SURFACE VEHICLE STANDARD

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Hardness Tests and Hardness Number Conversions

RATIONALE

The technical report covers technology, products, or processes which are mature and not likely to change in the foreseeable future.

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Foreword—This Document has not changed other than to put it into the new SAE Technical Standards Board Format.

1. Scope—This report lists approximate hardness conversion values; test methods for Vickers Hardness, Brinell Hardness, Rockwell Hardness Rockwell Superficial Hardness, Shore Hardness; and information regarding surface preparation, specimen thickness, effect of curved surfaces, and recommendations for Rockwell surface hardness testing for case hardened parts.

The tables in this report give the approximate relationship of Vickers Brinell, Rockwell, and Scleroscope hardness values and corresponding approximate tensile strengths of steels. It is impossible to give exact relationships because of the inevitable influence of size, mass, composition, and method of heat treatment. Where more precise conversions are required, they should be developed specially for each steel composition, heat treatment, and part.

The accompanying conversion tables for steel hardness numbers are based on extensive tests on carbon and alloy steels, mostly in the heat treated condition, but have been found to be reliable on practically all constructional alloy steels and tool steels in the as-forged, annealed, normalized, and quenched and tempered conditions, provided they are homogeneous. Such special cases as high manganese steel, 18% chromium—8% nickel steel and other austenitic steels, and nickel base alloys, as well as constructional alloy steels and tool steels in the cold worked condition, may not conform to the relationships given with the same degree of accuracy as the steels for which the tables are intended.

All numbers in these tables given in bold face type were prepared jointly by the American Society for Testing and Materials, the American Society for Metals, and SAE from carefully checked data. The values given in regular face type were taken from the Army-Navy Approximate Hardness Tensile Strength Relationship of Carbon and Low Alloy Steels (ANQQ-H-201) published in the 1943 SAE Handbook, with only minor adjustments.

2. References

2.1 Applicable Publications—The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest version of SAE publications shall apply.

2.1.1 SAE PUBLICATION—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J423—Methods of Measuring Case Depth
ANQQ-H-201—Army-Navy Approximate hardness Tensile Strength Relationship of Carbon and Low Alloy Steels (published in the 1943 SAE Handbook)

2.1.2 ASTM PUBLICATION—Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM E 10—Test Method for Brinell Hardness of Metallic Materials
ASTM E 18—Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials

3. Use of Conversion Tables—The conversions given in the accompanying Tables 1, 2, and 3 are recommended for use in converting the results of one form of hardness test to another only on flat surfaces and only when the specific test procedures and precautions outlined in the several hardness test methods are followed. Attention is called to the limitation in ASTM E 10 (Brinell Hardness Tests) on the use of the standard steel ball to hardness values less than 450 HB, and the use of a tungsten carbide ball to hardness values less than 630 HB. The Rockwell Superficial and Vickers Hardness tests require especially smooth surfaces for accurate results. In all tests, a specimen should be of sufficient thickness to avoid anvil effect—which thickness is roughly 10 times the depth of the indentation. It is important that conversions from Brinell Hardness to shallow impression type tests, such as Rockwell Superficial and Vickers Hardness tests, be made only on materials that are of uniform hardness to a depth at least 10 times that of the indentation. Such hardness conversions should not be made on surface hardened, coated, or decarburized surfaces. Although the Rockwell Hardness and the Rockwell Superficial Hardness values in the tables are given to tenths of a point in order to maintain exact relationships between the various scales, it is customary to report these values to the nearest point. Experience has shown that even under carefully controlled conditions, some deviations from the conversion relationships will occur.

The numbers given in parentheses in the tables are values beyond the practical range of usefulness of the type of' test under which they appear and have no strict application. They are included in the tables as a matter of information only, and should not be used for specifications.

4. Vickers Hardness (HV), Table I—Vickers Hardness is determined by forcing a square base diamond pyramid having an apex angle of 136 deg into the test specimen under loads usually of 3-50 kg and measuring the diagonals of the recovered indentations. The Vickers Hardness is defined as the load per unit area of surface contact in kilograms per square millimeter as calculated from the average diagonal as follows:

$$HV = \frac{2L \sin\frac{a}{2}}{d^2} \qquad \text{(Eq. 1)}$$

where:

HV = Vickers Hardness
d = length of average diagonal in millimeters
a = apex angle = 136 deg
L = load in kilograms

For further information on standard methods of Vickers Hardness Testing, refer to ASTM E 92-72.