



Designation: E 18 – 02

Standard Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials^{1,2}

This standard is issued under the fixed designation E 18; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 These test methods cover the determination of the Rockwell hardness and the Rockwell superficial hardness of metallic materials, including test methods for the verification of machines for Rockwell hardness testing (Part B) and the calibration of standardized hardness test blocks (Part C).

1.2 Values stated in inch-pound units are to be regarded as the standard. SI units are provided for information only.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* (See Note 6.)

NOTE 1—The National Institute of Standards and Technology (NIST) maintains the national Rockwell hardness standards for the United States. In June 1998, NIST released new Rockwell C scale (HRC) test blocks as Standard Reference Materials (SRMs). The blocks were calibrated using NIST's primary reference standardizing machine. The major benefit of the NIST standards is that their HRC levels are in line with the other industrialized countries around the world. The NIST HRC levels establish the hardness of materials slightly harder than the historical standards used in the United States for the past 75 years. The revision of E 18 requires that all performance verifications of Rockwell hardness indenters and hardness machines must be made using test blocks calibrated traceable to the Rockwell standards maintained by NIST. This can be accomplished through the use of commercial test blocks calibrated traceable to the NIST standards or by directly using the NIST SRMs. This requirement will apply only to the Rockwell scale(s) for which NIST supplies primary reference test blocks

NOTE 2—In previous editions of this standard, ball indenters were required to be of hard steel. Beginning with this edition, tungsten-carbide balls are also allowed. This change is a first step in a planned future transition to eliminate steel balls and allow only the use of tungsten carbide balls. The elimination of steel ball indenters is scheduled to occur in about two years. The use of tungsten carbide balls will provide an improvement to the Rockwell hardness test because of the tendency of

steel balls to flatten with use, which results in an erroneously elevated hardness value. In addition, NIST is planning to standardize the HRB scale using tungsten-carbide balls. As a result of this change, this edition also requires that when a ball indenter is used, the Rockwell hardness value must be reported with the scale designation followed by the letter "S" to indicate the use of a steel ball or the letter "W" to indicate the use of a tungsten carbide ball. The user is cautioned that Rockwell hardness tests comparing the use of steel and tungsten carbide balls have been shown to give different results. For example, depending on the material tested and its hardness level, Rockwell B scale tests using a tungsten carbide ball indenter have given results up to one Rockwell point lower than when a steel ball indenter is used.

2. Referenced Documents

2.1 ASTM Standards:

- A 370 Test Methods and Definitions for Mechanical Testing of Steel Products³
- B 19 Specification for Cartridge Brass Sheet, Strip, Plate, Bar, and Disks (Blanks)⁴
- B 36/B36 M Specification for Brass Plate, Sheet, Strip, and Rolled Bar⁴
- B 96 Specification for Copper-Silicon Alloy Plate, Sheet, Strip, and Rolled Bar for General Purposes and Pressure Vessels⁴
- B 97 Specification for Copper-Silicon Alloy Plate, Sheet, Strip, and Rolled Bar for General Purposes⁵
- B 103/B 103 M Specification for Phosphor Bronze Plate, Sheet, Strip, and Rolled Bar⁴
- B 121/B 121 M Specification for Leaded Brass Plate, Sheet, Strip, and Rolled Bar⁴
- B 122/B 122 M Specification for Copper-Nickel-Tin Alloy, Copper-Nickel-Zinc Alloy (Nickel Silver), and Copper-Nickel Alloy Plate, Sheet, Strip, and Rolled Bar⁴
- B 130 Specification for Commercial Bronze Strip for Bullet Jackets⁴
- B 134 Specification for Brass Wire⁴
- B 152 Specification for Copper Sheet, Strip, Plate, and Rolled Bar⁴
- B 291 Specification for Copper-Zinc-Manganese Alloy

¹ These test methods are under the jurisdiction of ASTM Committee E28 on Mechanical Testing and are the direct responsibility of Subcommittee E28.06 on Indentation Hardness Testing.

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² In this test method, the term Rockwell refers to an internationally recognized type of indentation hardness test as defined in Section 3, and not to the hardness testing equipment of a particular manufacturer.

³ Annual Book of ASTM Standards, Vol 01.03.

⁴ Annual Book of ASTM Standards, Vol 02.01.

⁵ Discontinued, see 1981 Annual Book of ASTM Standards, Part 6.

***A Summary of Changes section appears at the end of this standard.**

- (Manganese Brass) Sheet and Strip⁴
- B 370 Specification for Copper Sheet and Strip for Building Construction⁴
- E 4 Practices for Force Verification of Testing Machines⁶
- E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications⁷
- E 140 Hardness Conversion Tables for Metals⁶

3. Terminology

3.1 Definitions:

3.1.1 *calibration*—determination of the values of the significant parameters by comparison with values indicated by a reference instrument or by a set of reference standards.

3.1.2 *Rockwell hardness number, HR*—a number derived from the net increase in the depth of indentation as the force on an indenter is increased from a specified preliminary test force to a specified total test force and then returned to the preliminary test force.

3.1.2.1 *Discussion—Indenters*—Indenters for the Rockwell hardness test include a diamond spheroconical indenter and ball indenters (steel or tungsten carbide) of several specified diameters.

3.1.2.2 *Discussion*—Rockwell hardness numbers are always quoted with a scale symbol representing the indenter and forces used. The hardness number is followed by the symbol HR and the scale designation. When a ball indenter is used, the scale designation is followed by the letter “S” to indicate the use of a steel ball or the letter “W” to indicate the use of a tungsten carbide ball.

3.1.2.3 *Examples*—64 HRC = Rockwell hardness number of 64 on Rockwell C scale. 81 HR30N = Rockwell superficial hardness number of 81 on Rockwell 30N scale. 72 HRBW =

Rockwell hardness number of 72 on the Rockwell B scale measured using a tungsten carbide ball indenter.

3.1.3 *Rockwell hardness test*—an indentation hardness test using a verified machine to force a diamond spheroconical indenter (diamond indenter), or a ball indenter (steel or tungsten carbide) under specified conditions, into the surface of the material under test in two operations, and to measure the difference in depth of the indentation under the specified conditions of preliminary and total test forces (minor and major loads, respectively).

3.1.4 *Rockwell superficial hardness test*—same as the Rockwell hardness test except that smaller preliminary and total test forces are used.

3.1.5 *verification*—checking or testing to assure conformance with the specification.

4. Significance and Use

4.1 The Rockwell hardness test is an empirical indentation hardness test. Rockwell hardness tests provide useful information about metallic materials. This information may correlate to tensile strength, wear resistance, ductility, and other physical characteristics of metallic materials, and may be useful in quality control and selection of materials.

4.2 Rockwell hardness testing at a specific location on a part may not represent the physical characteristics of the whole part or end product.

4.3 Rockwell hardness tests are considered satisfactory for acceptance testing of commercial shipments, and have been used extensively in industry for this purpose.

4.4 Performance verifications of Rockwell hardness indenters and hardness machines shall be made using test blocks calibrated traceable to the Rockwell standards maintained by NIST when primary reference test blocks are available from NIST for the specific Rockwell scale.

⁶ Annual Book of ASTM Standards, Vol 03.01.

