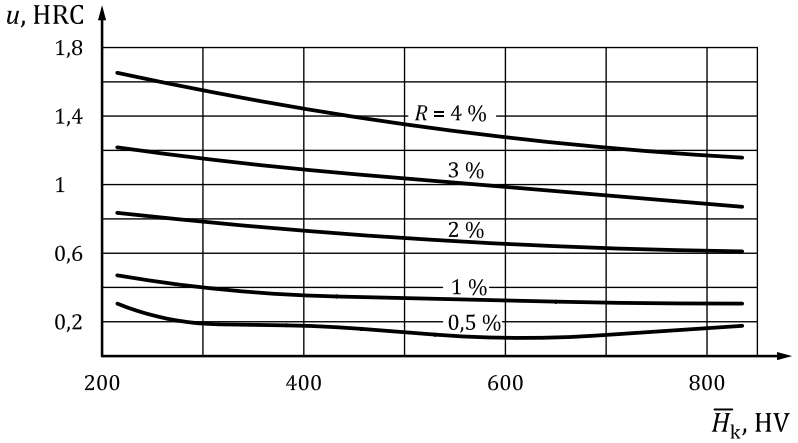



**Figure C.5**

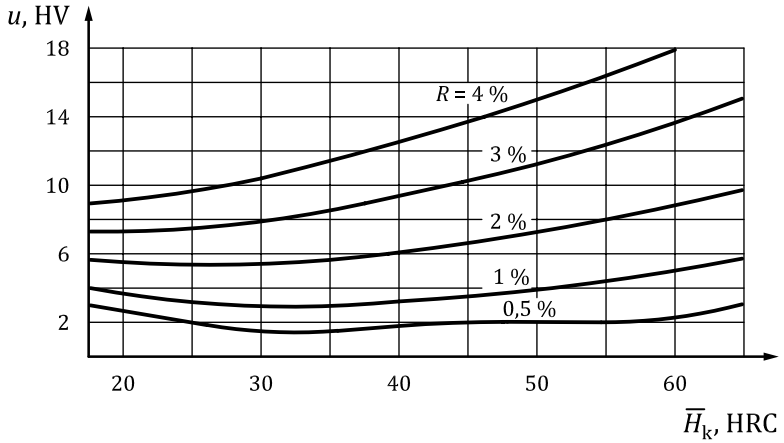



**Figure C.6**

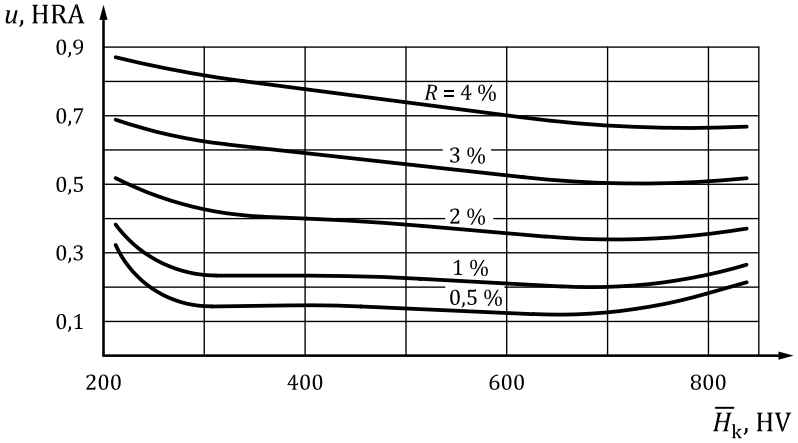



**Figure C.7**

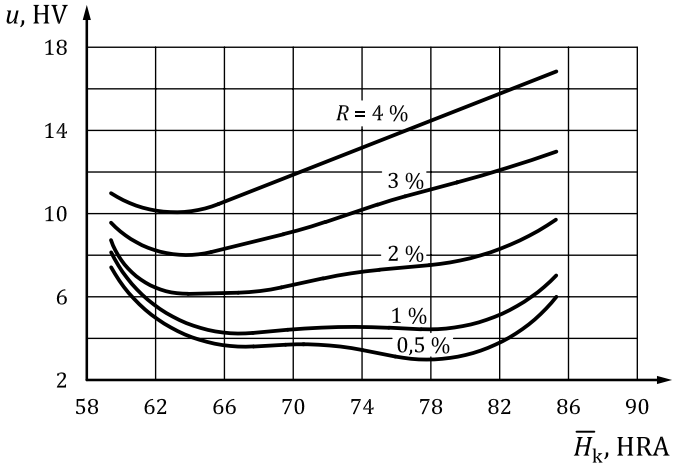



**Figure C.8**

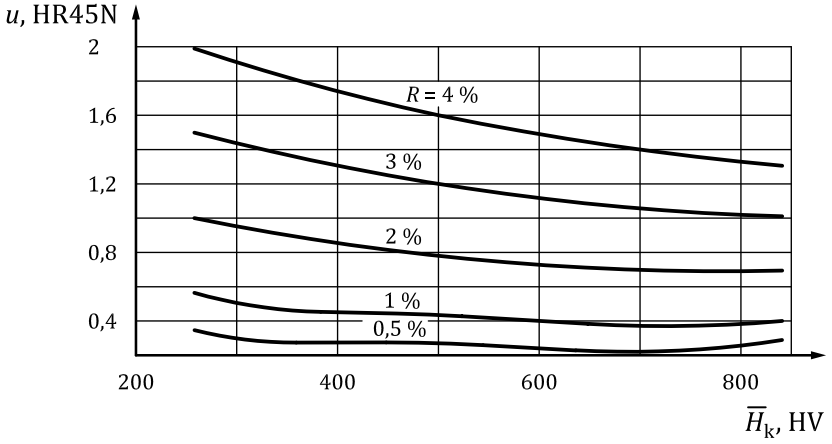



**Figure C.9**

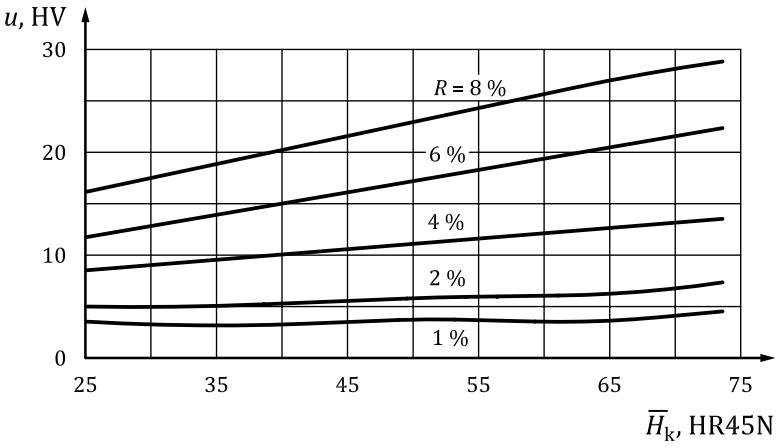



**Figure C.10**

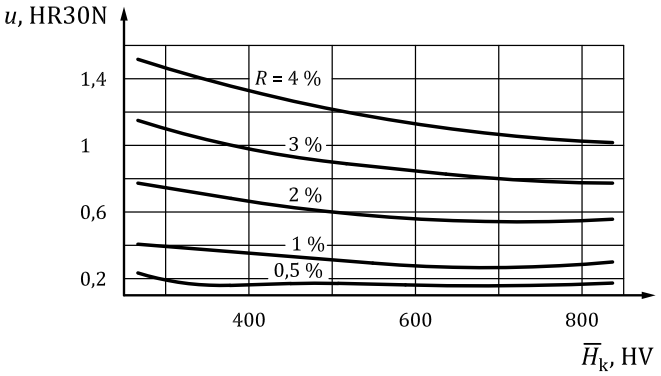



**Figure C.11**

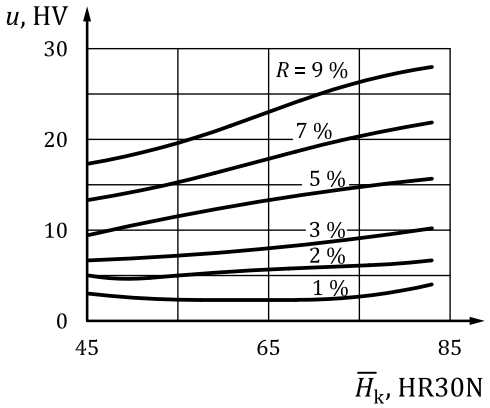



**Figure C.12**

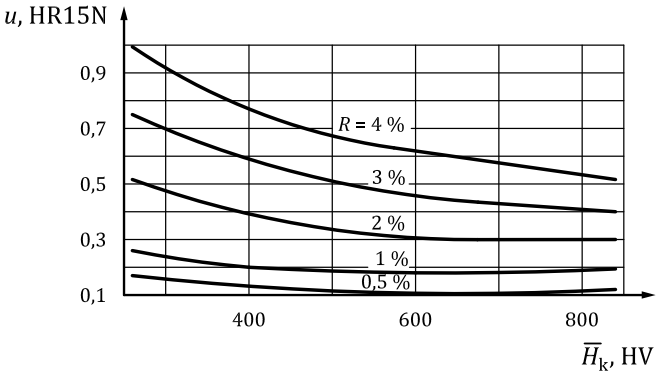



**Figure C.13**

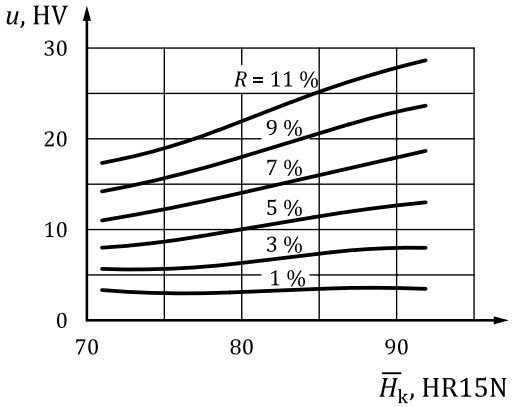



**Figure C.14**

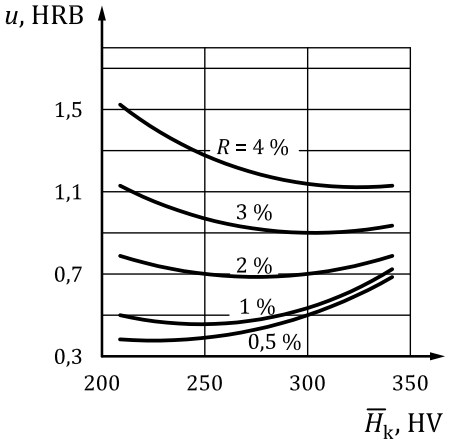



**Figure C.15**

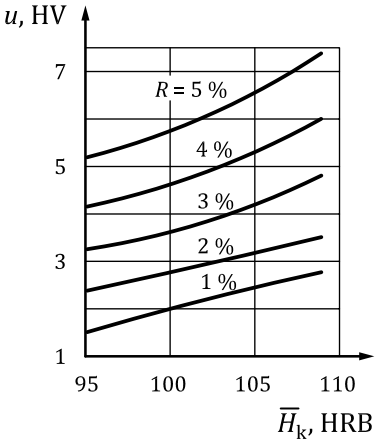



**Figure C.16**

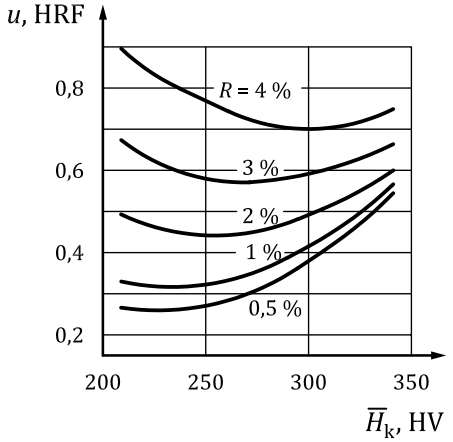



**Figure C.17**

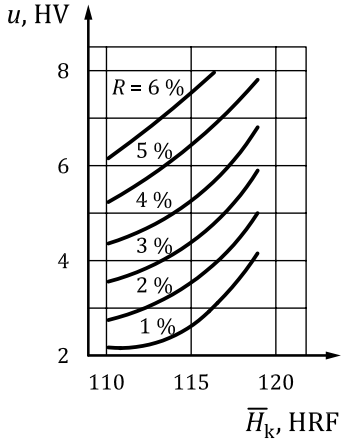



**Figure C.18**

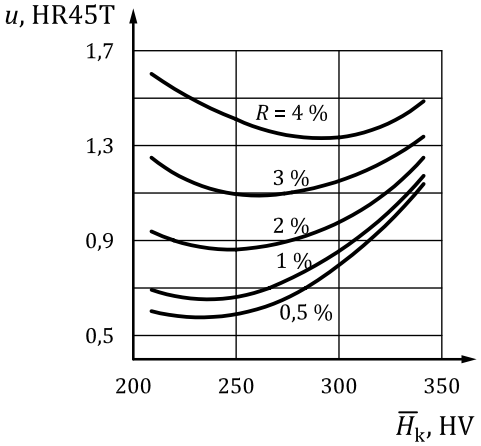



**Figure C.19**

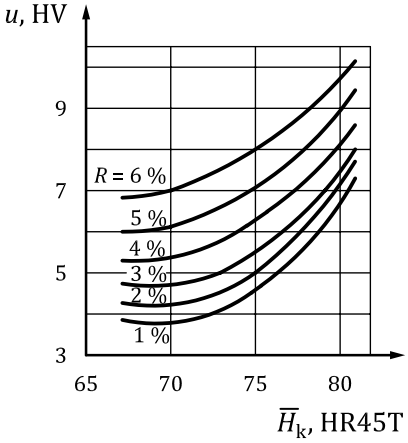



**Figure C.20**

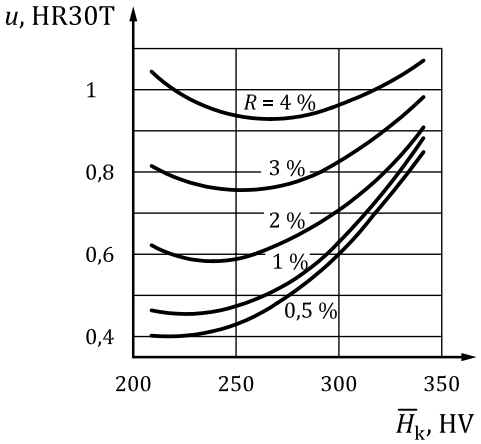



**Figure C.21**

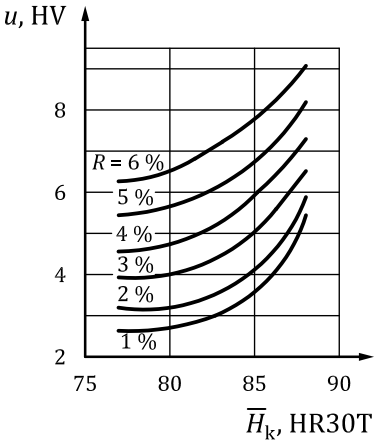



**Figure C.22**

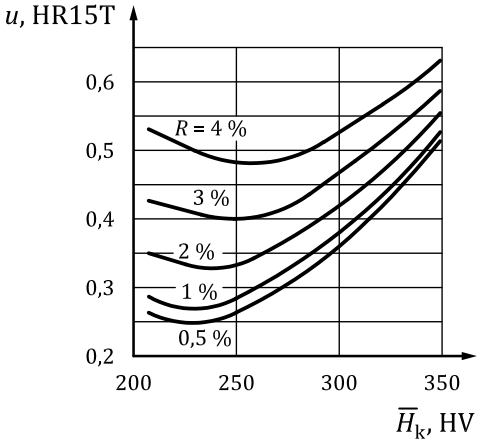



**Figure C.23**

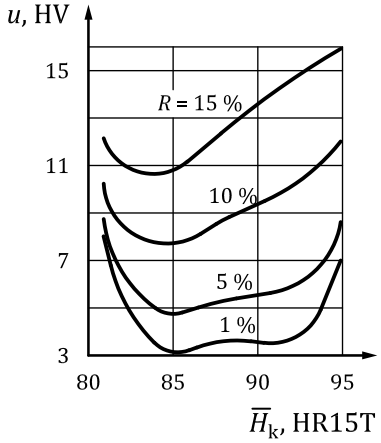



**Figure C.24**

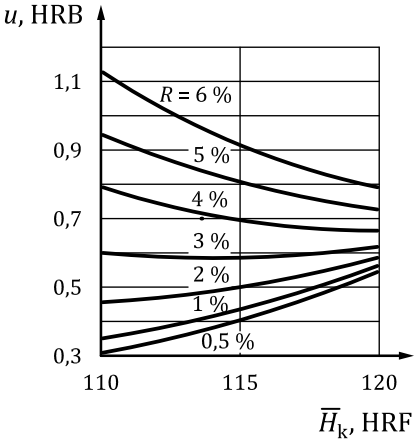



**Figure C.25**

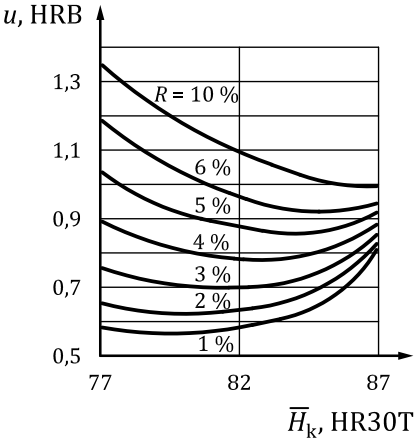



**Figure C.26**

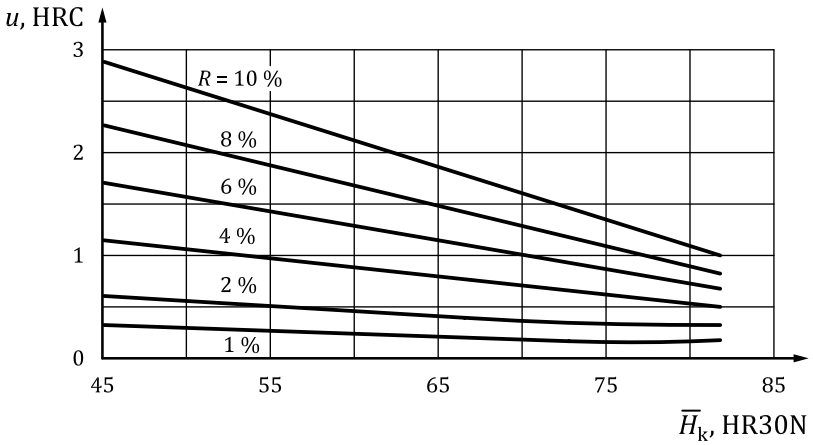



**Figure C.27**

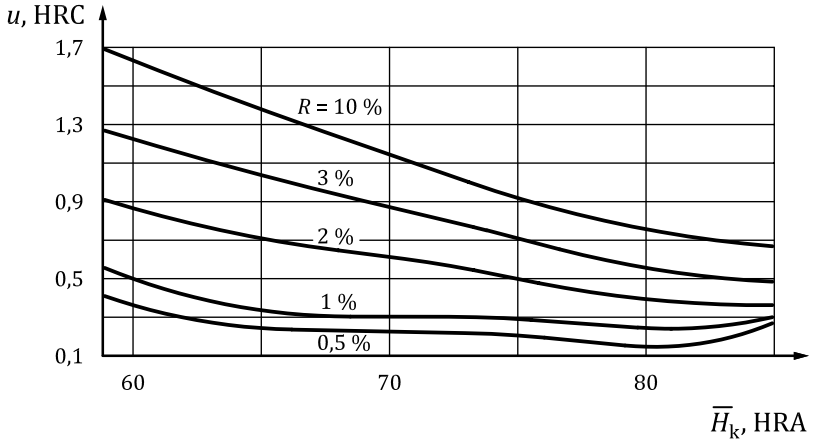



**Figure C.28**

# Annex D
(informative)

# Conversion tables for high speed steels

**WARNING — Hardness conversions are no substitute for direct measurements. These tables should be used with caution and only in accordance with the principles of conversions, see Clause 2.**

This Annex presents conversion values for high speed steels that have been quenched and tempered above the secondary hardening peak. These values are based on results of testing carried out on the high speed steel grades as in TGL 7571, listed in Table D.1, which also provides an overview of the former designations used in the TGL standard along with the corresponding designations as in ISO 4957. Tables D.2, D.4, D.6 and D.8 list the conversion values, while Tables D.3, D.5, D.7 and D.9 give an overview of the uncertainty curves presented in Figures D.1 to D.30 which are to be used in conjunction with the conversion tables.

NOTE A useful reference book is [24]. It provides information for the comparison of different national and international steel designations with regard to their compositions.

**Table D.1 — High speed steels tested**

| Steel grade (as in TGL 7571) | Steel grade (as in ISO 4957) | |
|---|---|---|
| | Material no. | Name |
| X80WMo6.5 | | X80WMo6.5 |
| X82WMo6.5 | | X82WMo6.5 |
| X90WMo6.5 | 1.3343 | X90WMo6.5 |
| X97WMo3.3 | | X97WMo3.3 |
| X100WMo6.5 | 1.3342 | X100WMo6.5 |
| X85WMoCo6.5.5 | 1.3243 | X85WMoCo6.5.5 |
| X105WMoCo6.5.5 | 1.3355 | X105WMoCo6.5.5 |
| X79WCo18.5 | 1.3255 | X79WCo18.5 |
| X110MoCo9.8 | 1.3247 | X110MoCo9.8 |

NOTE Where no material number is listed, no equivalent number could be found in ISO 4957.

**Table D.2 — Conversion of hardness-to-hardness values for high speed steels of steel grades X80WMo6.5, X82WMo6.5, X90WMo6.5, X97WMo3.3, X100WMo6.5, X85WMoCo6.5.5, X105WMoCo6.5.5 and X79WCo18.5**

高速钢（钢号详见英文标题）的硬度-硬度换算值

| Vickers hardness HV 30 | Rockwell hardness | | | | |
|---|---|---|---|---|---|
| | HRC | HRA | HR45N | HR30N | HR15N |
| 580 | 54,2 | 77,9 | 58,8 | 71,7 | 87,1 |
| 590 | 54,7 | 78,2 | 59,4 | 72,2 | 87,4 |
| 600 | 55,2 | 78,5 | 60,0 | 72,6 | 87,6 |
| | | | | | |
| 610 | 55,7 | 78,7 | 60,6 | 73,1 | 87,8 |
| 620 | 56,2 | 79,0[a] | 61,1 | 73,5 | 88,1 |
| 630 | 56,6 | 79,3 | 61,7 | 74,0 | 88,3 |
| 640 | 57,1 | 79,6 | 62,2 | 74,4 | 88,5 |
| 650 | 57,6 | 79,8 | 62,8 | 74,8 | 88,7 |
| | | | | | |
| 660 | 58,0 | 80,1 | 63,3 | 75,2 | 88,9 |
| 670 | 58,5 | 80,3 | 63,8 | 75,6 | 89,1 |
| 680 | 58,9 | 80,6 | 64,3 | 76,0 | 89,3 |
| 690 | 59,3 | 80,8 | 64,8 | 76,4 | 89,5 |
| 700 | 59,7 | 81,0 | 65,3 | 76,7 | 89,7 |
| | | | | | |
| 710 | 60,2 | 81,3 | 65,8 | 77,1 | 89,9 |
| 720 | 60,6 | 81,5 | 66,3 | 77,4 | 90,1 |
| 730 | 61,0 | 81,7 | 66,7 | 77,8 | 90,2 |
| 740 | 61,4 | 82,0 | 67,2 | 78,1 | 90,4 |
| 750 | 61,8 | 82,2 | 67,6 | 78,5 | 90,6 |
| | | | | | |
| 760 | 62,1 | 82,4 | 68,1 | 78,8 | 90,7 |
| 770 | 62,5 | 82,6 | 68,5 | 79,1 | 90,9 |
| 780 | 62,9 | 82,8 | 68,9 | 79,5 | 91,0 |
| 790 | 63,3 | 83,0 | 69,4 | 79,8 | 91,2 |
| 800 | 63,6 | 83,2 | 69,8 | 80,1 | 91,3 |
| | | | | | |
| 810 | 64,0 | 83,5 | 70,2 | 80,4 | 91,5 |
| 820 | 64,3 | 83,6 | 70,6 | 80,7 | 91,6 |
| 830 | 64,7 | 83,8 | 71,0 | 81,0 | 91,8 |
| 840 | 65,0 | 84,0 | 71,4 | 81,3 | 91,9 |
| 850 | 65,4 | 84,2 | 71,7 | 81,6 | 92,0 |
| | | | | | |
| 860 | 65,7 | 84,4 | 72,1 | 81,8 | 92,2 |
| 870 | 66,0 | 84,6 | 72,5 | 82,1 | 92,3 |
| 880 | 66,3 | 84,8 | 72,8 | 82,4 | 92,4 |
