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**Metallic materials -- Conversion of hardness values
(English Translation)**

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1 Scope

This standard specifies the principles for converting between hardness values and between hardness values and estimated tensile strength values; provides general rules for the use of conversion tables.

The conversion tables in Appendixes A ~ G of this standard are applicable to.

- Non-alloy steels, low-alloy steels, cast steels;
- Quenched and tempered steels;
- Cold-worked steels;
- High-speed steels;
- Cemented carbides;
- Non-ferrous metals and alloys;
- Tool steels.

Note 1: The conversion tables in Appendixes B ~ G are based on empirical results derived from regression analysis. A similar analysis could not be performed for the conversion table in Appendix A due to insufficient measurement data.

Note 2: Appendix H provides information regarding the effects of deviating from the standard hardness testing procedures.

Conversion values obtained using this standard apply only to the specific materials tested; for other materials, they serve only as a reference. In no case shall converted values replace hardness values, which are obtained through the correct testing method;

furthermore, estimating tensile strength using the conversion values in this standard is the least reliable form of conversion, as compared to conversions between hardness values.

2 Principles of conversion

Hardness testing is a method for determining the mechanical properties of a material, by causing only limited, minor damage to the specimen within a short period. In practice, when tensile testing is too time-consuming or complex, or when the component cannot be destroyed, hardness test results are often used to estimate the material's tensile strength.

Due to the influence of material stress, differences exist between hardness tests and tensile tests; consequently, it is difficult to establish a reliable functional relationship between the two parameters using a single model. However, since hardness values and tensile strength values are positively correlated, it is possible to establish empirical parameters defining the relationship between them, within a limited scope of application.

It is often necessary to compare a given hardness value with a value obtained via a different test method, particularly when constraints such as specific specimen types, coating thicknesses, specimen dimensions, surface quality, or available hardness tester types dictate the use of a particular test method. In such cases, conversion methods may be employed.

Conversion between hardness and tensile strength values makes it possible to substitute hardness testing for tensile testing; however, it shall be noted that such conversions are least reliable. Similarly, conversions between different hardness scales allow values obtained from a desired test method to substitute for values from another hardness scale.

Occasionally, a conversion relationship is derived from specific cases to determine material properties other than hardness, most commonly, a reliable estimate of tensile strength. When establishing specific hardness-to-hardness conversion relationships, the following conditions should be met.

- The hardness test method is for internal use only; the results cannot be compared with those from other methods; or the test procedure is sufficiently rigorous to allow the results to be reproduced in another laboratory or at a different time;
- The conversion table used is based on extensive testing of the material in question across different scales;
- Converted hardness values shall clearly indicate the test method used to obtain the original value.

However, the conversion values provided in this standard are for reference only. Test results obtained using the appropriate standard test methods for hardness (or tensile strength) always take precedence over values derived from the conversion tables in this standard. Furthermore, converted values shall not serve as the basis for resolving complaints or determining compliance with acceptance criteria.

Warning. Practical experience, as illustrated in Figures 1 and 2, demonstrates that it is generally impossible to establish a reliable relationship between original data and converted values, without considering specific material properties. Therefore, users of this standard shall ensure that all conditions for conversion are met (see

3.1 General

Conversions between different hardness values or between hardness values and tensile strength values have uncertainties, that shall be taken into account. Extensive research indicates that, regardless of how meticulously tests are conducted, it is difficult to establish a universally applicable conversion relationship between hardness values obtained via different methods. This is due to the complex relationship -- between the formation of an indentation in the material and the material's elastic and plastic deformation. Consequently, the closer the elastic properties of the material being tested are to those of the material used to establish the conversion relationship, the greater the equivalence of that relationship. Similarly, the greater the similarity in the indentation process (i.e., minimal differences in the force application process and test parameters), the greater the equivalence of the conversion relationship. Therefore, the reliability of conversions between hardness values and tensile strength values is the lowest.

Note: In many cases, yield strength or specified plastic extension strength provides information regarding the material's elastic properties.

The optimal test method shall be selected for hardness testing.

It shall be noted that the result of each hardness test applies only to the specific indentation area tested. For example, as the distance from the surface increases, Brinell and Vickers hardness test values, as well as tensile strength values, deviate from converted values due to changes in the material's elongation in that region. Indentations of different geometries are affected differently; consequently, even for the same specimen, conversion results between different hardness scales will not be consistent.

Hardness values shall only be converted, when the specified test methods cannot be used, for instance, if no suitable hardness tester is available or the required specimen cannot be obtained. Figures 3 and 4 assist in selecting the appropriate test method.

The average value derived from at least three hardness readings shall be used as the initial value for conversion.

To ensure acceptable measurement accuracy, the specimen surface shall be sufficiently smooth; the required degree of smoothness depends on the selected hardness test method, the test force, the appropriate specimen surface preparation method, for example, from machining (suitable for macro-hardness) to polishing (suitable for low test forces and micro-hardness).

The uncertainty of the converted values in these tables accounts for both the confidence interval of the hardness conversion curve, as derived from regression analysis, and the uncertainty of the original hardness or tensile strength test values. The confidence interval of the regression function is a parameter independent of the user; it is calculated based on the hardness function.

The uncertainty of the original test values is influenced by factors such as the repeatability of the hardness tester, specimen surface quality, uniformity of specimen hardness, the number of indentations made, that is, it depends on the test conditions under which the original values were obtained. This standard lists hardness values for various scales, and in some cases, corresponding tensile strength values enabling hardness conversion for different material types.

If the conversion tables are used solely for hardness comparison without performing actual hardness testing, the uncertainty of the converted value is reduced to that of the hardness conversion curve's confidence interval; in this scenario, it does not matter which value serves as the initial value and which as the converted value.

The supplier and purchaser may agree upon acceptable converted values and permissible deviation ranges. In such cases, the average of five measurement points shall be used as the initial test value.

3.2.1 Limits of error

Depending on actual test conditions, pairs of test/converted values (e.g., HV/HRC, HRC/HV, HRA/HRN, HB/Rm) can be found in the tables provided in Appendixes A ~ G. This article outlines the fundamental principles to consider when selecting a hardness test method.

The following example illustrates the situation regarding hardness values with associated errors, when performing hardness conversions using Table C.2.

Given hardness value. (300 ± 30) HV Expected scale. HRC