⁷ Annual Book of ASTM Standards, Vol 14.02.

A. GENERAL DESCRIPTION AND TEST PROCEDURE FOR ROCKWELL HARDNESS AND ROCKWELL SUPERFICIAL HARDNESS TESTS

5. Principles of Test and Apparatus

5.1 *General Principles*—The general principles of the Rockwell hardness test are illustrated in Fig. 1 (diamond indenter) and Fig. 2 (ball indenters) and the accompanying Table 1 and Table 2. In the case of the Rockwell superficial test the general principles are illustrated in Fig. 3 (diamond indenter) and Fig. 4 (ball indenter) and the accompanying Table 3 and Table 4.

5.1.1 See *Equipment Manufacturer’s Instruction Manual* for a description of the machine’s characteristics, limitations, and respective operating procedures. Typical applications of the various hardness scales are shown in Tables 5 and 6. Rockwell hardness values are usually determined and reported in accordance with one of these standard scales. An indenter is forced into the surface of a test piece in two steps under specified conditions (see Section 7) and the difference in depth of indentation is measured as *e*.

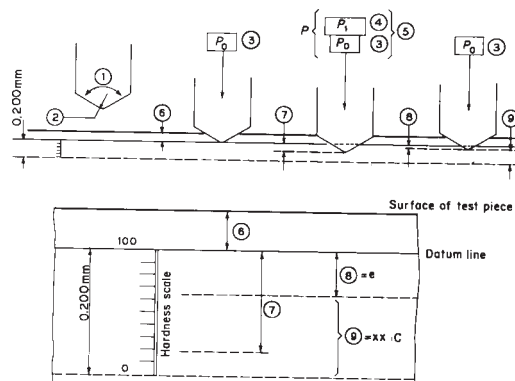


FIG. 1 Rockwell Hardness Test with Diamond Indenter (Rockwell C Example) (Table 1)

5.1.2 The unit measurement for *e* is 0.002 mm and 0.001 mm for the Rockwell hardness test and Rockwell superficial

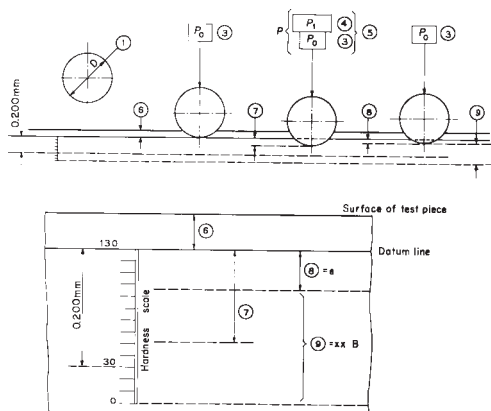


FIG. 2 Rockwell Hardness Test with Ball Indenter (Rockwell B Example) (Table 2)

TABLE 1 Symbols and Designations Associated with Fig. 3

Number	Symbol	Designation
1	...	Angle at the top of the diamond indenter (120°)
2	...	Radius of curvature at the tip of the cone (0.200 mm)
3	P_0	Preliminary Test Force = 10 kgf (98 N)
4	P_1	Additional Force = 140 kgf (1373 N)
5	P	Total Test Force = $P_0 + P_1 = 10 + 140 = 150$ kgf (1471 N)
6	...	Depth of penetration under preliminary test force before application of additional force
7	...	Increase in depth of penetration under additional force
8	e	Permanent increase in depth of penetration under preliminary test force after removal of additional force, the increase being expressed in units of 0.002 mm
9	xx HRC	Rockwell C hardness = $100 - e$

TABLE 2 Symbols and Designations Associated with Fig. 2

Number	Symbol	Designation
1	D	Diameter of ball = $\frac{1}{16}$ in. (1.588 mm)
3	P_0	Preliminary Test Force = 10 kgf (98 N)
4	P_1	Additional force = 90 kgf (883 N)
5	P	Total Test Force = $P_0 + P_1 = 10 + 90 = 100$ kgf (981 N)
6	...	Depth of penetration under preliminary test force before application of additional force
7	...	Increase in depth of penetration under additional force
8	e	Permanent increase in depth of penetration under preliminary test force after removal of the additional force, the increase being expressed in units of 0.002 mm
9	xx HRB	Rockwell B hardness = $130 - e$

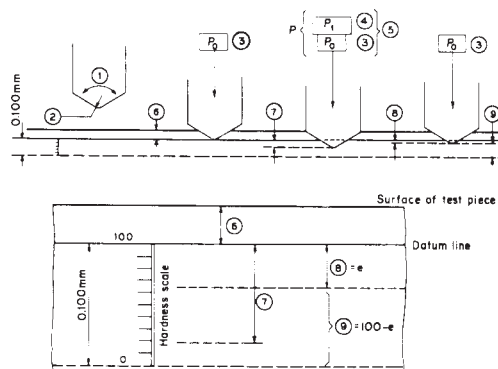


FIG. 3 Rockwell Superficial Hardness Test with Diamond Indenter (Rockwell 30N Example) (Table 3)

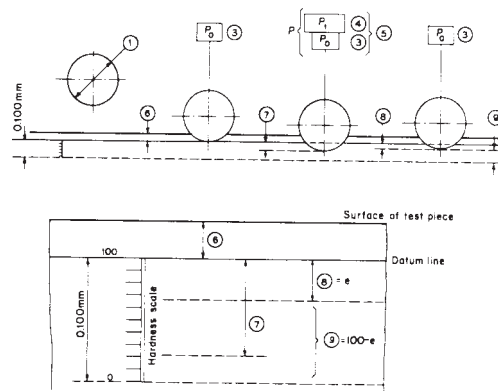


FIG. 4 Rockwell Superficial Hardness Test with Ball Indenter (Rockwell 30T Example) (Table 4)

TABLE 3 Symbols and Designations Associated with Fig. 3

Number	Symbol	Designation
1	...	Angle at the tip of the diamond indenter (120°)
2	...	Radius of curvature at the tip of the cone (0.200 mm)
3	P_0	Preliminary Test Force = 3 kgf (29 N)
4	P_1	Additional force = 27 kgf (265 N)
5	P	Total Test Force = $P_0 + P_1 = 3 + 27 = 30$ kgf (294 N)
6	...	Depth of penetration under preliminary test force before application of additional force
7	...	Increase in depth of penetration under additional force
8	e	Permanent increase in depth of penetration under preliminary test force after removal of additional force, the increase being expressed in units of 0.001 mm
9	xx HR30N	Rockwell 30N hardness = $100 - e$

hardness test, respectively. From the value of e , a number known as the Rockwell hardness is derived. There is no Rockwell hardness value designated by a number alone because it is necessary to indicate which indenter and force have been employed in making the test (see Table 5 and Table 6).

5.2 Description of Machine and Method of Test—The tester for making Rockwell hardness determinations is a machine that measures hardness by determining the difference in penetration depths of an indenter under two specified forces, called preliminary and total test forces.

5.2.1 There are two general classifications of the Rockwell test: the Rockwell hardness test and the Rockwell superficial hardness test.