| 890 | 66,7 | 85,0 | 73,2 | 82,7 | 92,5 |
| 900 | 67,0 | 85,0 | 73,6 | 82,9 | 92,6 |
| | | | | | |
| 910 | 67,3 | 85,3 | 73,9 | 83,2 | 92,8 |
| 920 | 67,6 | 85,5 | 74,2 | 83,4 | 92,9 |

[a] Recalculated in 2012 by interpolation

**Table D.3 — Uncertainty curves to be used for conversion as in Table D.2**

| To obtain uncertainty $u$, in | of conversion from/to | use |
|---|---|---|
| HRC | HV/HRC | Figure D.1 |
| HV | HRC/HV | Figure D.2 |
| HRA | HV/HRA | Figure D.3 |
| HV | HRA/HV | Figure D.4 |
| HR45N | HV/HR45N | Figure D.5 |
| HR30N | HV/HR30N | Figure D.6 |
| HR15N | HV/HR15N | Figure D.7 |
| HV | HR45N/HV | Figure D.8 |
| HV | HR30N/HV | Figure D.9 |
| HV | HR15N/HV | Figure D.10 |
| HRC | HRA/HRC | Figure D.11 |
| HRC | HR30N/HRC | Figure D.12 |
| NOTE If only HV is given without a number, then most probably HV30 is meant. | | |

**Table D.4 — Conversion between various Vickers hardness scales for high speed steels of steel grades X80WMo6.5, X82WMo6.5, X90WMo6.5, X97WMo3.3, X100WMo6.5, X85WMoCo6.5.5 and X105WMoCo6.5.5**

高速钢（钢号详见英文标题）的不同维氏硬度单位换算值

| HV | HV 10 | HV 5 | HV | HV 10 | HV 5 |
|---|---|---|---|---|---|
| 580 | 587 | 589 | 750 | 760 | 762 |
| 590 | 598 | 599 | | | |
| 600 | 608 | 609 | 760 | 770 | 772 |
| | | | 770 | 780 | 782 |
| 610 | 618 | 620 | 780 | 790 | 792 |
| 620 | 628 | 630 | 790 | 801 | 802 |
| 630 | 638 | 640 | 800 | 811 | 813 |
| 640 | 648 | 650 | 810 | 821 | 823 |
| 650 | 658 | 660 | 820 | 831 | 833 |
| | | | 830 | 841 | 843 |
| 660 | 669 | 670 | 840 | 851 | 853 |
| 670 | 679 | 681 | 850 | 862 | 863 |
| 680 | 689 | 691 | | | |
| 690 | 699 | 701 | 860 | 872 | 874 |
| 700 | 709 | 711 | 870 | 882 | 884 |
| | | | 880 | 892 | 894 |
| 710 | 719 | 721 | 890 | 902 | 904 |
| 720 | 730 | 731 | 900 | 912 | 914 |
| 730 | 740 | 742 | 910 | 923 | 924 |
| 740 | 750 | 752 | 920 | 933 | 935 |
| NOTE If only HV is given without a number, then most probably HV30 is meant. | | | | | |

**Table D.5 — Uncertainty curves to be used for conversion as in Table D.4**

| To obtain uncertainty $u$, in | of conversion from/to | use |
|---|---|---|
| HV 10, HV 5 | HV/HV 10, HV/HV5 | Figure D.13 |
| HV | HV 10/HV, HV5/HV | Figure D.14 |
| NOTE If only HV is given without a number, then most probably HV30 is meant. | | |

**Table D.6 — Conversion between various Vickers hardness scales for high speed steels of steel grade X79WCo18.5**

X79WCo18.5高速钢的不同维氏硬度单位换算值

| HV | HV 10 | HV 5 |
|---|---|---|
| 790 | 795 | 794 |
| 800 | 806 | 805 |
| | | |
| 810 | 817 | 816 |
| 820 | 828 | 826 |
| 830 | 839 | 837 |
| 840 | 850 | 847 |
| 850 | 861 | 858 |
| | | |
| 860 | 872 | 868 |
| 870 | 883 | 879 |
| 880 | 894 | 890 |
| 890 | 905 | 900 |
| 900 | 916 | 911 |
| | | |
| 910 | 927 | 921 |
| 920 | 938 | 932 |
| NOTE If only HV is given without a number, then most probably HV30 is meant. | | |

**Table D.7 — Uncertainty curves to be used for conversion as in Table D.6**

| To obtain uncertainty $u$, in | of conversion from/to | use |
|---|---|---|
| HV 10 | HV/HV 10 | Figure D.15 |
| HV | HV 10/HV | Figure D.16 |
| HV 5 | HV/HV 5 | Figure D.17 |
| HV | HV 5/HV | Figure D.18 |
| NOTE If only HV is given without a number, then most probably HV30 is meant. | | |

**Table D.8 — Conversion of hardness-to-hardness values for high speed steels of steel grade X110MoCo9.8**

X110MoCo9.8高速钢的硬度-硬度换算值

| Vickers hardness | | | Rockwell hardness | | | | |
|---|---|---|---|---|---|---|---|
| HV | HV 10 | HV 5 | HRC | HRA | HR45N | HR30N | HR15N |
| 740 | – | – | – | 82,0 | 67,8 | 77,9 | 90,7 |
| 750 | – | – | – | 82,2 | 68,1 | 78,3 | 90,8 |
| | | | | | | | |
| 760 | – | – | 63,2 | 82,5 | 68,4 | 78,6 | 90,9 |
| 770 | 768 | 759 | 63,5 | 82,7 | 68,8 | 79,0 | 91,0 |
| 780 | 779 | 770 | 63,9 | 82,9 | 69,1 | 79,3 | 91,1 |
| 790 | 790 | 781 | 64,2 | 83,1 | 69,4 | 79,6 | 91,2 |
| 800 | 801 | 791 | 64,5 | 83,3 | 69,7 | 79,9 | 91,3 |
| | | | | | | | |
| 810 | 812 | 802 | 64,8 | 83,5 | 70,0 | 80,2 | 91,4 |
| 820 | 822 | 813 | 65,1 | 83,7 | 70,3 | 80,5 | 91,6 |
| 830 | 833 | 823 | 65,4 | 83,9 | 70,6 | 80,8 | 91,7 |
| 840 | 844 | 834 | 65,7 | 84,1 | 71,0 | 81,0 | 91,8 |
| 850 | 855 | 845 | 66,0 | 84,2 | 71,3 | 81,3 | 91,9 |
| | | | | | | | |
| 860 | 866 | 856 | 66,3 | 84,4 | 71,6 | 81,5 | 92,0 |
| 870 | 876 | 866 | 66,6 | 84,5 | 71,9 | 81,8 | 92,1 |
| 880 | 887 | 877 | 66,9 | 84,7 | 72,2 | 82,0 | 92,2 |
| 890 | 898 | 888 | 67,1 | 84,8 | 72,5 | 82,3 | 92,4 |
| 900 | 909 | 899 | 67,4 | 85,0 | 72,8 | 82,5 | 92,5 |
| | | | | | | | |
| 910 | 920 | 909 | 67,6 | 85,1 | 73,1 | 82,7 | 92,6 |
| 920 | 931 | 920 | 67,9 | 85,3 | 73,4 | 83,0 | 92,7 |
| 930 | 942 | 931 | 68,2 | 85,4 | 73,7 | 83,2 | 92,8 |
| 940 | – | – | 68,5 | 85,5 | 74,0 | 83,4 | 92,9 |
| 950 | – | – | – | 85,7 | 74,3 | 83,6 | 93,0 |

NOTE If only HV is given without a number, then most probably HV30 is meant.

**Table D.9 — Uncertainty curves to be used for conversion as in Table D.8**

| To obtain uncertainty $u$, in | of conversion from/to | use |
|---|---|---|
| HV10 | HV/HV10 | Figure D.15 |
| HV | HV10/HV | Figure D.16 |
| HV5 | HV/HV5 | Figure D.17 |
| HV | HV5/HV | Figure D.18 |
| HRC | HV/HRC | Figure D.19 |
| HV | HRC/HV | Figure D.20 |
| HRA | HV/HRA | Figure D.21 |
| HV | HRA/HV | Figure D.22 |
| HR45N | HV/HR45N | Figure D.23 |
| HV | HR45N/HV | Figure D.24 |
| HR30N | HV/HR30N | Figure D.25 |
| HV | HR30N/HV | Figure D.26 |
| HR15N | HV/HR15N | Figure D.27 |
| HV | HR15N/HV | Figure D.28 |
| HRC | HRA/HRC | Figure D.29 |
| HRC | HR30N/HRC | Figure D.30 |
| NOTE If only HV is given without a number, then most probably HV30 is meant. | | |

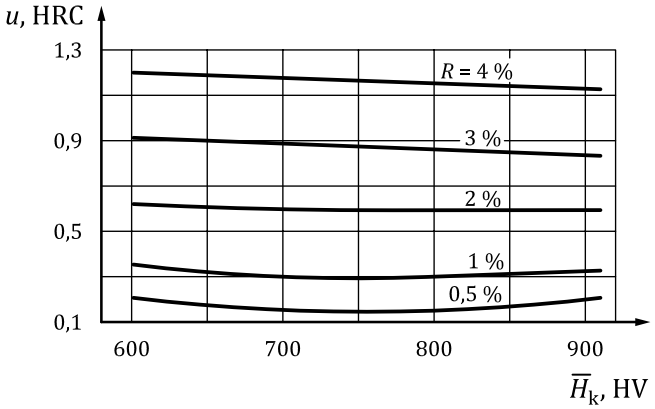



**Figure D.1**

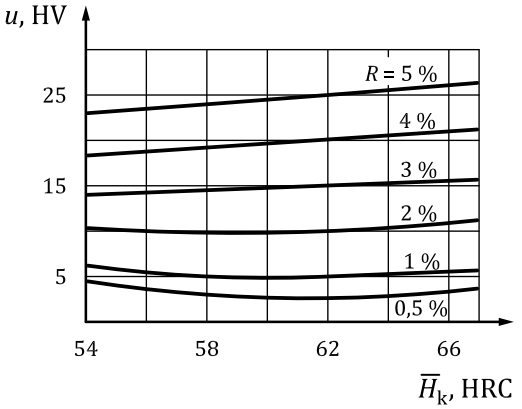



**Figure D.2**

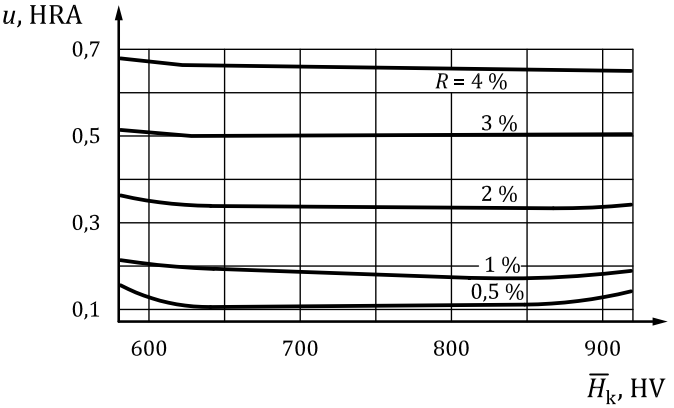



**Figure D.3**

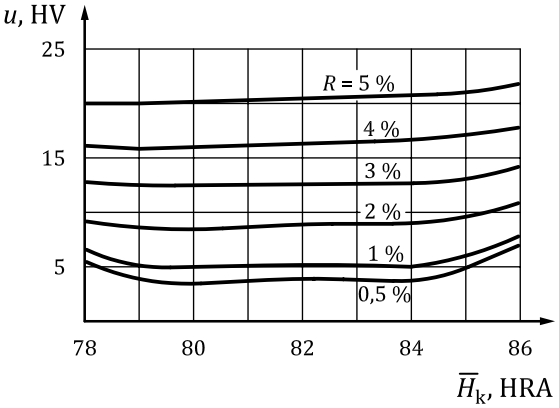



**Figure D.4**

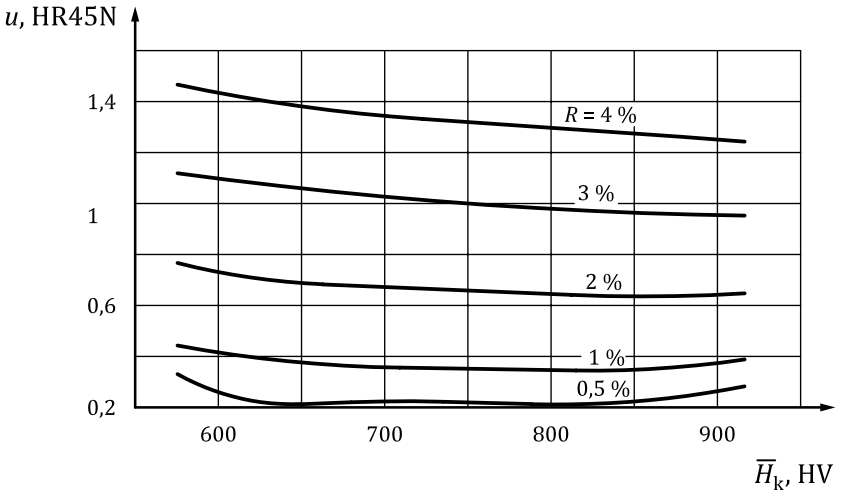



**Figure D.5**

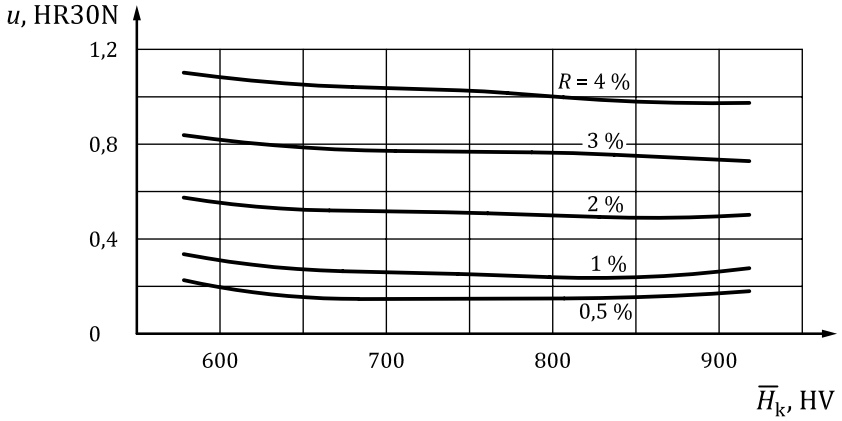



**Figure D.6**

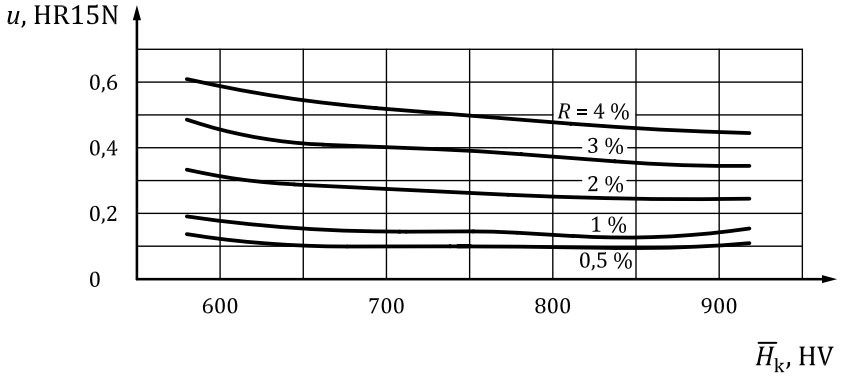



**Figure D.7**

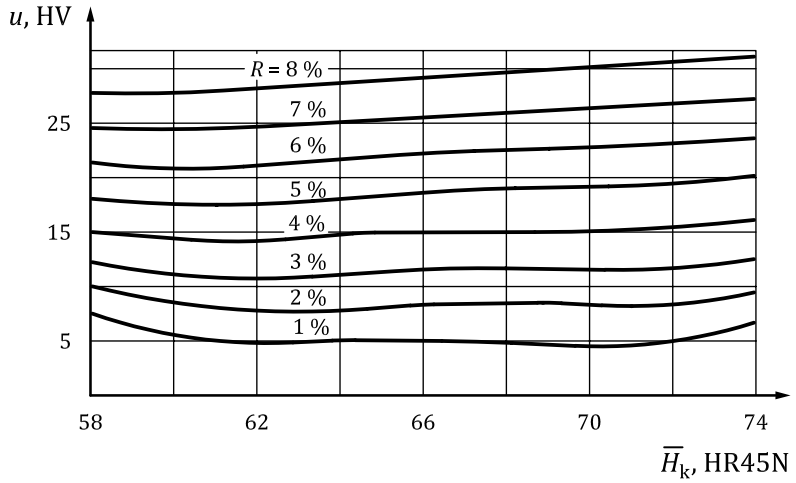



**Figure D.8**

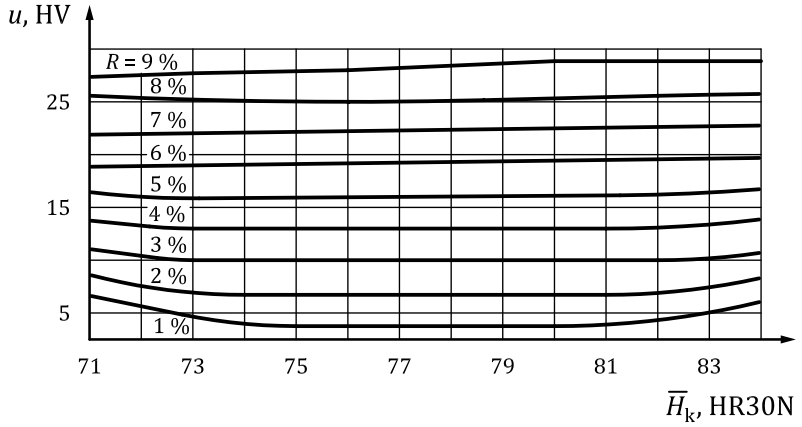



**Figure D.9**

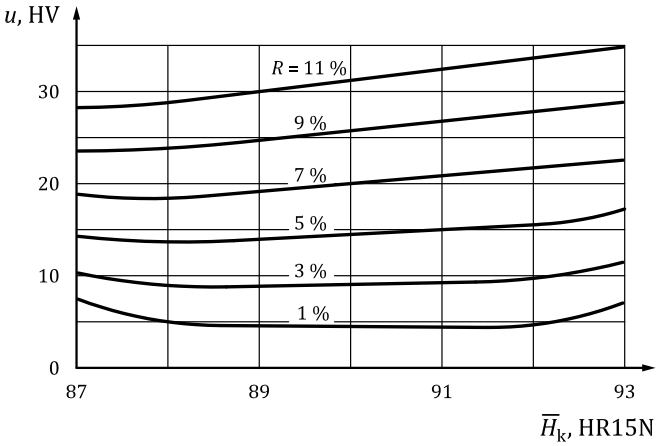



**Figure D.10**

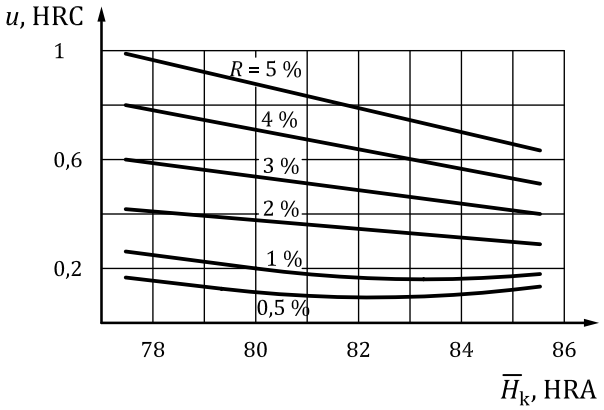



**Figure D.11**

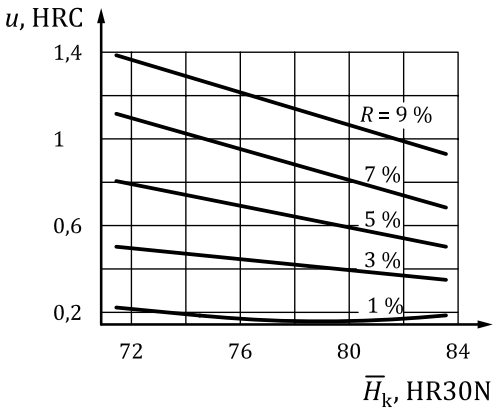



**Figure D.12**

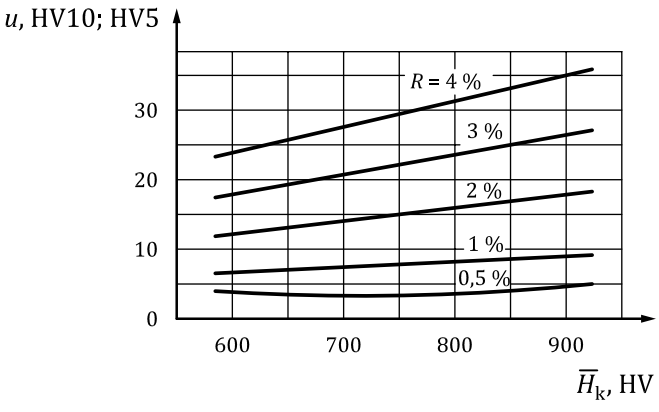



**Figure D.13**

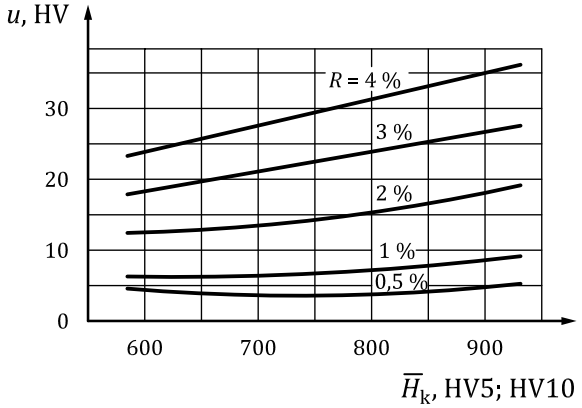