5.2.2 In the Rockwell hardness test the preliminary test force is 10 kgf (98 N). Total test forces are 60 kgf (589 N), 100 kgf (981 N) and 150 kgf (1471 N). In the Rockwell superficial hardness test the preliminary test force is 3 kgf (29 N) and total test forces are 15 kgf (147 N), 30 kgf (294 N), and 45 kgf (441 N). The indenter for either test shall be of a spheroconical or spherical configuration. Scales vary by a combination of total test force and type of indenter.

TABLE 4 Symbols and Designations Associated with Fig. 4

Number	Symbol	Designation
1	D	Diameter of ball = $\frac{1}{16}$ in. (1.588 mm)
3	P_0	Preliminary Test Force = 3 kgf (29 N)
4	P_1	Additional force = 27 kgf (265 N)
5	P	Total Test Force = $P_0 + P_1 = 3 + 27 = 30$ kgf (294 N)
6	...	Depth of penetration under preliminary test force before application of additional force
7	...	Increase in depth of penetration under additional force
8	e	Permanent increase in depth of penetration under preliminary test force after removal of the additional force, the increase being expressed in units of 0.001 mm
9	XXHR30T	Rockwell 30T hardness = 100-e

5.2.3 The difference in depth is normally measured by an electronic device or by a dial indicator. The hardness value, as read from the instrument, is an arbitrary number which is related to the difference in the depths produced by the two forces; and since the scales are reversed, the higher the number the harder the material.

5.2.4 In accordance with the operating procedures recommended by the manufacturer of the hardness tester, the test is started by applying the preliminary test force causing an initial penetration of the specimen. Since measurement of the difference in depth starts after the preliminary force has been applied, the dial gage pointer is set to zero if the instrument is a dial indicator model. On a digital readout instrument, the zero point is captured by the electronics automatically. The instrument shall be designed to eliminate the effect of impact in applying the preliminary test force.

5.2.5 The additional force is applied for the required dwell time and then removed. The return to the preliminary test force position holds the indenter at the point of deepest penetration yet allows elastic recovery to occur and the stretch of the frame to be factored out. The test result is displayed by the testing machine.

5.3 Indenters:

5.3.1 The standard indenters are the diamond spheroconical indenter and steel ball indenters having steel or tungsten carbide balls $\frac{1}{16}$, $\frac{1}{8}$, $\frac{1}{4}$, and $\frac{1}{2}$ in. (1.588, 3.175, 6.350, and 12.70 mm) in diameter.

5.3.2 The diamond indenter shall conform to the requirements prescribed in 13.1.2.1.

5.3.3 Indenter balls can be either tungsten carbide or hardened steel; however, tungsten carbide balls are recommended to reduce errors associated with the tendency of steel balls to flatten with use. Indenter balls shall conform to the requirements prescribed in 13.1.2.2.

5.3.4 Dust, dirt, grease, and scale shall not be allowed to accumulate on the indenter as this will affect the test results.

5.4 *Anvils*—An anvil shall be used that is suitable for the specimen to be tested. The seating and supporting surfaces of all anvils shall be clean and smooth and shall be free from pits, deep scratches, and foreign material. If the provisions of 6.3 on thickness of the test piece are complied with, there will be no danger of indenting the anvil, but, if it is so thin that the impression shows through on the under side, the anvil may be damaged. Damage may also occur from accidental contacting

of the anvil by the indenter. If the anvil is damaged from any cause, it shall be replaced. Anvils showing the least visible dent will give inaccurate results on thin material.

5.4.1 Cylindrical pieces shall be tested with a V-grooved anvil that will support the specimen with the axis of the V-groove directly under the indenter or on hard, parallel, twin cylinders properly positioned and clamped in their base.

5.4.2 Flat pieces shall be tested on a flat anvil that has a smooth, flat bearing surface whose plane is perpendicular to the axis of the indenter.

5.4.3 For thin materials or specimens that are not perfectly flat, an anvil having an elevated, flat spot about $\frac{1}{4}$ in. (6 mm) in diameter shall be used. This spot shall be polished smooth and flat and shall have a Rockwell hardness of at least 60 HRC. Very soft material should not be tested on the spot anvil because the applied force may cause the penetration of the anvil into the under side of the specimen regardless of its thickness.

5.4.4 When testing thin sheet material with a ball indenter, it is recommended that a diamond spot anvil be used.

NOTE 3—Caution: A diamond spot anvil should only be used with a superficial hardness tester and ball indenter. This recommendation should be followed, except when directed otherwise by material specification.

5.5 *Test Blocks*—Test blocks meeting the requirements of Part C shall be used to periodically verify the hardness tester.

6. Test Piece

6.1 The test shall be carried out on a smooth, even surface that is free from oxide scale, foreign matter, and, in particular, completely free from lubricants. An exception is made for reactive metals, such as titanium, that may adhere to the indenter. In such situations, a suitable lubricant such as kerosene may be used. The use of a lubricant shall be reported on the test report.

6.2 Preparation shall be carried out in such a way that any alteration of the surface hardness (for example, due to heat or cold-working) is minimized.

6.3 The thickness of the test piece or of the layer under test should be as dictated in Tables 7-9, and Table 10 and as presented graphically in Figs. 5 and 6. These tables were determined from studies on strips of carbon steel and give reliable results. For all other materials it is recommended that the thickness exceed 10 times the depth of indentation with a diamond indenter and 15 times the depth of indentation with a ball indenter. As a rule, no deformation should be visible on the back of the test piece after the test although not all such marking is indicative of a bad test.

6.4 For tests on convex cylindrical surfaces the corrections given in Tables 11-13, and Table 14 shall be applied. Corrections for tests on spherical and concave surfaces should be the subject of special agreement. When testing cylindrical specimens, the accuracy of the test will be seriously affected by alignment of elevating screw, V-anvil, indenters, surface finish, and the straightness of the cylinder. For diameters between those given in the tables, correction factors may be derived by linear interpolation. Tests performed on diameters smaller than those given in Tables 11-14 are not acceptable.



TABLE 5 Rockwell Hardness Scales

Scale Symbol	Indenter	Total Test Force, kgf	Dial Figures	Typical Applications of Scales
B	1/16 -in. (1.588-mm) ball	100	red	Copper alloys, soft steels, aluminum alloys, malleable iron, etc.
C	diamond	150	black	Steel, hard cast irons, pearlitic malleable iron, titanium, deep case hardened steel, and other materials harder than B100.
A	diamond	60	black	Cemented carbides, thin steel, and shallow case-hardened steel.
D	diamond	100	black	Thin steel and medium case hardened steel, and pearlitic malleable iron.
E	1/8 -in. (3.175-mm) ball	100	red	Cast iron, aluminum and magnesium alloys, bearing metals.
F	1/16 -in. (1.588-mm) ball	60	red	Annealed copper alloys, thin soft sheet metals.
G	1/16 -in. (1.588-mm) ball	150	red	Malleable irons, copper-nickel-zinc and cupro-nickel alloys. Upper limit G92 to avoid possible flattening of ball.
H	1/8 -in. (3.175-mm) ball	60	red	Aluminum, zinc, lead. Bearing metals and other very soft or thin materials. Use smallest ball and heaviest load that does not give anvil effect.
K	1/8 -in. (3.175-mm) ball	150	red	
L	1/4 -in. (6.350-mm) ball	60	red	
M	1/4 -in. (6.350-mm) ball	100	red	
P	1/4 -in. (6.350-mm) ball	150	red	
R	1/2 -in. (12.70-mm) ball	60	red	
S	1/2 -in. (12.70-mm) ball	100	red	
V	1/2 -in. (12.70-mm) ball	150	red	