**Figure D.14**

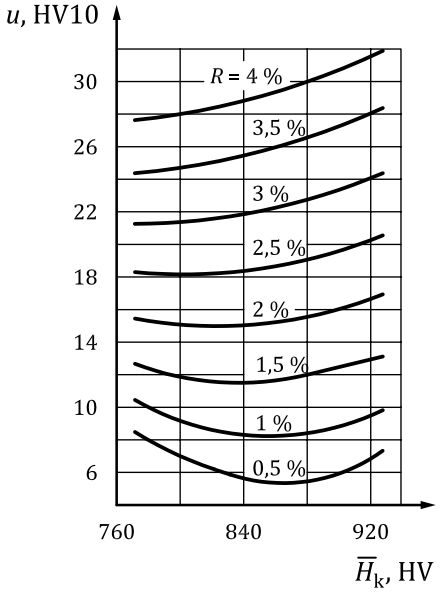



**Figure D.15**

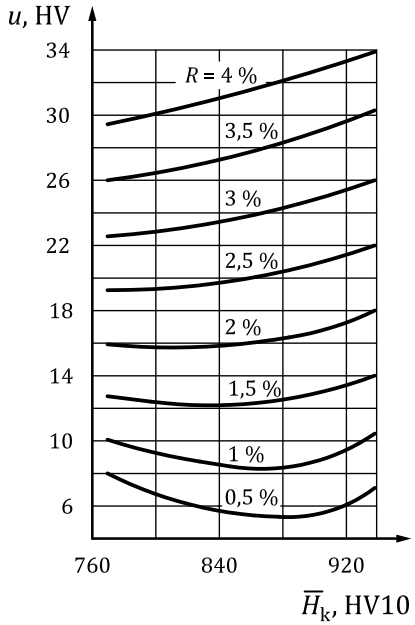



**Figure D.16**

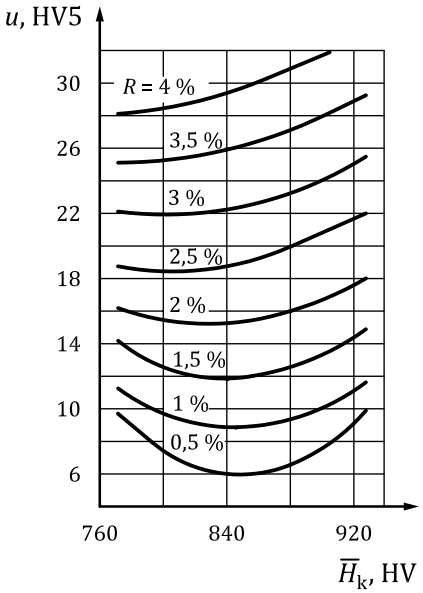



**Figure D.17**

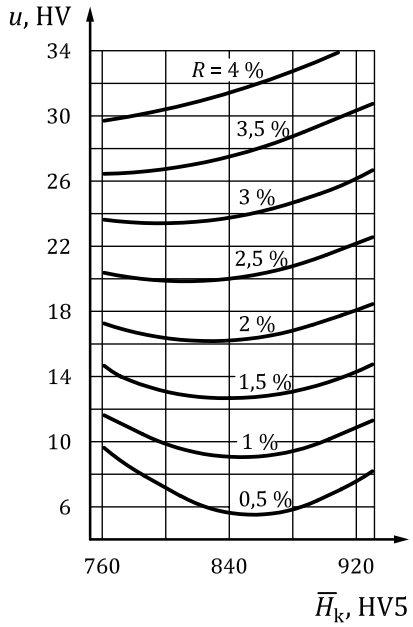



**Figure D.18**

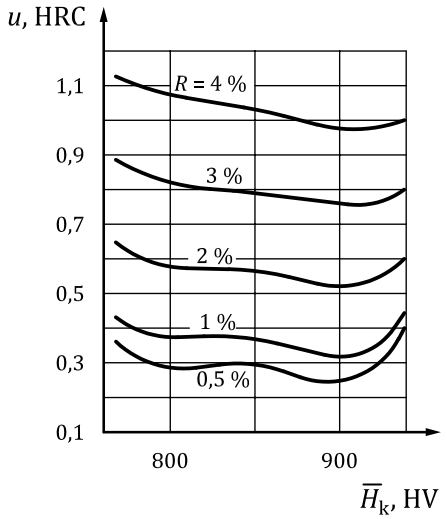



**Figure D.19**

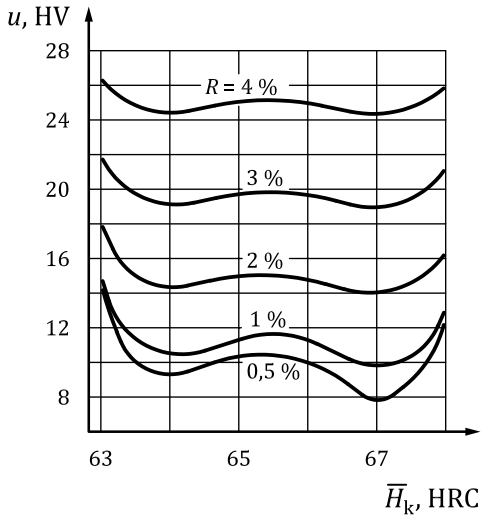



**Figure D.20**

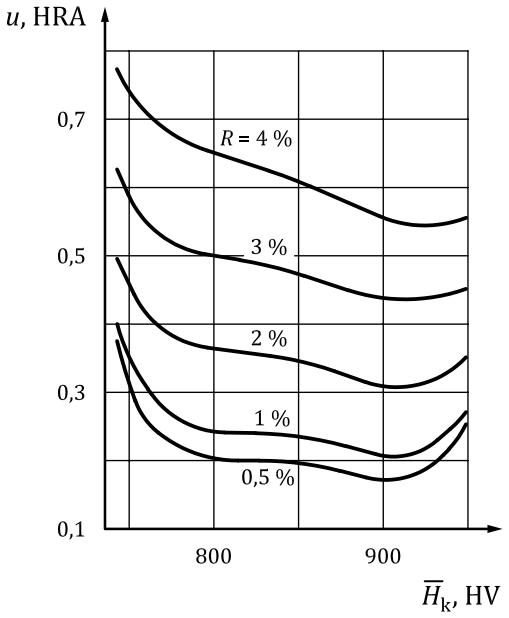



**Figure D.21**

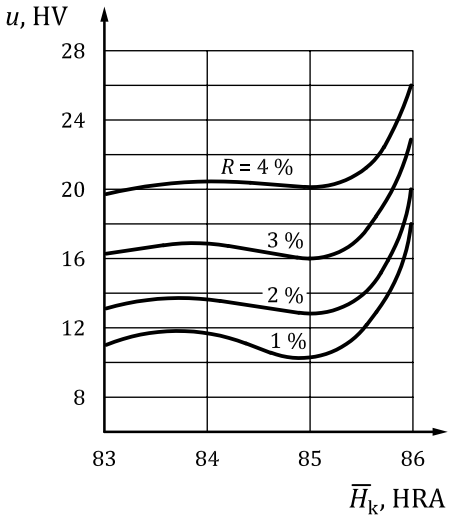



**Figure D.22**

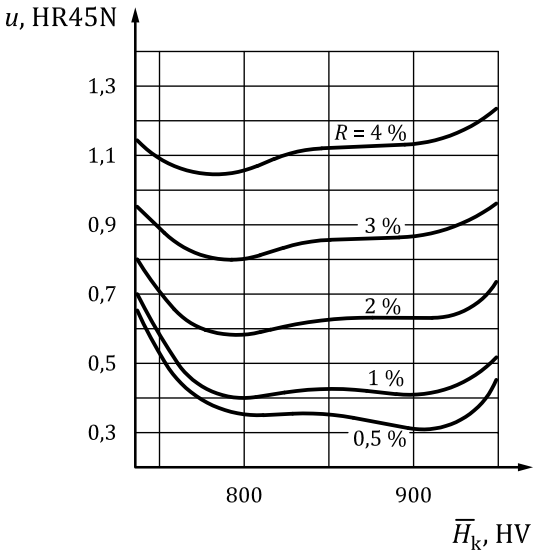



**Figure D.23**

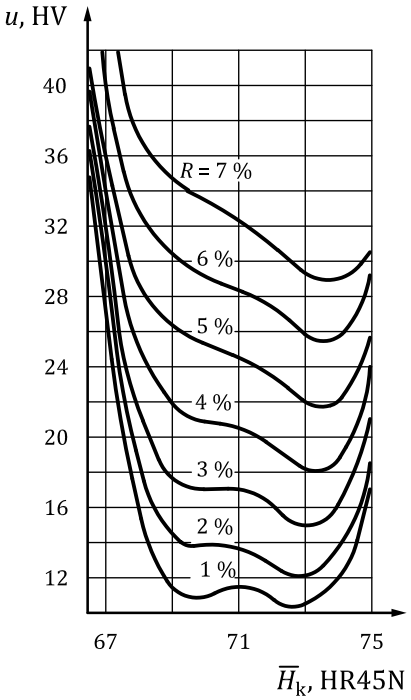



**Figure D.24**

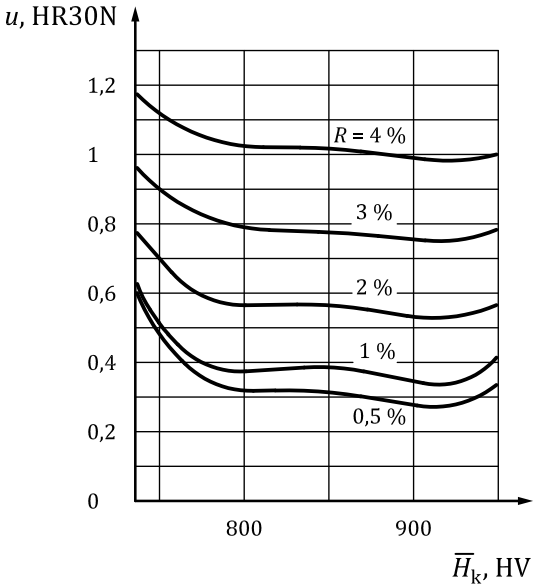



**Figure D.25**

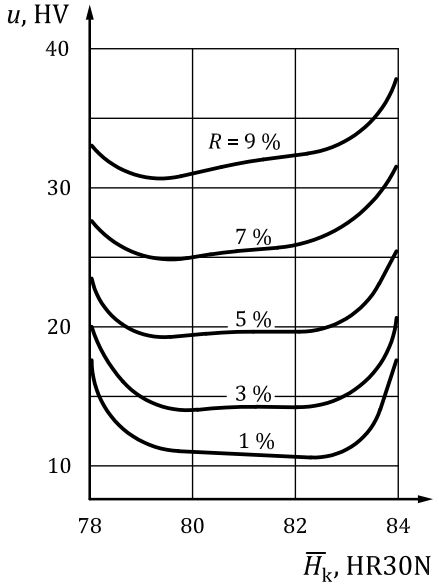



**Figure D.26**

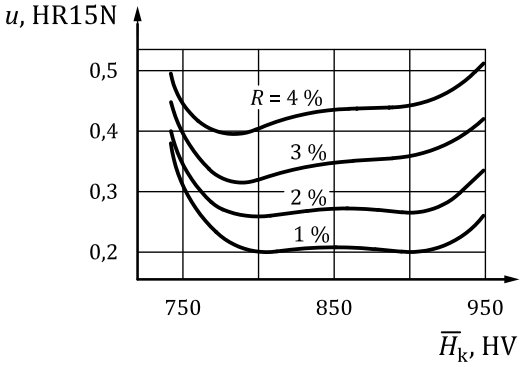



**Figure D.27**

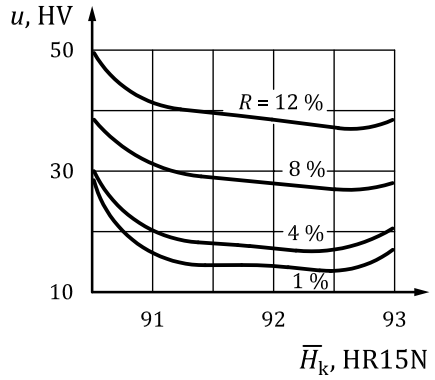



**Figure D.28**

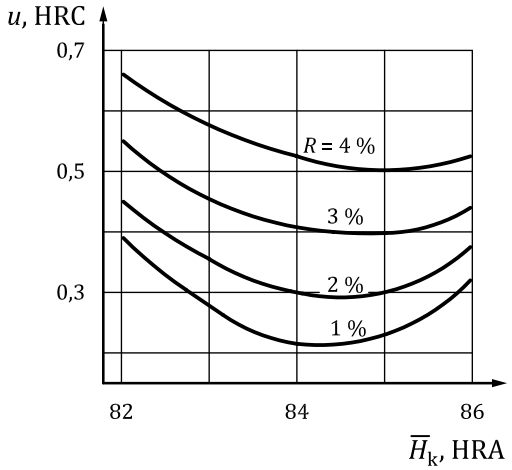



**Figure D.29**

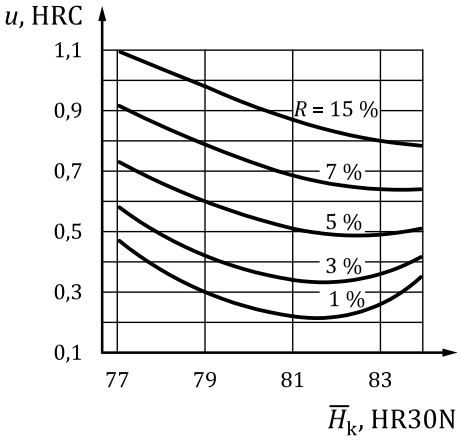



**Figure D.30**

# Annex E
(informative)

# Conversion tables for hardmetals

**WARNING — Hardness conversions are no substitute for direct measurements. These tables should be used with caution and only in accordance with the principles of conversions, see Clause 2.**

The conversion values presented here for hardmetals are based on results of testing carried out on the hardmetals as in TGL 7965-02, listed in Table E.1. Table E.2 lists the conversion values, while Table E.3 gives an overview of the uncertainty curves presented in Figures E.1 and E.2 which are to be used in conjunction with the conversion tables.

NOTE A useful reference book is [24]. It provides information for the comparison of different national and international steel designations with regard to their compositions.

**Table E.1 — Designation and chemical composition of hardmetals tested**

| Hardmetal grade as in TGL 7965-02 | WC content (% m/m) | TiC content (% m/m) | TaC and NbC (% m/m) | Co content (% m/m) |
|---|---|---|---|---|
| HS 021 | 65,8 | 23,0 | 8,0 | 3,2 |
| HS 123 | 67,3 | 16,8 | 7,9 | 8,0 |
| HS 10 | 69,0 | 17,0 | 8,0 | 6,0 |
| HS 20 | 74,0 | 12,0 | 6,0 | 8,0 |
| HS 25 | 76,0 | 5,0 | 10,0 | 9,0 |
| HS 30 | 83,0 | 5,0 | 5,0 | 7,0 |
| HS 345 | 76,9 | 7,2 | 7,2 | 8,7 |
| HS 40 | 82,0 | 5,0 | 4,0 | 9,0 |
| HS 50 | 80,0 | 5,0 | 3,0 | 12,0 |
| HG 01 | 96,0 | | | 4,0 |
| HG 110 | 94,0 | | | 6,0 |
| HG 20 | 94,0 | | | 6,0 |
| HG 30 | 91,5 | | | 8,5 |
| HG 40 | 89,0 | | | 11,0 |
| HG 50 | 85,0 | | | 15,0 |
| HG 60 | 80,0 | | | 20,0 |
| HU 10 | 79,0 | 10,0 | 5,0 | 6,0 |

**Table E.2 — Conversion from HV 50 values to HRA values of hardmetals**

硬质合金的HV 50到HRA换算值

| Vickers hardness<br>HV 50 | Rockwell hardness<br>HRA |
|---|---|
| 780 | 82,5 |
| 800 | 82,8 |
| | |
| 820 | 83,1 |
| 840 | 83,4 |
| 860 | 83,7 |
| 880 | 84,0 |
| 900 | 84,2 |
| | |
| 920 | 84,5 |
| 940 | 84,8 |
| 960 | 85,1 |
| 980 | 85,3 |
| 1 000 | 85,6 |
| 1 020 | 85,8 |
| 1 040 | 86,1 |
| 1 060 | 86,4 |
| 1 080 | 86,6 |
| 1 100 | 86,8 |
| | |
| 1 120 | 87,1 |
| 1 140 | 87,3 |
| 1 160 | 87,6 |
| 1 180 | 87,8 |
| 1 200 | 88,0 |
| | |
| 1 220 | (88,2) |
| 1 240 | (88,4) |
| 1 260 | (88,7) |
| 1 280 | (88,9) |
| 1 300 | (89,1) |
| | |
| 1 320 | (89,3) |
| 1 340 | (89,5) |
| 1 360 | (89,7) |
| 1 380 | (89,9) |
| 1 400 | (90,1) |

NOTE Values in parentheses are those lying outside the defined range of the standard test method but which may used as estimates.

**Table E.2** *(continued)*

| Vickers hardness HV 50 | Rockwell hardness HRA |
|---|---|
| 1 420 | (90,3) |
| 1 440 | (90,5) |
| 1 460 | (90,7) |
| 1 480 | (90,9) |
| 1 500 | (91,0) |
| | |
| 1 520 | (91,2) |
| 1 540 | (91,4) |
| 1 560 | (91,6) |
| 1 580 | (91,8) |
| 1 600 | (91,9) |
| | |
| 1 620 | (92,1) |
| 1 640 | (92,3) |
| 1 660 | (92,4) |
| 1 680 | (92,6) |
| 1 700 | (92,8) |
| | |
| 1 720 | (92,9) |
| 1 740 | (93,1) |
| 1 760 | (93,2) |

NOTE Values in parentheses are those lying outside the defined range of the standard test method but which may used as estimates.

**Table E.3 — Uncertainty curves to be used for conversion as in Table E.2**

| To obtain uncertainty $u$, in | of conversion from/to | use |
|---|---|---|
| HRA | HV 50/HRA | Figure E.1 |
| HV 50 | HRA/HV 50 | Figure E.2 |

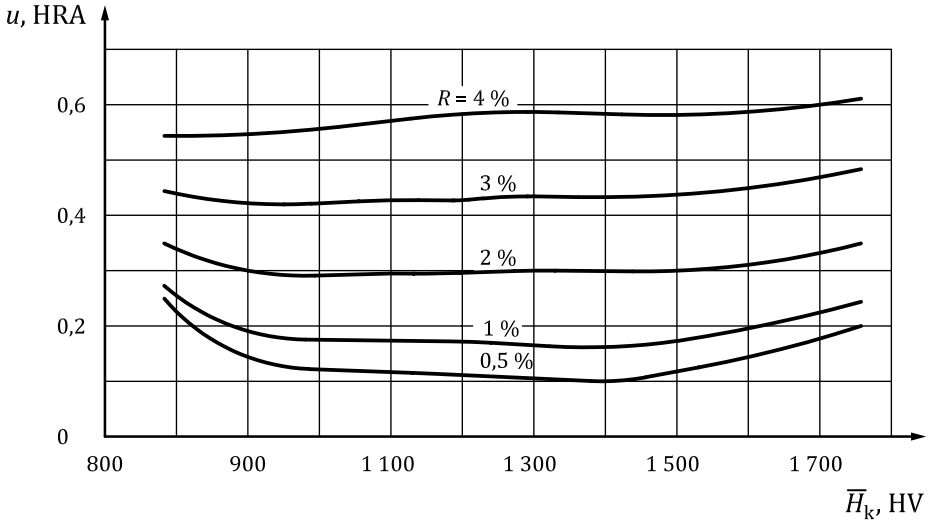



**Figure E.1**

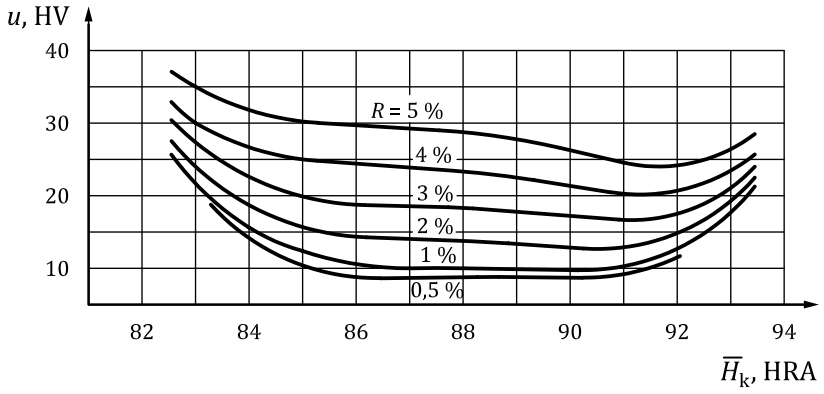



**Figure E.2**

# Annex F
(informative)

# Conversion tables for non-ferrous metals and alloys

**WARNING — Hardness conversions are no substitute for direct measurements. These tables should be used with caution and only in accordance with the principles of conversions, see Clause 2. The user of Annex F should consider that the given metals and alloys in most cases are not specified with respect to their composition and treatment conditions.**

The following tables are provided.

## Table F.1 — Nickel and High-Nickel Alloys (ASTM E 140-97, Table 3)

镍及高镍合金硬度换算表

| HV | HB | Rockwell Hardness Number | | | | | | | | | | | | | | HK |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HV1, HV5, HV10, HV30 | HBS 10/3000 | HRA | HRB | HRC | HRD | HRE | HRF | HRG | HRK | HR15N | HR30N | HR45N | HR15T | HR30T | HR45T | HK0,5, HK1 |
| 513 | (479) | 75,5 | ... | 50,0 | 63,0 | ... | ... | ... | ... | 85,5 | 68,0 | 54,5 | ... | ... | ... | ... |
| 481 | 450 | 74,5 | ... | 48,0 | 61,5 | ... | ... | ... | ... | 84,5 | 66,5 | 52,5 | ... | ... | ... | ... |
| 452 | 425 | 73,5 | ... | 46,0 | 60,0 | ... | ... | ... | ... | 83,5 | 64,5 | 50,0 | ... | ... | ... | ... |
| 427 | 403 | 72,5 | ... | 44,0 | 58,5 | ... | ... | ... | ... | 82,5 | 63,0 | 47,5 | ... | ... | ... | ... |
| 404 | 382 | 71,5 | ... | 42,0 | 57,0 | ... | ... | ... | ... | 81,5 | 61,0 | 45,5 | ... | ... | ... | ... |
| 382 | 363 | 70,5 | ... | 40,0 | 55,5 | ... | ... | ... | ... | 80,5 | 59,5 | 43,0 | ... | ... | ... | 436 |
| 362 | 346 | 69,5 | ... | 38,0 | 54,0 | ... | ... | ... | ... | 79,5 | 58,0 | 41,0 | ... | ... | ... | 413 |
| 344 | 329 | 68,5 | ... | 36,0 | 52,5 | ... | ... | ... | ... | 78,5 | 56,0 | 38,5 | ... | ... | ... | 392 |
| 326 | 313 | 67,5 | ... | 34,0 | 50,5 | ... | ... | ... | ... | 77,5 | 54,5 | 36,0 | ... | ... | ... | 372 |
| 309 | 298 | 66,5 | (106) | 32,0 | 49,5 | ... | (116,5) | 94,0 | ... | 76,5 | 52,5 | 34,0 | 94,5 | 85,5 | 77,0 | 352 |
| 285 | 275 | 64,5 | (104) | 28,5 | 46,5 | ... | (115,5) | 91,0 | ... | 75,0 | 49,5 | 30,0 | 94,0 | 84,5 | 75,0 | 325 |
| 266 | 258 | 63,0 | (102) | 25,5 | 44,5 | ... | (114,5) | 87,5 | ... | 73,5 | 47,0 | 26,5 | 93,0 | 83,0 | 73,0 | 304 |
| 248 | 241 | 61,5 | 100 | 22,5 | 42,0 | ... | (113,0) | 84,5 | ... | 72,0 | 44,5 | 23,0 | 92,5 | 81,5 | 71,0 | 283 |
| 234 | 228 | 60,5 | 98 | 20,0 | 40,0 | ... | (112,0) | 81,5 | ... | 70,5 | 42,0 | 20,0 | 92,0 | 80,5 | 69,0 | 267 |
| 220 | 215 | 59,0 | 96 | (17,0) | 38,0 | ... | (111,0) | 78,5 | 100,0 | 69,0 | 39,5 | 17,0 | 91,0 | 79,0 | 67,0 | 251 |
| 209 | 204 | 57,5 | 94 | (14,5) | 36,0 | ... | (110,0) | 75,5 | 98,0 | 68,0 | 37,5 | 14,0 | 90,5 | 77,5 | 65,0 | 239 |
| 198 | 194 | 56,5 | 92 | (12,0) | 34,0 | ... | (108,5) | 72,0 | 96,5 | 66,5 | 35,5 | 11,0 | 89,5 | 76,0 | 63,0 | 226 |
| 188 | 184 | 55,0 | 90 | (9,0) | 32,0 | (108,5) | (107,5) | 69,0 | 94,5 | 65,0 | 32,5 | 7,5 | 89,0 | 75,0 | 61,0 | 215 |
| 179 | 176 | 53,5 | 88 | (6,5) | 30,0 | (107,0) | (106,5) | 65,5 | 93,0 | 64,0 | 30,5 | 5,0 | 88,0 | 73,5 | 59,5 | 204 |
| 171 | 168 | 52,5 | 86 | (4,0) | 28,0 | (106,0) | (105,0) | 62,5 | 91,0 | 62,5 | 28,5 | 2,0 | 87,5 | 72,0 | 57,5 | 195 |
| 164 | 161 | 51,5 | 84 | (2,0) | 26,5 | (104,5) | (104,0) | 59,5 | 89,0 | 61,5 | 26,5 | (-0,5) | 87,0 | 70,5 | 55,5 | 187 |
| 157 | 155 | 50,0 | 82 | ... | 24,5 | (103,0) | (103,0) | 56,5 | 87,5 | ... | ... | ... | 86,0 | 69,5 | 53,5 | 179 |
| 151 | 149 | 49,0 | 80 | ... | 22,5 | (102,0) | (101,5) | 53,0 | 85,5 | ... | ... | ... | 85,5 | 68,0 | 51,5 | 173 |
| 145 | 144 | 47,5 | 78 | ... | 21.0 | (100,6) [a] | (100,5) | 50,0 | 83,5 | ... | ... | ... | 84,5 | 66,5 | 49,5 | 166 |
| 140 | 139 | 46,5 | 76 | ... | (19,0) | 99,5 | 99,5 | 47,0 | 82,0 | ... | ... | ... | 84,0 | 65,5 | 47,5 | 160 |
| 135 | 134 | 45,5 | 74 | ... | (17,5) | 98,0 | 98,5 | 43,5 | 80,0 | ... | ... | ... | 83,0 | 64,0 | 45,5 | 154 |

[a] Recalculated in 2012 by interpolation

The use of the hardness scales for the hardness values shown in parentheses is not recommended since they are beyond the ranges recommended for accuracy. Such values are shown for comparative purposes only, where comparisons may be desired and the recommended machine and scale are not available.