TABLE 6 Rockwell Superficial Hardness Scales

Total Test Force, kgf (N)	Scale Symbols				
	N Scale, Diamond Indenter	T Scale, 1/16 -in. (1.588-mm) Ball	W Scale, 1/8 -in. (3.175-mm) Ball	X Scale, 1/4 -in. (6.350-mm) Ball	Y Scale, 1/2 -in. (12.70-mm) Ball
15 (147)	15N	15T	15W	15X	15Y
30 (294)	30N	30T	30W	30X	30Y
45 (441)	45N	45T	45W	45X	45Y

TABLE 7 A Minimum Thickness Guide for Selection of Scales Using the Diamond Indenter (see Fig. 5)

NOTE 1—For any given thickness, the indicated Rockwell hardness is the minimum value acceptable for testing. For a given hardness, material of any greater thickness than that corresponding to that hardness can be tested on the indicated scale.

Minimum Thickness		Rockwell Scale		
		A	C	
in.	mm	Hardness Reading	Approximate Hardness C-Scale ^A	Dial Reading
0.014	0.36	...	...	...
0.016	0.41	86	69	...
0.018	0.46	84	65	...
0.020	0.51	82	61.5	...
0.022	0.56	79	56	69
0.024	0.61	76	50	67
0.026	0.66	71	41	65
0.028	0.71	67	32	62
0.030	0.76	60	19	57
0.032	0.81	...	...	52
0.034	0.86	...	...	45
0.036	0.91	...	...	37
0.038	0.96	...	...	28
0.040	1.02	...	...	20

^A These approximate hardness numbers are for use in selecting a suitable scale and should not be used as hardness conversions. If necessary to convert test readings to another scale, refer to Hardness Conversion Tables E 140 (Relationship Between Brinell Hardness, Vickers Hardness, Rockwell Hardness, Rockwell Superficial Hardness, and Knoop Hardness).

6.5 Precautions for materials having excessive, time-dependent plasticity (indentation creep): In the case of materials exhibiting plastic flow after application of the total test force, the indenter will continue to move. The total test force should be removed after the specified dwell time, and the time recorded after the test results (that is, 65 HRFW, 4 s) if longer

TABLE 8 A Minimum Thickness Guide for Selection of Scales Using the 1/16 -in. (1.588-mm) Diameter Ball Indenter (see Fig. 6)

NOTE 1—For any given thickness, the indicated Rockwell hardness is the minimum value acceptable for testing. For a given hardness, material of any greater thickness than that corresponding to that hardness can be tested on the indicated scale.

Minimum Thickness		Rockwell Scale		
		F	B	
in.	mm	Hardness Reading	Approximate Hardness B-Scale ^A	Hardness Reading
0.022	0.56	...	...	...
0.024	0.61	98	72	94
0.026	0.66	91	60	87
0.028	0.71	85	49	80
0.030	0.76	77	35	71
0.032	0.81	69	21	62
0.034	0.86	...	...	52
0.036	0.91	...	...	40
0.038	0.96	...	...	28
0.040	1.02	...	...	...

^A These approximate hardness numbers are for use in selecting a suitable scale and should not be used as hardness conversions. If necessary to convert test readings to another scale refer to Hardness Conversion Tables E 140 (Relationship Between Brinell Hardness, Vickers Hardness, Rockwell Hardness, Rockwell Superficial Hardness and Knoop Hardness).

than 3 s. When materials require the use of a dwell time greater than 3 s, this should be specified in the product specification.

7. Procedure

7.1 As part of the test procedure, periodic checks shall be performed. See Section 14 for recommendations.

7.2 The test is normally carried out at ambient temperature within the limits of 50 to 95°F (10 to 35°C). However, because



TABLE 9 A Minimum Thickness Guide for Selection of Scales Using the Diamond Indenter (see Fig. 5)

NOTE 1—For any given thickness, the indicated Rockwell hardness is the minimum value acceptable for testing. For a given hardness, material of any greater thickness than that corresponding to that hardness can be tested on the indicated scale

Minimum Thickness		Rockwell Superficial Scale					
		15N		30N		45N	
in.	mm	Hardness Reading	Approximate Hardness C-Scale ^A	Hardness Reading	Approximate Hardness C-Scale ^A	Hardness Reading	Approximate Hardness C-Scale ^A
0.006	0.15	92	65	...	...	...	...
0.008	0.20	90	60	...	...	...	...
0.010	0.25	88	55	...	...	...	...
0.012	0.30	83	45	82	65	77	69.5
0.014	0.36	76	32	78.5	61	74	67
0.016	0.41	68	18	74	56	72	65
0.018	0.46	...	...	66	47	68	61
0.020	0.51	...	...	57	37	63	57
0.022	0.56	...	...	47	26	58	52.5
0.024	0.61	...	...	...	...	51	47
0.026	0.66	...	...	...	...	37	35
0.028	0.71	...	...	...	...	20	20.5
0.030	0.76	...	...	...	...	...	...

^A These approximate hardness numbers are for use in selecting a suitable scale, and should not be used as hardness conversions. If necessary to convert test readings to another scale, refer to Hardness Conversion Tables E 140 (Relationship Between Brinell Hardness, Vickers Hardness, Rockwell Hardness, Rockwell Superficial Hardness and Knoop Hardness).

TABLE 10 A Minimum Thickness Guide for Selection of Scales Using the 1/16 in. (1.588 mm) Diameter Ball Indenter (see Fig. 6)

NOTE 1—For any given thickness, the indicated Rockwell hardness is the minimum value acceptable for testing. For a given hardness, material of any greater thickness than that corresponding to that hardness can be tested on the indicated scale.

Minimum Thickness		Rockwell Superficial Scale					
		15T		30T		45T	
in.	mm	Hardness Reading	Approximate Hardness B-Scale ^A	Hardness Reading	Approximate Hardness B-Scale ^A	Hardness Reading	Approximate Hardness B-Scale ^A
0.010	0.25	91	93	...	...	...	...
0.012	0.30	86	78	...	...	...	...
0.014	0.36	81	62	80	96	...	...
0.016	0.41	75	44	72	84	71	99
0.018	0.46	68	24	64	71	62	90
0.020	0.51	...	...	55	58	53	80
0.022	0.56	...	...	45	43	43	70
0.024	0.61	...	...	34	28	31	58
0.026	0.66	...	...	...	...	18	45
0.028	0.71	...	...	...	...	4	32
0.030	0.76	...	...	...	...	...	...

^A These approximate hardness numbers are for use in selecting a suitable scale, and should not be used as hardness conversions. If necessary to convert test readings to another scale refer to Hardness Conversion Tables E 140 (Relationship Between Brinell Hardness, Vickers Hardness, Rockwell Hardness, Rockwell Superficial Hardness and Knoop Hardness).

temperature variation may affect the results, users of the Rockwell test may choose to control the temperature within a tighter range.

7.3 The test piece shall be supported rigidly so that no effects of displacement occur during the test.

7.4 Bring the indenter into contact with the test surface and apply the preliminary test force P_0 (minor load) of 10 kgf (98 N) for the Rockwell hardness test or 3 kgf (29 N) for Rockwell superficial hardness test in a direction perpendicular to the surface without shock or vibration. (See Table 15 for tolerances of test forces.) The dwell time for the preliminary test force shall not exceed 3 s.

7.5 Establish the reference position (see *Manufacturer's Instruction Manual*) and increase the force, without shock or

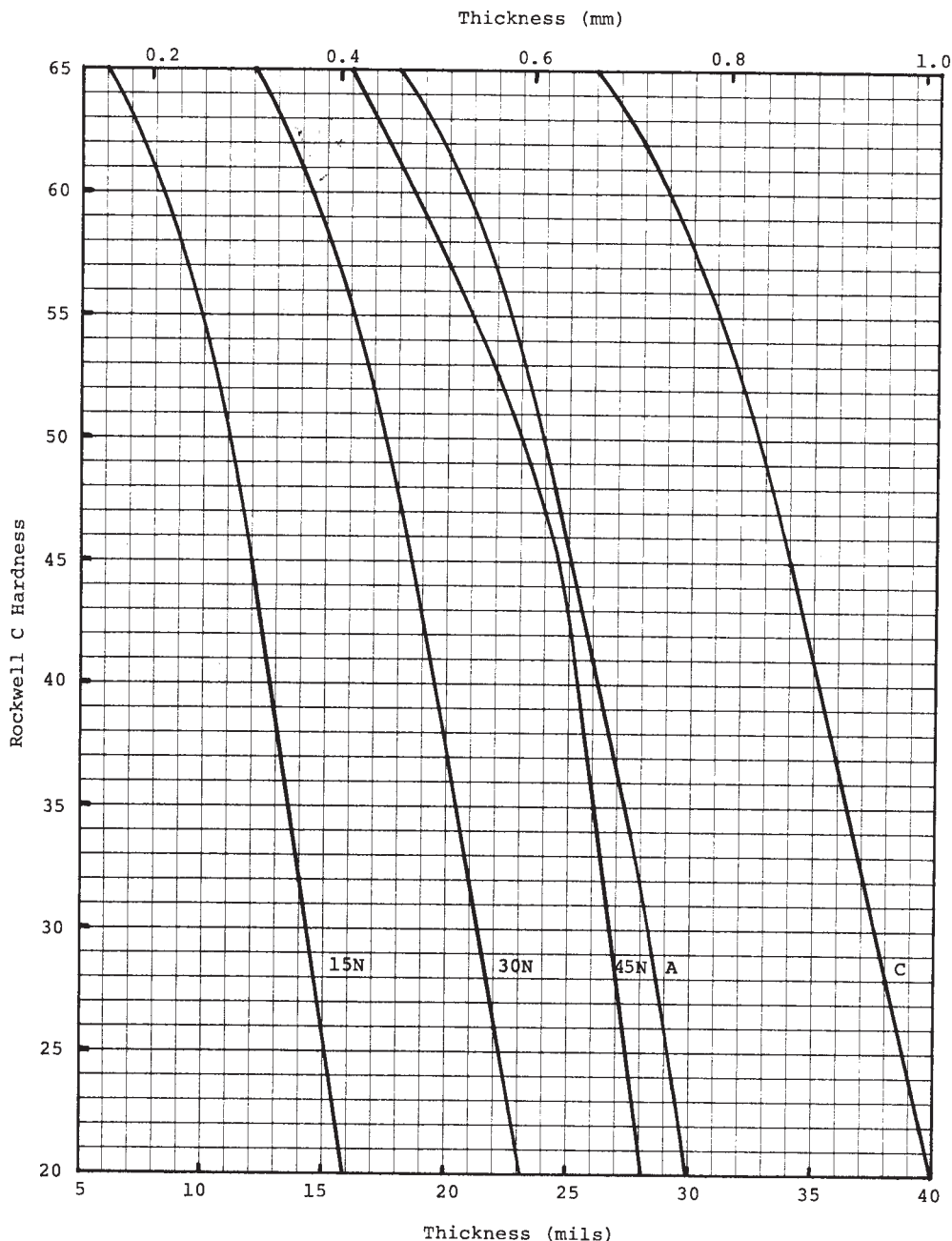
vibration, over a period of 1 to 8 s by the value of the additional test force, P_1 (additional load) needed to obtain the required total test force P for a given hardness scale (see Tables 5 and 6).

7.6 While maintaining the preliminary test force P_0 , remove the additional test force P_1 in accordance with the following:

7.6.1 For materials which, under the conditions of the test, show no time-dependent plasticity, remove P_1 within 3 s after the total test force is applied.

7.6.2 For materials which, under the conditions of the test, show some time-dependent plasticity, remove P_1 within 5 to 6 s when using diamond cone indenter and within 6 to 8 s when using steel ball indenter after the application of the total test force begins.

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NOTE 1—Locate a point corresponding to the thickness-hardness combination to be tested. Only scales falling to the left of this point may be used to test this combination.

FIG. 5 Thickness Limits for Rockwell Hardness Testing Using the Diamond Indenter

7.6.3 In special cases where the material, under the conditions of the test, shows considerable time-dependent plasticity, remove P_1 within 20 to 25 s after the application of the total test force begins.