**Table F.1** *(continued)*

| HV | HB | Rockwell Hardness Number | | | | | | | | | | | | | | HK |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HV1, HV5, HV10, HV30 | HBS 10/3000 | HRA | HRB | HRC | HRD | HRE | HRF | HRG | HRK | HR15N | HR30N | HR45N | HR15T | HR30T | HR45T | HK0,5, HK1 |
| 130 | 129 | 44,0 | 72 | … | (16,0) | 97,0 | 97,0 | 40,5 | 78,0 | … | … | … | 82,5 | 62,5 | 43,5 | 149 |
| 126 | 125 | 43,0 | 70 | … | (14,5) | 95,5 | 96,0 | 37,5 | 76,5 | … | … | … | 82,0 | 61,0 | 41,5 | 144 |
| 122 | 121 | 42,0 | 68 | … | (13,0) | 94,5 | 95,0 | 34,5 | 74,5 | … | … | … | 81,0 | 60,0 | 39,5 | 140 |
| 119 | 118 | 41,0 | 66 | … | (11,5) | 93,0 | 93,5 | 31,0 | 72,5 | … | … | … | 80,5 | 58,5 | 37,5 | 136 |
| 115 | 114 | 40,0 | 64 | … | (10,0) | 91,5 | 92,5 | … | 71,0 | … | … | … | 79,5 | 57,0 | 35,5 | … |
| 112 | 111 | 39,0 | 62 | … | (8,0) | 90,5 | 91,5 | … | 69,0 | … | … | … | 79,0 | 56,0 | 33,5 | … |
| 108 | 108 | … | 60 | … | … | 89,0 | 90,0 | … | 67,5 | … | … | … | 78,5 | 54,5 | 31,5 | … |
| 106 | 106 | … | 58 | … | … | 88,0 | 89,0 | … | 65,5 | … | … | … | 77,5 | 53,0 | 29,5 | … |
| 103 | 103 | … | 56 | … | … | 86,5 | 88,0 | … | 63,5 | … | … | … | 77,0 | 51,5 | 27,5 | … |
| 100 | 100 | … | 54 | … | … | 85,5 | 87,0 | … | 62,0 | … | … | … | 76,0 | 50,5 | 25,5 | … |
| 98 | 98 | … | 52 | … | … | 84,0 | 85,5 | … | 60,0 | … | … | … | 75,5 | 49,0 | 23,5 | … |
| 95 | 95 | … | 50 | … | … | 83,0 | 84,5 | … | 58,0 | … | … | … | 74,5 | 47,5 | 21,5 | … |
| 93 | 93 | … | 48 | … | … | 81,5 | 83,5 | … | 56,5 | … | … | … | 74,0 | 46,5 | 19,5 | … |
| 91 | 91 | … | 46 | … | … | 80,5 | 82,0 | … | 54,5 | … | … | … | 73,5 | 45,0 | 17,0 | … |
| 89 | 89 | … | 44 | … | … | 79,0 | 81,0 | … | 52,5 | … | … | … | 72,5 | 43,5 | 14,5 | … |
| 87 | 87 | … | 42 | … | … | 78,0 | 80,0 | … | 51,0 | … | … | … | 72,0 | 42,0 | 12,5 | … |
| 85 | 85 | … | 40 | … | … | 76,5 | 79,0 | … | 49,0 | … | … | … | 71,0 | 41,0 | 10,0 | … |
| 83 | 83 | … | 38 | … | … | 75,0 | 77,5 | … | 47,0 | … | … | … | 70,5 | 39,5 | 7,5 | … |
| 81 | 81 | … | 36 | … | … | 74,0 | 76,5 | … | 45,5 | … | … | … | 70,0 | 38,0 | 5,5 | … |
| 79 | 79 | … | 34 | … | … | 72,5 | 75,5 | … | 43,5 | … | … | … | 69,0 | 36,5 | 3,0 | … |
| 78 | 78 | … | 32 | … | … | 71,5 | 74,0 | … | 42,0 | … | … | … | 68,5 | 35,5 | 1,0 | … |
| 77 | 77 | … | 30 | … | … | 70,0 | 73,0 | … | 40,0 | … | … | … | 67,5 | 34,0 | | … |

[a] Recalculated in 2012 by interpolation

The use of the hardness scales for the hardness values shown in parentheses is not recommended since they are beyond the ranges recommended for accuracy. Such values are shown for comparative purposes only, where comparisons may be desired and the recommended machine and scale are not available.

## Table F.2 — Cartridge brass (70 % Copper, 30 % Zinc Alloy) (ASTM E 140-97, Table 4)

弹壳黄铜（70%铜、30%锌）硬度换算表

| HV 30 | Rockwell Hardness Number | | | | | HB |
|---|---|---|---|---|---|---|
| | HRB | HRF | HR15T | HR30T | HR45T | HBS10/500 |
| 196 | 93,5 | 110,0 | 90.0 | 77,5 | 66,0 | 169 |
| 194 | ... | 109,5 | ... | ... | 65,5 | 167 |
| 192 | 93,0 | ... | ... | 77,0 | 65,0 | 166 |
| 190 | 92,5 | 109,0 | ... | 76,5 | 64,5 | 164 |
| 188 | 92,0 | ... | 89,5 | ... | 64,0 | 162 |
| 186 | 91,5 | 108,5 | ... | 76,0 | 63,5 | 161 |
| 184 | 91,0 | ... | ... | 75,5 | 63,0 | 159 |
| 182 | 90,5 | 108,0 | 89,0 | ... | 62,5 | 157 |
| 180 | 90,0 | 107,5 | ... | 74,5 | 62,0 | 156 |
| 178 | 89,0 | ... | ... | ... | 61,5 | 154 |
| 176 | 88,5 | 107,0 | ... | ... | 61,0 | 152 |
| 174 | 88,0 | ... | 88,5 | 74,0 | 60,5 | 150 |
| 172 | 87,5 | 106,5 | ... | 73,5 | 60,0 | 149 |
| 170 | 87,0 | ... | ... | ... | 59,5 | 147 |
| 168 | 86,0 | 106,0 | 88,0 | 73,0 | 59,0 | 146 |
| 166 | 85,5 | ... | ... | 72,5 | 58,5 | 144 |
| 164 | 85,0 | 105,5 | ... | 72,0 | 58,0 | 142 |
| 162 | 84,0 | 105,0 | 87,5 | ... | 57,5 | 141 |
| 160 | 83,5 | ... | ... | 71,5 | 56,5 | 139 |
| 158 | 83,0 | 104,5 | ... | 71,0 | 56,0 | 138 |
| 156 | 82,0 | 104,0 | 87,0 | 70,5 | 55,5 | 136 |
| 154 | 81,5 | 103,5 | ... | 70,0 | 54,5 | 135 |
| 152 | 80,5 | 103,0 | ... | ... | 54,0 | 133 |
| 150 | 80,0 | ... | 86,5 | 69,5 | 53,5 | 131 |
| 148 | 79,0 | 102,5 | ... | 69,0 | 53,0 | 129 |
| 146 | 78,0 | 102,0 | ... | 68,5 | 52,5 | 128 |
| 144 | 77,5 | 101,5 | 86,0 | 68,0 | 51,5 | 126 |
| 142 | 77,0 | 101,0 | ... | 67,5 | 51,0 | 124 |

[a]Recalculated in 2012 by interpolation

**Table F.2** *(continued)*

| HV 30 | Rockwell Hardness Number | | | | | HB |
|---|---|---|---|---|---|---|
| | HRB | HRF | HR15T | HR30T | HR45T | HBS10/500 |
| 140 | 76,0 | 100,5 | 85,5 | 67,0 | 50,0 | 122 |
| 138 | 75,0 | 100,0 | … | 66,5 | 49,0 | 121 |
| 136 | 74,5 | 99,5 | 85,0 | 66,0 | 48,0 | 120 |
| 134 | 73,5 | 99,0 | … | 65,5 | 47,5 | 118 |
| 132 | 73,0 | 98,5 | 84,5 | 65,0 | 46,5 | 116 |
| 130 | 72,0 | 98,0 | 84,0 | 64,5 | 45,5 | 114 |
| 128 | 71,0 | 97,5 | … | 63,5 | 45,0 | 113 |
| 126 | 70,0 | 97,0 | 83,5 | 63,0 | 44,0 | 112 |
| 124 | 69,0 | 96,5 | … | 62,5 | 43,0 | 110 |
| 122 | 68,0 | 96,0 | 83,0 | 62,0 | 42,0 | 108 |
| 120 | 67,0 | 95,5 | … | 61,0 | 41,0 | 106 |
| 118 | 66,0 | 95,0 | 82,5 | 60,5 | 40,0 | 105 |
| 116 | 65,0 | 94,5 | 82,0 | 60,0 | 39,0 | 103 |
| 114 | 64,0 | 94,0 | 81,5 | 59,5 | 38,0 | 101 |
| 112 | 63,0 | 93,0 | 81,0 | 58,5 | 37,0 | 99 |
| 110 | 62,0 | 92,6 | 80,5 | 58,0 | 35,5 | 97 |
| 108 | 61,0 | 92,0 | … | 57,0 | 34,5 | 95 |
| 106 | 59,5 | 91,2 | 80,0 | 56,0 | 33,0 | 94 |
| 104 | 58,0 | 90,5 | 79,5 | 55,0 | 32,0 | 92 |
| 102 | 57,0 | 89,8 | 79,0 | 54,5 | 30,5 | 90 |
| 100 | 56,0 | 89,0 | 78,5 | 53,5 | 29,5 | 88 |
| 98 | 54,0 | 88,0 | 78,0 | 52,5 | 28,0 | 86 |
| 96 | 53,0 | 87,2 | 77,5 | 51,5 | 26,5 | 85 |
| 94 | 51,0 | 86,3 | 77,0 | 50,5 | 24,5 | 83 |
| 92 | 49,5 | 85,4 | 76,5 | 49,0 | 23,0 | 82 |
| 90 | 47,5 | 84,4 | 75,5 | 48,0 | 21,0 | 80 |
| 88 | 46,0 | 83,5 | 75,0 | 47,0 | 19,0 | 79 |
| 86 | 44,0 | 82,3 | 74,5 | 45,5 | 17,0 | 77 |

[a] Recalculated in 2012 by interpolation

**Table F.2** *(continued)*

| HV 30 | Rockwell Hardness Number | | | | | HB |
|---|---|---|---|---|---|---|
| | HRB | HRF | HR15T | HR30T | HR45T | HBS10/500 |
| 84 | 42,0 | 81,2 | 72,5 | 44,0 | 14,5 | 76 |
| 82 | 40,0 | 80,0 | 73,0 | 43,0 | 12,5 | 74 |
| 80 | 37,5 | 78,6 | 72,0 | 41,0 | 10,0 | 72 |
| 78 | 35,0 | 77,4 | 71,5 | 39,5 | 7,5 | 70 |
| 76 | 32,5 | 76,0 | 70,5 | 38,0 | 4,5 | 68 |
| 74 | 30,0 | 74,8 | 70,0 | 36,0 | 1,0 | 66 |
| 72 | 27,5 | 73,2 | 69,0 | 34,0 | ... | 64 |
| 70 | 24,5 | 71,8 | 68,0 | 32,0 | ... | 63 |
| 68 | 21,5 | 70,0 | 67,0 | 30,0 | ... | 62 |
| 66 | 18,5 | 68,5 | 66,0 | 27,8 [a] | ... | 61 |
| 64 | 15,5 | 66,8 | 65,0 | 25,5 | ... | 59 |
| 62 | 12,5 | 65,0 | 63,5 | 23,0 | ... | 57 |
| 60 | 10,0 | 62,5 | 62,5 | 20,5 | ... | 55 |
| 58 | ... | 61,0 | 61,0 | 18,0 | ... | 53 |
| 56 | ... | 58,8 | 60,0 | 15,0 | ... | 52 |
| 54 | ... | 56,5 | 58,5 | 12,0 | ... | 50 |
| 52 | ... | 53,5 | 57,0 | ... | ... | 48 |
| 50 | ... | 50,5 | 55,5 | ... | ... | 47 |
| 48 | ... | 49,0 | 54,5 | ... | ... | 46 |
| 47 | ... | 47,0 | 53,5 | ... | ... | 45 |
| 46 | ... | 45,0 | ... | ... | ... | 44 |
| 45 | ... | 40,0 | ... | ... | ... | 42 |

[a] Recalculated in 2012 by interpolation

## Table F.3 — Copper (ASTM E 140-97, Table 7)

紫铜硬度换算表

| Vickers Hardness Number | | Knoop Hardness Number | | Rockwell Hardness Number | | | | | | | | Brinell Hardness Number | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HV1 | HV0,1 | HK1 | HK0,5 | HR15T | HR15T | HR30T | HRB | HRF | HR15T | HR30T | HR45T | HBS 10/500 | HBS 2/20 |
| | | | | Strip 0,25 mm | Strip 0,51 mm | | | Strip 1,02 mm and greater | | | | Strip 2,03 mm | Strip 1,02 mm |
| 130 | 127,0 | 138,7 | 133,8 | ... | 85,0 | ... | 67,0 | 99,0 | ... | 69,5 | 49,0 | ... | 119,0 |
| 128 | 125,2 | 136,8 | 132,1 | 83,0 | 84,5 | ... | 66,0 | 98,0 | 87,0 | 68,5 | 48,0 | ... | 117,5 |
| 126 | 123,6 | 134,9 | 130,4 | ... | 84,0 | ... | 65,0 | 97,0 | ... | 67,5 | 46,5 | 120,0 | 115,0 |
| 124 | 121,9 | 133,0 | 128,7 | 82,5 | 83,5 | ... | 64,0 | 96,0 | 86,0 | 66,5 | 45,0 | 117,5 | 113,0 |
| 122 | 121,1 | 131,0 | 127,0 | ... | 83,0 | ... | 62,5 | 95,5 | 85,5 | 66,0 | 44,0 | 115,0 | 111,0 |
| 120 | 118,5 | 129,0 | 125,2 | 82,0 | 82,5 | ... | 61,5 | 95,0 | ... | 65,0 | 42,5 | 112,0 | 109,0 |
| 118 | 116,8 | 127,1 | 123,5 | 81,5 | ... | ... | 59,5 | 94,0 | 85,0 | 64,0 | 41,0 | 110,0 | 107,5 |
| 116 | 115,0 | 125,1 | 121,7 | ... | 82,0 | ... | 58,5 | 93,0 | ... | 63,0 | 40,0 | 107,0 | 105,5 |
| 114 | 113,5 | 123,2 | 119,9 | 81,0 | 81,5 | ... | 57,0 | 92,5 | 84,5 | 62,0 | 38,5 | 105,0 | 103,5 |
| 112 | 111,8 | 121,4 | 118,1 | 80,5 | 81,0 | ... | 55,0 | 91,5 | ... | 61,0 | 37,0 | 102,0 | 102,0 |
| 110 | 109,9 | 119,5 | 116,3 | 80,0 | ... | ... | 53,5 | 91,0 | 84,0 | 60,0 | 36,0 | 99,5 | 100,0 |
| 108 | 108,3 | 117,5 | 114,5 | ... | 80,5 | ... | 52,0 | 90,5 | 83,5 | 59,0 | 34,5 | 97,0 | 98,0 |
| 106 | 106,6 | 115,6 | 112,6 | 79,5 | 80,0 | ... | 50,0 | 89,5 | ... | 58,0 | 33,0 | 94,5 | 96,0 |
| 104 | 104,9 | 113,5 | 110,1 | 79,0 | 79,5 | ... | 48,0 | 88,5 | 83,0 | 57,0 | 32,0 | 92,0 | 94,0 |
| 102 | 103,2 | 111,5 | 108,0 | 78,5 | 79,0 | ... | 46,5 | 87,5 | 82,5 | 56,0 | 30,0 | 89,5 | 92,0 |
| 100 | 101,5 | 109,4 | 106,0 | 78,0 | 78,0 | ... | 44,5 | 87,0 | 82,0 | 55,0 | 28,5 | 87,0 | 90,0 |
| 98 | 99,8 | 107,3 | 104,0 | 77,5 | 77,5 | ... | 42,0 | 85,5 | 81,0 | 53,5 | 26,5 | 84,5 | 88,0 |
| 96 | 98,0 | 105,3 | 102,1 | 77,0 | 77,0 | ... | 40,0 | 84,5 | 80,5 | 52,0 | 25,5 | 82,0 | 86,6 |
| 94 | 96,4 | 103,2 | 100,0 | 76,5 | 76,5 | ... | 38,0 | 83,0 | 80,0 | 51,0 | 23,0 | 79,5 | 85,0 |
| 92 | 94,7 | 101,0 | 98,0 | 76,0 | 75,5 | ... | 35,5 | 82,0 | 79,0 | 49,0 | 21,0 | 77,0 | 83,0 |
| 90 | 93,0 | 98,9 | 96,0 | 75,5 | 75,0 | ... | 33,0 | 81,0 | 78,0 | 47,5 | 19,0 | 74,5 | 81,0 |
| 88 | 91,2 | 96,9 | 94,0 | 75,0 | 74,5 | ... | 30,5 | 79,5 | 77,0 | 46,0 | 16,5 | ... | 79,0 |
| 86 | 89,7 | 95,5 | 92,0 | 74,5 | 73,5 | ... | 28,0 | 78,0 | 76,0 | 44,0 | 14,0 | ... | 77,0 |
| 84 | 87,9 | 92,3 | 90,0 | 74,0 | 73,0 | ... | 25,5 | 76,5 | 75,0 | 43,0 | 12,0 | ... | 75,0 |
| 82 | 86,1 | 90,1 | 87,9 | 73,5 | 72,0 | ... | 23,0 | 74,5 | 74,5 | 41,0 | 9,5 | ... | 73,0 |
| 80 | 84,5 | 87,9 | 86,0 | 72,5 | 71,0 | ... | 20,0 | 73,0 | 73,5 | 39,5 | 7,0 | ... | 71,5 |
| 78 | 82,8 | 85,7 | 84,0 | 72,0 | 70,0 | ... | 17,0 | 71,0 | 72,5 | 37,5 | 6,0 | ... | 69,5 |