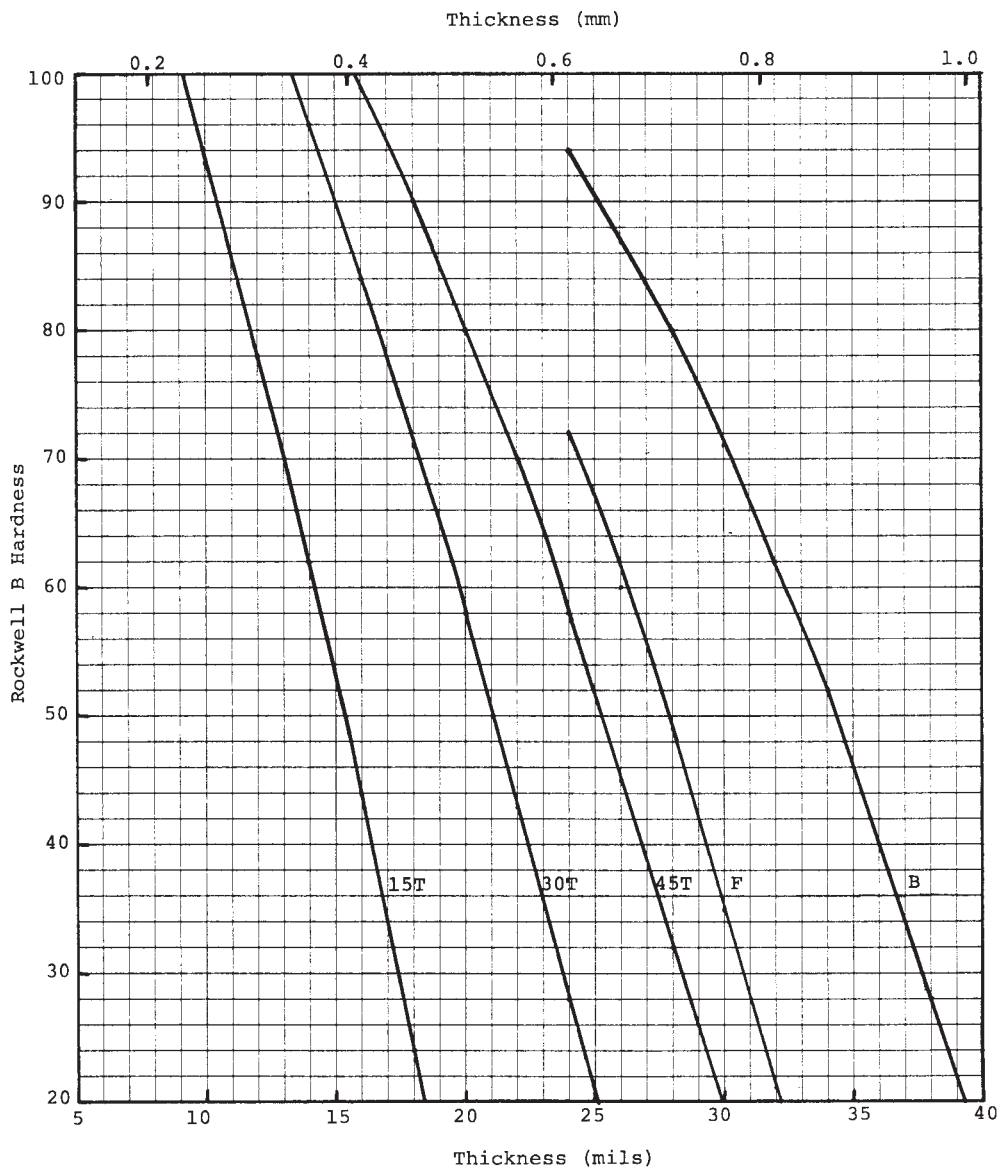
7.6.4 When materials require the use of a dwell time greater than 3 s, this shall be specified in the product specification, and the dwell time shall be recorded.

7.7 Throughout the test, the apparatus shall be protected from shock or vibration.

7.8 The Rockwell hardness number is derived from the differential increase in depth of indentation e and is usually read directly. The derivation of the Rockwell hardness number is illustrated in Figs. 1-4.

7.9 After each change, or removal and replacement, of the indenter or the anvil, it shall be ascertained that the indenter (or the new anvil) is correctly mounted in its housing.

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NOTE 1—Locate a point corresponding to the thickness-hardness combination to be tested. Only scales falling to the left of this point may be used to test this combination.

FIG. 6 Thickness Limits for Rockwell Hardness Testing Using the 1/16 -in. (1.588-mm) Diameter Ball Indenter

7.9.1 The first two readings after an indenter or anvil has been mounted shall be disregarded, and the operation of the machine checked with the appropriate standardized hardness test block.

NOTE 4—It is recognized that appropriate standardized test blocks are not available for all geometric shapes, or materials, or both.

7.10 The distance between the center of two adjacent indentations shall be at least three times the diameter of the indentation.

7.10.1 The distance from the center of any indentation to an edge of the test piece shall be at least two and a half times the diameter of the indentation.

7.11 Unless otherwise specified, all readings are to be reported to the nearest whole number, rounding in accordance with Practice E 29.

8. Conversion to Other Hardness Scales or Tensile Strength Values

8.1 There is no general method of accurately converting the Rockwell hardness numbers on one scale to Rockwell hardness numbers on another scale, or to other types of hardness numbers, or to tensile strength values. Such conversions are, at best, approximations and, therefore, should be avoided except for special cases where a reliable basis for the approximate conversion has been obtained by comparison tests.

NOTE 5—The Standard Hardness Conversion Tables E 140, for Metals, give approximate conversion values for specific materials such as steel, austenitic stainless steel, nickel and high-nickel alloys, cartridge brass, copper alloys, and alloyed white cast irons.

NOTE 6—ASTM Specifications giving approximate hardness-tensile strength relationships are listed in Appendix X1.



TABLE 11 Corrections to Be Added to Rockwell C, A, and D Values Obtained on Convex Cylindrical Surfaces^A of Various Diameters

Dial Reading	Diameters of Convex Cylindrical Surfaces								
	¼ in. (6.4 mm)	⅜ in. (10 mm)	½ in. (13 mm)	⅝ in. (16 mm)	¾ in. (19 mm)	⅞ in. (22 mm)	1 in. (25 mm)	1¼ in. (32 mm)	1½ in. (38 mm)
Corrections to be Added to Rockwell C, A, and D Values ^B									
20	6.0	4.5	3.5	2.5	2.0	1.5	1.5	1.0	1.0
25	5.5	4.0	3.0	2.5	2.0	1.5	1.0	1.0	1.0
30	5.0	3.5	2.5	2.0	1.5	1.5	1.0	1.0	0.5
35	4.0	3.0	2.0	1.5	1.5	1.0	1.0	0.5	0.5
40	3.5	2.5	2.0	1.5	1.0	1.0	1.0	0.5	0.5
45	3.0	2.0	1.5	1.0	1.0	1.0	0.5	0.5	0.5
50	2.5	2.0	1.5	1.0	1.0	0.5	0.5	0.5	0.5
55	2.0	1.5	1.0	1.0	0.5	0.5	0.5	0.5	0
60	1.5	1.0	1.0	0.5	0.5	0.5	0.5	0	0
65	1.5	1.0	1.0	0.5	0.5	0.5	0.5	0	0
70	1.0	1.0	0.5	0.5	0.5	0.5	0.5	0	0
75	1.0	0.5	0.5	0.5	0.5	0.5	0	0	0
80	0.5	0.5	0.5	0.5	0.5	0	0	0	0
85	0.5	0.5	0.5	0	0	0	0	0	0
90	0.5	0	0	0	0	0	0	0	0

^A When testing cylindrical specimens, the accuracy of the test will be seriously affected by alignment of elevating screw, V-anvil, indenters, surface finish, and the straightness of the cylinder.

^B These corrections are approximate only and represent the averages to the nearest 0.5 Rockwell number, of numerous actual observations.

TABLE 12 Corrections to Be Added to Rockwell B, F, and G Values Obtained on Convex Cylindrical Surfaces^A of Various Diameters

Hardness Reading	Diameters of Convex Cylindrical Surfaces						
	¼ in. (6.4 mm)	⅜ in. (10 mm)	½ in. (13 mm)	⅝ in. (16 mm)	¾ in. (19 mm)	⅞ in. (22 mm)	1 in. (25 mm)
Corrections to be Added to Rockwell B, F, and G Values ^B							
0	12.5	8.5	6.5	5.5	4.5	3.5	3.0
10	12.0	8.0	6.0	5.0	4.0	3.5	3.0
20	11.0	7.5	5.5	4.5	4.0	3.5	3.0
30	10.0	6.5	5.0	4.5	3.5	3.0	2.5
40	9.0	6.0	4.5	4.0	3.0	2.5	2.5
50	8.0	5.5	4.0	3.5	3.0	2.5	2.0
60	7.0	5.0	3.5	3.0	2.5	2.0	2.0
70	6.0	4.0	3.0	2.5	2.0	2.0	1.5
80	5.0	3.5	2.5	2.0	1.5	1.5	1.5
90	4.0	3.0	2.0	1.5	1.5	1.5	1.0
100	3.5	2.5	1.5	1.5	1.0	1.0	0.5

^A When testing cylindrical specimens, the accuracy of the test will be seriously affected by alignment of elevating screw, V-anvil, indenters, surface finish, and the straightness of the cylinder.

^B These corrections are approximate only and represent the averages to the nearest 0.5 Rockwell number, of numerous actual observations.

9. Report

9.1 The report shall include the following information:

9.1.1 The Rockwell hardness number (see 3.1.2).

9.1.1.1 All reports of Rockwell hardness test readings shall indicate the scale used and also the ambient temperature of test if it was outside the 50 to 95°F (10 to 35°C) range (see 7.2).

Unless otherwise specified, all readings are to be reported to the nearest whole number, rounding to be in accordance with Practice E 29.

9.1.2 The time of application of the total test force if greater than 3 s.

9.1.3 Any lubricant that is used on the test surface (see 6.1).



TABLE 13 Corrections to Be Added to Rockwell Superficial 15N, 30N, and 45N Values Obtained on Convex Cylindrical Surfaces of Various Diameters^A

Hardness Reading	Diameters of Convex Cylindrical Surfaces					
	1/8 in. (3.2 mm)	1/4 in. (6.4 mm)	3/8 in. (10 mm)	1/2 in. (13 mm)	3/4 in. (19 mm)	1 in. (25 mm)
	Corrections to be Added to Rockwell Superficial 15N, 30N, and 45N Values ^B					
20	6.0	3.0	2.0	1.5	1.5	1.5
25	5.5	3.0	2.0	1.5	1.5	1.0
30	5.5	3.0	2.0	1.5	1.0	1.0
35	5.0	2.5	2.0	1.5	1.0	1.0
40	4.5	2.5	1.5	1.5	1.0	1.0
45	4.0	2.0	1.5	1.0	1.0	1.0
50	3.5	2.0	1.5	1.0	1.0	0.5
55	3.5	2.0	1.5	1.0	0.5	0.5
60	3.0	1.5	1.0	1.0	0.5	0.5
65	2.5	1.5	1.0	0.5	0.5	0.5
70	2.0	1.0	1.0	0.5	0.5	0.5
75	1.5	1.0	0.5	0.5	0.5	0
80	1.0	0.5	0.5	0.5	0	0
85	0.5	0.5	0.5	0.5	0	0
90	0	0	0	0	0	0

^A When testing cylindrical specimens the accuracy of the test will be seriously affected by alignment of elevating screw, V-anvil, indenters, surface finish, and the straightness of the cylinder.

^B These corrections are approximate only and represent the averages, to the nearest 0.5 Rockwell superficial number, of numerous actual observations.

TABLE 14 Corrections to Be Added to Rockwell Superficial 15T, 30T, and 45T Values Obtained on Convex Cylindrical Surfaces^A of Various Diameters

Hardness Reading	Diameters of Convex Cylindrical Surfaces						
	1/8 in. (3.2 mm)	1/4 in. (6.4 mm)	3/8 in. (10 mm)	1/2 in. (13 mm)	5/8 in. (16 mm)	3/4 in. (19 mm)	1 in. (25 mm)
	Corrections to be Added to Rockwell Superficial 15T, 30T, and 45T Values ^B						
20	13.0	9.0	6.0	4.5	4.5	3.0	2.0
30	11.5	7.5	5.0	3.5	3.5	2.5	2.0
40	10.0	6.5	4.5	3.5	3.0	2.5	2.0
50	8.5	5.5	4.0	3.0	2.5	2.0	1.5
60	6.5	4.5	3.0	2.5	2.0	1.5	1.5
70	5.0	3.5	2.5	2.0	1.5	1.0	1.0
80	3.0	2.0	1.5	1.5	1.0	1.0	0.5
90	1.5	1.0	1.0	0.5	0.5	0.5	0.5

^A When testing cylindrical specimens, the accuracy of the test will be seriously affected by alignment of elevating screw, V-anvil, indenters, surface finish, and the straightness of the cylinder.

^B These corrections are approximate only and represent the averages, to the nearest 0.5 Rockwell superficial number, of numerous actual observations.

TABLE 15 Tolerances on Applied Forces

Load, kgf (N)	Tolerance, kgf (N)
10 (98)	±0.20 (±1.96)
60 (589)	±0.45 (±4.41)
100 (981)	±0.65 (±4.57)
150 (147)	±0.90 (±8.83)
3 (29)	±0.060 (±0.589)
15 (147)	±0.100 (±0.981)
30 (294)	±0.200 (±1.961)
45 (441)	±0.300 (±2.943)

10. Precision and Bias

10.1 *Precision*—An interlaboratory test program is now in progress. When completed, it will be the basis of a statement on precision.

10.2 *Bias*—There is no basis for defining the bias for this method.

B. VERIFICATION OF MACHINES FOR ROCKWELL HARDNESS AND ROCKWELL SUPERFICIAL HARDNESS TESTING

11. Scope

11.1 Part B covers two procedures for the verification of machines for Rockwell hardness and Rockwell superficial hardness testing and a procedure which is recommended for use to confirm that the machine is operating satisfactorily in the intervals between the periodical routine checks made by the user. The two methods of verification are:

11.1.1 Separate verification of test force, indenter, and the depth measuring device followed by a performance test (13.2). This method shall be used for new and rebuilt machines.

11.1.2 Verification by standardized test block method. This test method shall be used in referee, laboratory, or routine testing to assure the operator that the machine for Rockwell hardness testing is operating properly (see 13.2).

12. General Requirements

12.1 Before a Rockwell hardness testing machine is verified, it shall be checked to ensure that:

12.1.1 The machine is properly set up.

12.1.2 The indenter-holder is properly seated in the plunger.

12.1.3 When the indenter is a steel ball, the holder is fitted with a new ball that complies with 13.1.2.2. A new ball is not required when a tungsten carbide ball is used.

12.1.4 When the indenter is a diamond indenter, it must be free from defects which may affect the accuracy of the test (See 13.1.2.1).

12.1.5 The test force can be applied and removed without shock or vibration and in such a manner that the readings are not influenced.

12.1.6 The readings are not affected by deformations of the frame.

13. Verification

13.1 Direct Verification—Direct verification involves verification of the test force, verification of the indenter, and verification of the measuring device.

13.1.1 *Verification of the Test Force:*

13.1.1.1 The preliminary test force P_0 and each total test force P used (see Table 15) shall be measured, and this shall be done at not less than three positions of the plunger uniformly spaced throughout its range of movement during testing.

13.1.1.2 The forces shall be measured by one of the following two methods described in Practices E 4.

(1) Measuring by means of an elastic proving device previously calibrated to Class A accuracy of $\pm 0.25\%$, or

(2) balancing against a force, accurate to $\pm 0.25\%$ applied by means of standardized masses with mechanical advantage.