**Table F.3** *(continued)*

| Vickers Hardness Number | | Knoop Hardness Number | | Rockwell Hardness Number | | | | | | | | Brinell Hardness Number | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | HR15T | HR15T | HR30T | HRB | HRF | HR15T | HR30T | HR45T | HBS 10/500 | HBS 2/20 |
| HV1 | HV0,1 | HK1 | HK0,5 | Strip 0,25 mm | Strip 0,51 mm | | | Strip 1,02 mm and greater | | | | Strip 2,03 mm | Strip 1,02 mm |
| 76 | 81,0 | 83,5 | 81,9 | 71,5 | 69,5 | ... | 14,5 | 69,0 | 71,5 | 36,0 | 2,0 | ... | 67,5 |
| 74 | 79,2 | 81,1 | 79,9 | 71,0 | 68,5 | ... | 11,5 | 67,5 | 70,0 | 34,0 | ... | ... | 66,0 |
| 72 | 77,6 | 78,9 | 78,7 | 70,0 | 67,5 | ... | 8,5 | 66,0 | 69,0 | 32,0 | ... | ... | 64,0 |
| 70 | 75,8 | 76,8 | 76,6 | 69,5 | 66,5 | ... | 5,0 | 64,0 | 67,5 | 30,0 | ... | ... | 62,0 |
| 68 | 74,3 | 74,1 | 74,4 | 69,0 | 65,5 | ... | 2,0 | 62,0 | 66,0 | 28,0 | ... | ... | 60,5 |
| 66 | 72,6 | 71,9 | 71,9 | 68,0 | 64,5 | ... | ... | 60,0 | 64,5 | 25,5 | ... | ... | 58,5 |
| 64 | 70,9 | 69,5 | 70,0 | 67,5 | 63,5 | ... | ... | 58,0 | 63,5 | 23,5 | ... | ... | 57,0 |
| 62 | 69,1 | 67,0 | 67,9 | 66,5 | 62,0 | ... | ... | 56,0 | 61,0 | 21,0 | ... | ... | 55,0 |
| 60 | 67,5 | 64,6 | 65,9 | 66,0 | 61,0 | ... | ... | 54,0 | 59,0 | 18,0 | ... | ... | 53,0 |
| 58 | 65,8 | 62,0 | 63,8 | 65,0 | 60,0 | ... | ... | 51,5 | 57,0 | 15,5 | ... | ... | 51,5 |
| 56 | 64,0 | 59,8 | 61,8 | 64,5 | 58,5 | ... | ... | 49,0 | 55,0 | 13,0 | ... | ... | 49,5 |
| 54 | 62,3 | 57,4 | 59,5 | 63,5 | 57,5 | ... | ... | 47,0 | 53,0 | 10,0 | ... | ... | 48,0 |
| 52 | 60,7 | 55,0 | 57,2 | 63,0 | 56,0 | ... | ... | 44,0 | 51,5 | 7,5 | ... | ... | 46,5 |
| 50 | 58,9 | 52,8 | 55,0 | 62,0 | 55,0 | ... | ... | 41,5 | 49,5 | 4,5 | ... | ... | 44,5 |
| 48 | 57,3 | 50,3 | 52,7 | 61,0 | 53,5 | ... | ... | 39,0 | 47,5 | 1,5 | ... | ... | 42,0 |
| 46 | 55,8 | 48,0 | 50,2 | 60,5 | 52,0 | ... | ... | 36,0 | 45,0 | ... | ... | ... | 41,0 |
| 44 | 53,9 | 45,9 | 47,8 | 59,5 | 51,0 | ... | ... | 33,5 | 43,0 | ... | ... | ... | ... |
| 42 | 52,2 | 43,7 | 45,2 | 58,5 | 49,5 | ... | ... | 30,5 | 41,0 | ... | ... | ... | ... |
| 40 | 51,3 | 40,2 | 42,8 | 57,5 | 48,0 | ... | ... | 28,0 | 38,5 | ... | ... | ... | ... |

## Table F.4 — Wrought Aluminium Products (ASTM E 140-97, Table 9)

锻铝制品硬度换算表

| HBS10/500 | HV15 | Rockwell Hardness Number | | | | | |
|---|---|---|---|---|---|---|---|
| | | HRB | HRE | HRH | HR15T | HR30T | HR15W |
| 160 | 189 | 91 | ... | ... | 89 | 77 | 95 |
| 155 | 183 | 90 | ... | ... | 89 | 76 | 95 |
| 150 | 177 | 89 | ... | ... | 89 | 75 | 94 |
| 145 | 171 | 87 | ... | ... | 88 | 74 | 94 |
| 140 | 165 | 86 | ... | ... | 88 | 73 | 94 |
| 135 | 159 | 84 | ... | ... | 87 | 71 | 93 |
| 130 | 153 | 81 | ... | ... | 87 | | |
| 125 | 147 | 79 | ... | ... | 86 | 68 | 92 |
| 120 | 141 | 76 | ... | ... | 86 | 67 | 92 |
| 115 | 135 | 72 | 101 | ... | 86 | 65 | 91 |
| 110 | 129 | 69 | 100 | ... | 85 | 63 | 91 |
| 105 | 123 | 65 | 99 | ... | 84 | 61 | 91 |
| 100 | 117 | 60 | 98 | ... | 83 | 59 | 90 |
| 95 | 111 | 56 | 96 | ... | 82 | 57 | 90 |
| 90 | 105 | 51 | 94 | 108 | 81 | 54 | 89 |
| 85 | 98 | 46 | 91 | 107 | 80 | 52 | 89 |
| 80 | 92 | 40 | 88 | 106 | 78 | 50 | 88 |
| 75 | 86 | 34 | 84 | 104 | 76 | 47 | 87 |
| 70 | 80 | 28 | 80 | 102 | 74 | 44 | 86 |
| 65 | 74 | ... | 75 | 100 | 72 | ... | 85 |
| 60 | 68 | ... | 70 | 97 | 70 | ... | 83 |
| 55 | 62 | ... | 65 | 94 | 67 | ... | 82 |
| 50 | 56 | ... | 59 | 91 | 64 | ... | 80 |
| 45 | 50 | ... | 53 | 87 | 62 | ... | 79 |
| 40 | 44 | ... | 46 | 83 | 59 | ... | 77 |

**Table F.5 — Aluminium and its Alloys (BS 860:1967, Table 1)**
铝及铝合金硬度换算表

| HV10 | HB (0,102 $F/D^2$ = 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 |
| 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 | ... |
| | | |

**Table F.5** *(continued)*

| HV10 | HB (0,102 $F/D^2$ = 5 or 10) | HRB |
|---|---|---|
| 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 | ... |
| 32 | 30,4 | ... |
| 30 | 28,5 | ... |
| 28 | 26,6 | ... |
| 26 | 24,7 | ... |
| 24 | 22,8 | ... |
| 22 | 20,9 | ... |
| 20 | 19,0 | ... |
| 18 | 17,1 | ... |

# Annex G
(informative)

# Conversion tables for tool steels

The following conversion tables (Tables G.1 and G.2) for two tool steels were established in 2007 under application of the valid test conditions in ISO 6506-1, ISO 6507-1 and ISO 6508-1.

**WARNING — Hardness conversions are no substitute for direct measurements. These tables should be used with caution and only in accordance with the principles of conversions, see Clause 2.**

**Table G.1 — Conversion of hardness-to-hardness values and tensile strength for tool steel 1.1243**

1.1243工具钢硬度-硬度换算值

| Tensile strength $R_m$, N/mm² | HBW2,5/187,5 | HV30 | HRA | HRC |
|---|---|---|---|---|
| 950 | 297 | 305 | 65,9 | 31,2 |
| 960 | 300 | 308 | 66,1 | 31,5 |
| 970 | 303 | 311 | 66,2 | 31,8 |
| 980 | 306 | 314 | 66,4 | 32,0 |
| 990 | 309 | 316 | 66,5 | 32,3 |
| 1 000 | 312 | 319 | 66,7 | 32,6 |
| 1 010 | 315 | 322 | 66,8 | 32,9 |
| 1 020 | 318 | 325 | 67,0 | 33,2 |
| 1 030 | 321 | 328 | 67,1 | 33,4 |
| 1 040 | 324 | 331 | 67,3 | 33,7 |
| 1 050 | 327 | 333 | 67,4 | 34,0 |
| 1 060 | 330 | 336 | 67,6 | 34,3 |
| 1 070 | 333 | 339 | 67,7 | 34,6 |
| 1 080 | 335 | 342 | 67,9 | 34,8 |
| 1 090 | 338 | 345 | 68,0 | 35,1 |
| 1 100 | 341 | 347 | 68,2 | 35,4 |
| 1 110 | 344 | 350 | 68,3 | 35,7 |
| 1 120 | 347 | 353 | 68,5 | 36,0 |
| 1 130 | 350 | 356 | 68,6 | 36,2 |
| 1 140 | 353 | 359 | 68,8 | 36,5 |
| 1 150 | 356 | 362 | 68,9 | 36,8 |
| 1 160 | 359 | 364 | 69,1 | 37,1 |
| 1 170 | 362 | 367 | 69,2 | 37,4 |
| 1 180 | 365 | 370 | 69,4 | 37,6 |
| 1 190 | 368 | 373 | 69,5 | 37,9 |
| 1 200 | 371 | 376 | 69,7 | 38,2 |
| 1 210 | 374 | 378 | 69,8 | 38,5 |

NOTE The values of the tension tests are not based on method A (10.3 Testing rate based on close-loop control at the rate of the extension) in ISO 6892-1:2009

**Table G.1** *(continued)*

| Tensile strength $R_m$, N/mm² | HBW2,5/187,5 | HV30 | HRA | HRC |
|---|---|---|---|---|
| 1 220 | 377 | 381 | 70,0 | 38,8 |
| 1 230 | 380 | 384 | 70,1 | 39,0 |
| 1 240 | 382 | 387 | 70,3 | 39,3 |
| 1 250 | 385 | 390 | 70,4 | 39,6 |
| 1 260 | 388 | 392 | 70,6 | 39,9 |
| 1 270 | 391 | 395 | 70,7 | 40,2 |
| 1 280 | 394 | 398 | 70,9 | 40,4 |
| 1 290 | 397 | 401 | 71,0 | 40,7 |
| 1 300 | 400 | 404 | 71,2 | 41,0 |
| 1 310 | 403 | 407 | 71,3 | 41,3 |
| 1 320 | 406 | 409 | 71,5 | 41,6 |
| 1 330 | 409 | 412 | 71,6 | 41,8 |
| 1 340 | 412 | 415 | 71,8 | 42,1 |
| 1 350 | 415 | 418 | 71,9 | 42,4 |
| 1 360 | 418 | 421 | 72,1 | 42,7 |
| 1 370 | 421 | 423 | 72,2 | 43,0 |
| 1 380 | 424 | 426 | 72,4 | 43,2 |
| 1 390 | 427 | 429 | 72,5 | 43,5 |
| 1 400 | 430 | 432 | 72,7 | 43,8 |
| 1 410 | 432 | 435 | 72,8 | 44,1 |
| 1 420 | 435 | 438 | 73,0 | 44,4 |
| 1 430 | 438 | 440 | 73,1 | 44,6 |
| 1 440 | 441 | 443 | 73,3 | 44,9 |
| 1 450 | 444 | 446 | 73,4 | 45,2 |
| 1 460 | 447 | 449 | 73,6 | 45,5 |
| 1 470 | 450 | 452 | 73,7 | 45,8 |
| 1 480 | 453 | 454 | 73,9 | 46,1 |
| 1 490 | 456 | 457 | 74,0 | 46,3 |
| 1 500 | 459 | 460 | 74,2 | 46,6 |
| 1 510 | 462 | 463 | 74,3 | 46,9 |
| 1 520 | 465 | 466 | 74,5 | 47,2 |
| 1 530 | 468 | 468 | 74,6 | 47,5 |
| 1 540 | 471 | 471 | 74,8 | 47,7 |
| 1 550 | 474 | 474 | 74,9 | 48,0 |
| | | | | |
| Function | $R_m$ = f(HBW) | $R_m$ = f(HV) | $R_m$=f(HRA) | $R_m$=f(HRC) |
| Standard deviation | 15,7 | 16,4 | 20,6 | 23,3 |

NOTE The values of the tension tests are not based on method A (10.3 Testing rate based on close-loop control at the rate of the extension) in ISO 6892-1:2009

**Table G.2 — Conversion of hardness-to-hardness values and tensile strength for tool steel 1.2714**

1.2714工具钢硬度-硬度换算值

| Tensile strength $R_m$, N/mm² | HBW2,5/187,5 | HV30 | HRA | HRC |
|---|---|---|---|---|
| 880 | 279 | 280 | 62,9 | 27,7 |
| 890 | 282 | 283 | 63,5 | 28,2 |
| 900 | 285 | 286 | 63,9 | 28,7 |
| 910 | 288 | 289 | 64,3 | 29,2 |
| 920 | 291 | 292 | 64,7 | 29,7 |
| 930 | 294 | 295 | 65,0 | 30,1 |
| 940 | 296 | 298 | 65,3 | 30,6 |
| 950 | 299 | 300 | 65,6 | 31,0 |
| 960 | 302 | 303 | 65,9 | 31,4 |
| 970 | 305 | 306 | 66,1 | 31,8 |
| 980 | 308 | 309 | 66,3 | 32,2 |
| 990 | 311 | 312 | 66,6 | 32,6 |
| 1 000 | 314 | 315 | 66,8 | 32,9 |
| 1 010 | 316 | 318 | 67,0 | 33,3 |
| 1 020 | 319 | 321 | 67,2 | 33,6 |
| 1 030 | 322 | 324 | 67,4 | 34,0 |
| 1 040 | 325 | 327 | 67,6 | 34,3 |
| 1 050 | 328 | 330 | 67,8 | 34,7 |
| 1 060 | 331 | 333 | 68,0 | 35,0 |
| 1 070 | 333 | 336 | 68,2 | 35,3 |
| 1 080 | 336 | 339 | 68,3 | 35,6 |
| 1 090 | 339 | 342 | 68,5 | 35,9 |
| 1 100 | 342 | 345 | 68,7 | 36,2 |
| 1 110 | 345 | 347 | 68,8 | 36,5 |
| 1 120 | 348 | 350 | 69,0 | 36,8 |
| 1 130 | 351 | 353 | 69,1 | 37,1 |
| 1 140 | 353 | 356 | 69,3 | 37,4 |
| 1 150 | 356 | 359 | 69,4 | 37,7 |
| 1 160 | 359 | 362 | 69,6 | 38,0 |
| 1 170 | 362 | 365 | 69,7 | 38,2 |
| 1 180 | 365 | 368 | 69,9 | 38,5 |
| 1 190 | 368 | 371 | 70,0 | 38,8 |
| 1 200 | 370 | 374 | 70,2 | 39,0 |
| 1 210 | 373 | 377 | 70,3 | 39,3 |
| 1 220 | 376 | 380 | 70,4 | 39,6 |
| 1 230 | 379 | 383 | 70,6 | 39,8 |
| 1 240 | 382 | 386 | 70,7 | 40,1 |
| 1 250 | 385 | 389 | 70,8 | 40,3 |

NOTE The values of the tension tests are not based on method A (10.3 Testing rate based on close-loop control at the rate of the extension) in ISO 6892-1:2009

**Table G.2** *(continued)*

| **Tensile strength $R_m$, N/mm²** | **HBW2,5/187,5** | **HV30** | **HRA** | **HRC** |
|---|---|---|---|---|
| 1 260 | 388 | 392 | 71,0 | 40,6 |
| 1 270 | 390 | 395 | 71,1 | 40,8 |
| 1 280 | 393 | 397 | 71,2 | 41,0 |
| 1 290 | 396 | 400 | 71,3 | 41,3 |
| 1 300 | 399 | 403 | 71,4 | 41,5 |
| 1 310 | 402 | 406 | 71,6 | 41,7 |
| 1 320 | 405 | 409 | 71,7 | 42,0 |
| 1 330 | 407 | 412 | 71,8 | 42,2 |
| 1 340 | 410 | 415 | 71,9 | 42,4 |
| 1 350 | 413 | 418 | 72,0 | 42,7 |
| 1 360 | 416 | 421 | 72,1 | 42,9 |
| 1 370 | 419 | 424 | 72,3 | 43,1 |
| | | | | |
| Function | $R_m = f(HBW)$ | $R_m = f(HV)$ | $R_m=f(HRA)$ | $R_m=f(HRC)$ |
| Standard deviation | 10,2 | 11,2 | 22,1 | 35,0 |

NOTE The values of the tension tests are not based on method A (10.3 Testing rate based on close-loop control at the rate of the extension) in ISO 6892-1:2009

# Annex H
(informative)

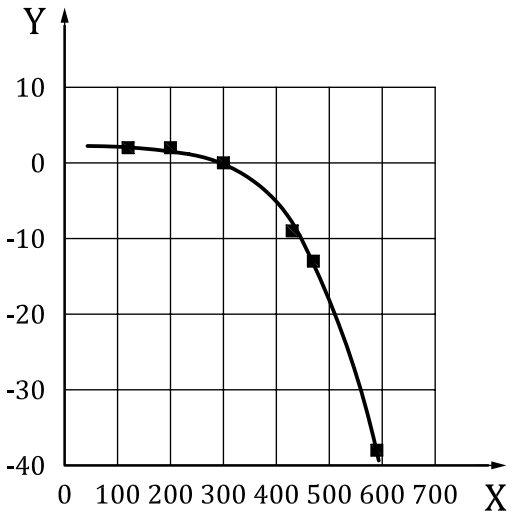
# Remarks on the effect of the changed test conditions

Because the test conditions which were applied for the tables in the Annexes A to F (in the period from approximately 1950 until approximately 1990) are not further valid in the present ISO standards, effects on the converted hardness values should be considered. These changed test conditions refer to

a) the replacement of steel ball indenters by hardmetal ball indenters for the Rockwell and Brinell scales;

b) the introduction of a shorter test force duration time for the Rockwell scales, which was reduced from 30 s to (4 ± 2) s.

Preliminary investigations, which were carried out in Germany on hardness reference blocks (made from not or low alloyed steels), led to the results shown in Figures H.1 to H.5 for the effect of the changed test conditions.

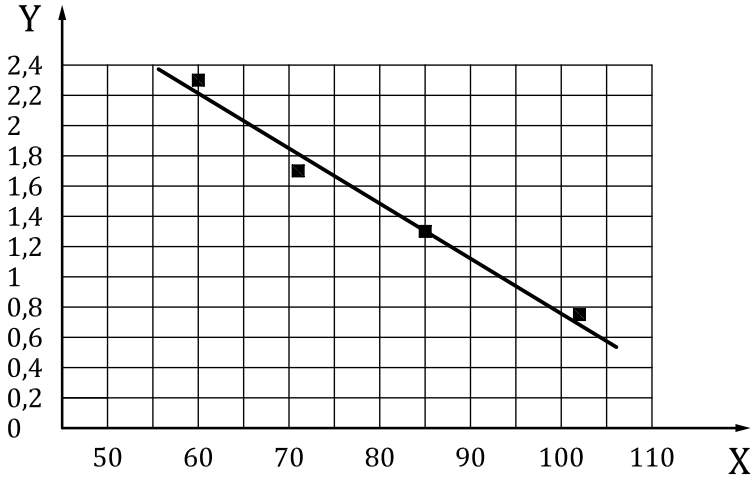



**Key**

X Brinell hardness in HB

Y Hardness difference in using a steel ball as a carbide ball

**Figure H.1 — Influence of the material of Brinell indenter balls on hardness**

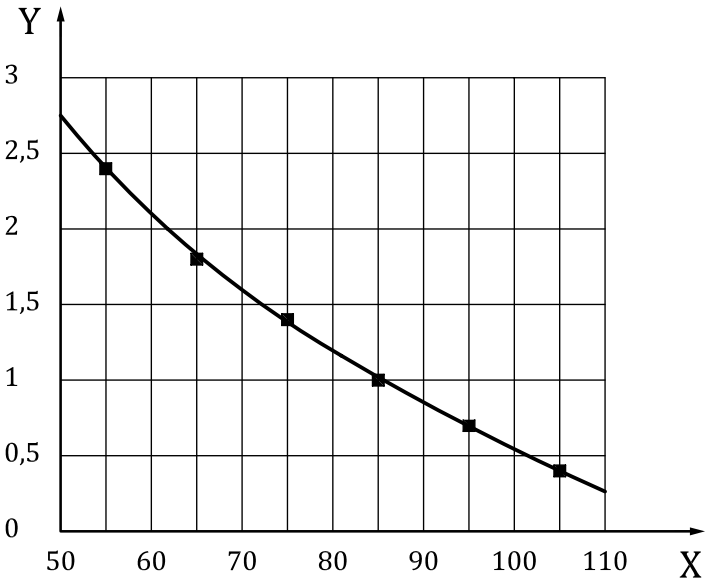



**Key**

X Rockwell hardness in HRB

Y Hardness difference in using a steel ball as a carbide ball

**Figure H.2 — Influence of the material of Rockwell indenter balls on hardness**

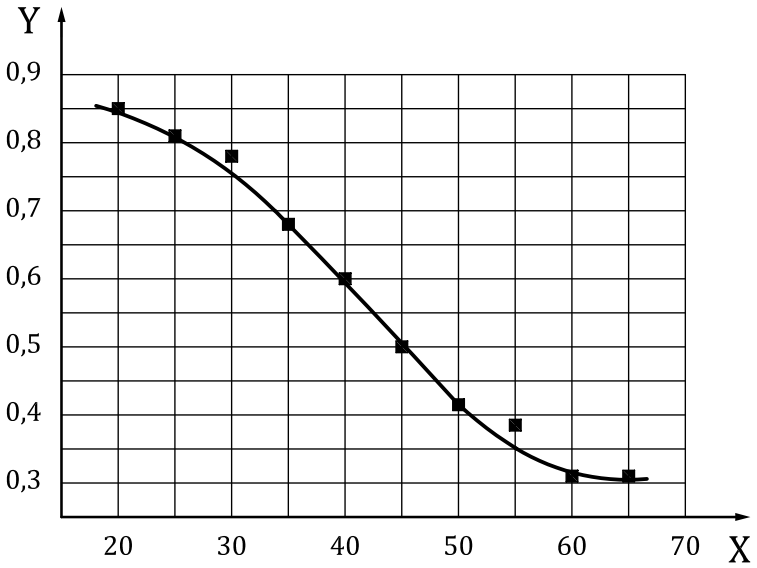



**Key**

X Rockwell hardness in HRB

Y Hardness difference in using 6 s as 30 s test force duration time

**Figure H.3 — Influence of changed test force duration time at HRB**



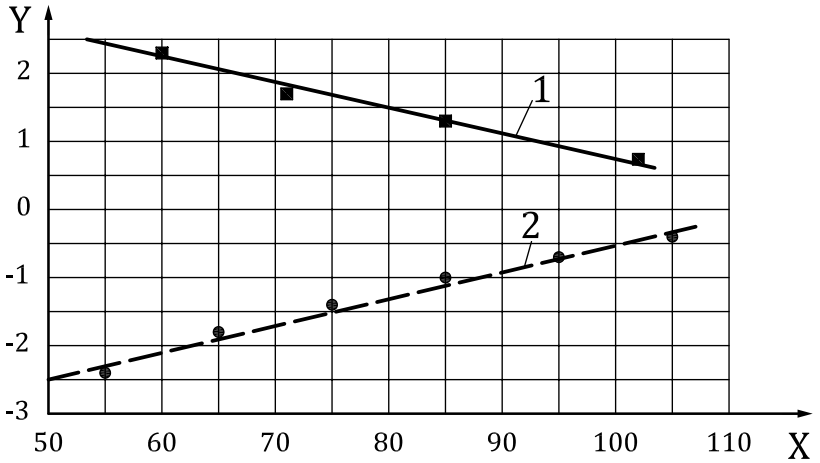

**Key**

X Rockwell hardness in HRC

Y Hardness difference in using 6 s as 30 s test force duration time

**Figure H.4 — Influence of changed test force duration time at HRC**

It should be noted that the combined influence of changed indenter ball material and of changed test force duration time at HRB obviously offset each other.




**Key**

X Rockwell hardness in HRB

Y Hardness difference in HRB

1 Hardness difference in using a steel ball as a carbide ball

2 Hardness difference in using 6 s as 30 s test force duration time

**Figure H.5 — Influence of changed indenter ball material and of changed test force duration time at HRB**

In summary, the following orders of magnitude of determined deviations due to changed test conditions for unalloyed or low alloyed steels were found in this investigation (see Table H.1).

**Table H.1 — Order of magnitude of determined deviations due to changed test conditions for unalloyed or low alloyed steels found in this investigation**

| Hardness test method | HB 5/750 | HRC | HRB |
|---|---|---|---|
| Changed indenter material | −40 HBW | - | 2,3 HRB |
| Changed test force duration time | - | 0,6 HRC | −2,0 HRB |

These results are only intended to raise the consciousness of the user of this International Standard toward the effects of the changed test conditions on the converted hardness value. In each actual case, the user should carry out corresponding comparative measurements as shown above. Other studies have shown differing magnitudes in the differences of the test results due to the changes in the ball material and test force duration, likely due to testing different alloys or using different testing conditions.

# Bibliography


[1] PTB-Bericht, PTB-F-10 February 1992. Eckhart, H. and Otto, M. *Vergleichswerte Härte/Zugfestigkeit und Härtevergleichstabellen für Vergütungsstähle*

[2] Schmidt W.*Vorsicht bei der Bewertung des Werkstoffverhaltens mit Hilfe nichtgenormter Härteprüfverfahren*. Z. Draht 46 (1995) 5, S. 255

[3] Schmidt W.*Betrachtungen zur Umwertung von Härtewerten*. VDI-Berichte Nr. 1194, 1995

[4] Hahn F.*Die Prüfung der Festigkeit harter Stähle im Zugversuch*. Dissertation TU Berlin 1968

[5] TGL 4393, *Kaltarbeitsstähle, legiert, gewalzt, geschmiedet, gezogen*

[6] TGL 7571, *Schnellarbeitsstähle, geschmiedet, warm gewalzt, gezogen*

[7] TGL 6547, *Vergütungsstähle, Technische Bedingungen für Stabstahl, warmgewalzt und Freiformschmiedestücke*

[8] TGL 7975, *Bandstahl*

[9] TGL 7965-02, *Gesinterte Hartmetalle, Sorten, Anwendung*

[10] ISO 4957, *Tool steels*

[11] DIN 17200, *Vergütungsstähle – Technische Lieferbedingungen (zurückgezogen und ersetzt durch EN 10083-1)*

[12] EN 10083-1, *Quenched and tempered steels – Part 1: Technical delivery conditions for stainless steels (contains A1:1996)*

[13] TGL 43212-01, *Metalle, Härtenvergleichswerte, Allgemeine Festlegungen*

[14] TGL 43212-02, *Metalle, Härtenvergleichswerte, Hartmetalle*

[15] TGL 43212-03, *Metalle, Härtenvergleichswerte, Kaltarbeitsstähle*

[16] TGL 43212-04, *Metalle, Härtenvergleichswerte, Schnellarbeitsstähle*

[17] ISO 4964, *Steel – Hardness conversions*

[18] ISO/TR 10108, *Steel — Conversion of hardness values to tensile strength values*

[19] Mitteilung Nr. 3:1980-03, *Vergleichszahlen für Härtewerte bei Stahl (Europäische Gemeinschaft für Kohle und Stahl)*

[20] Mitteilung Nr. 4:1982-03, *Umwertung von Härte (HB + HV) und Zugfestigkeit bei Stahl (Europäische Gemeinschaft für Kohle und Stahl)*

[21] Otto M. *"Umwertung von Härtewerten", Tagungsband der Tagung Werkstoffprüfung*. DVM, Berlin, 1999

[22] ASTM E 140-97, *Standard Hardness Conversion Tables for Metals*

[23] BS 860:1967, *Tables for comparison of hardness scales*

[24] Stahlschlüssel (steel key). *Verlag Stahlschlüssel Wegst GmbH, **10***. Edition, 2001

[25] ISO 6506-1, *Metallic materials — Brinell hardness test — Part 1: Test method*

[26] ISO 6507-1, *Metallic materials — Vickers hardness test — Part 1: Test method*

[27] ISO 6507-2, *Metallic materials — Vickers hardness test — Part 2: Verification and calibration of testing machines*.

[28] ISO 6508-1, *Metallic materials — Rockwell hardness test — Part 1: Test method*

[29] ISO 6508-2, *Metallic materials — Rockwell hardness test — Part 2: Verification and calibration of testing machines and indenters*

[30] ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

[31] ISO 7500-1, *Metallic materials — Verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Verification and calibration of the force-measuring system*

[32] ISO 9513, *Metallic materials — Calibration of extensometer systems used in uniaxial testing*

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