13.1.1.3 Three readings shall be taken for each force at each position of the plunger. Immediately before each reading is taken, the plunger shall have been moved in the same direction as during testing.

13.1.1.4 Each measurement of the preliminary test force before application and after removal of the additional test force and each measurement of the total force shall be within the tolerances given in Table 15.

13.1.2 Verification of the indenter.

13.1.2.1 *Diamond Indenter:*

(1) The diamond indenter shall be free from surface defects (cracks, chips, pits, etc.) and polished to such an extent that no unpolished part of its surface makes contact with the test piece when the indenter penetrates to a depth of 0.3 mm for Rockwell hardness testing and 0.2 mm for Rockwell superficial hardness testing.

(2) The verification of the shape of the indenter can be made by direct measurement or by measurement of its projection on a screen. The verification shall be made at not less than four approximately equally spaced sections.

(3) The diamond indenter shall have an included angle of $120^\circ \pm 0.35^\circ$.

(4) The angle between the axis of the diamond indenter and the axis of the indenter holder (normal to the seating surface) shall not exceed 0.5° .

(5) The spherical tip of the diamond cone shall have a mean radius of 0.200 ± 0.010 mm. In each measured section the radius shall not exceed 0.200 ± 0.015 mm and local deviations from a true radius shall not exceed 0.002 mm. The surfaces of the cone and spherical tip shall blend in a truly tangential manner.

(6) The hardness values given by the testing machine do not depend only on the dimensions given in 13.1.2.1 (c-e), but also on the surface roughness and the position of the crystallographic axis of the diamond and the seating of the diamond in its holder. For this reason, a performance test is considered necessary. The indenter shall be used in a standardizing machine in which the test force applied and the measuring device can be verified by fundamental measurement. Tests shall be made on a minimum of two standardized blocks, that comply with the requirements of Part C, one from each of the minimum and maximum ranges specified in Table 16. Three test impressions shall be made on each of these blocks. The

TABLE 16 Hardness Ranges Used in Verification by Standardized Test Block Method^A

Rockwell Scale	Hardness Ranges
C	$\left\{ \begin{array}{l} 20 \text{ to } 30 \\ 35 \text{ to } 55 \\ 59 \text{ to } 65 \end{array} \right.$
B	$\left\{ \begin{array}{l} 40 \text{ to } 59 \\ 60 \text{ to } 79 \\ 80 \text{ to } 100 \end{array} \right.$
30N	$\left\{ \begin{array}{l} 40 \text{ to } 50 \\ 55 \text{ to } 73 \\ 75 \text{ to } 80 \end{array} \right.$
30T	$\left\{ \begin{array}{l} 43 \text{ to } 56 \\ 57 \text{ to } 70 \text{ incl} \\ \text{over } 70 \text{ to } 82 \end{array} \right.$

^A For scales not listed, use equivalent hardness ranges as those shown; for example, 20 HRC to 30 HRC corresponds to 69.4 HR 15N to 75.0 HR 15N.

mean of these readings shall not differ from the value of the standardized test block by more than the amount shown in Table 17.

13.1.2.2 Indenter Balls:

NOTE 7—Caution: Steel balls have been shown to give different results than tungsten carbide balls.

(1) For the purpose of verifying the size and the hardness of the indenter, it is considered sufficient to test a sample selected at random from a batch. The ball(s) verified for hardness shall be discarded.

(2) The ball shall be polished and free from surface defects.

(3) The user shall either measure the balls to ensure that they meet the following requirements, or he shall obtain balls from a supplier who can certify that the following conditions are met. The diameter, when measured at not less than three positions, shall not differ from the nominal diameter by more than the tolerance given in Table 18.

Steel ball: The hardness of the steel ball shall not be less than 746 HV10. Mean diagonals of Vickers impressions corresponding to this hardness level are given in Table 19.

Tungsten carbide ball: The hardness of the tungsten carbide ball shall not be less than 1500 HV10. The material of the tungsten carbide balls shall have a density of $14.8 \text{ g/cm}^3 \pm 0.2 \text{ g/cm}^3$ and the following chemical composition:

Total other carbides	2.0 % maximum
Cobalt (Co)	5.0 to 7.0 %
Tungsten carbide (WC)	balance

13.1.3 Verification of the Measuring Device:

13.1.3.1 The depth-measuring device shall be verified over not less than three intervals, including the intervals corresponding to the lowest and highest hardnesses for which the scales are normally used by making known incremental movements of the indenter.

13.1.3.2 The instrument used to verify the depth measuring device shall have an accuracy of 0.0002 mm.

13.1.3.3 The depth-measuring device shall correctly indicate within ± 0.5 of Rockwell unit, over each interval. This corresponds to ± 0.001 mm for regular Rockwell ranges and ± 0.0005 mm on Rockwell superficial ranges.

13.2 Indirect Verification—Indirect verification may be carried out by means of standardized blocks calibrated in accordance with Part C. For Rockwell hardness scales that use a ball indenter, the standardized blocks to be used for the indirect verification shall have been calibrated with the same type of ball indenter (that is, steel or tungsten carbide) as the indenter that will be used for the indirect verification.

13.2.1 Procedure:

13.2.1.1 For indirect verification of a testing machine, the following procedures shall be applied: The testing machine

TABLE 17 Allowable Deviation in Hardness Readings for Verified Diamond Indenters

For Hardness Readings in Range of:	Allowable Deviation, Rockwell Units
C 63	± 0.5
C 25	± 1.0
30N 80	± 0.5
30N 45	± 1.0

TABLE 18 Tolerances for Rockwell Hardness Ball Indenters

Diameter of Ball		Tolerance ^A	
in.	mm	in.	mm
1/16	1.588	± 0.0001	± 0.0025
1/8	3.175	± 0.0001	± 0.0025
1/4	6.350	± 0.0001	± 0.0025
1/2	12.700	± 0.0001	± 0.0025

^A For balls in the range of diameters specified, these tolerances and the permissible variation in the diameter of any one ball, as specified in 19.1.3, are met by Grade 24 balls of the Anti-Friction Bearing Manufacturers' Association (ABMA).

TABLE 19 Maximum Mean Diagonal of Vickers Hardness Indentation on Steel Balls

Ball Diameters		Maximum Mean Diagonal of Indentation on the Ball Made with Vickers Indenter Under 10-kgf (98-N) Load, mm
in.	mm	
1/16	1.588	0.141
1/8	3.175	0.144
1/4	6.350	0.145
1/2	12.700	0.147

shall be verified using standardized test blocks in the low, middle, and high hardness ranges for each scale to be used. Commonly used hardness scales and hardness ranges are given in Table 16. The testing machine shall not be adjusted between tests made on the three test blocks. The verification is incomplete unless the requirements of 13.5 are met.

13.2.1.2 In accordance with Part A of this test method, make five indentations on each standardized block, distributed uniformly over the block's surface and report the hardness values to within 0.2 of a Rockwell unit. Before making these indentations, at least two indentations shall be made to ensure that the machine is working freely and that the standardized block, the indenter, and the anvil are seating correctly. The results of these preliminary indentations shall be ignored.

13.2.1.3 For each standardized test block, let R_1, R_2, \dots, R_5 be the hardness readings of the 5 indentations arranged in increasing order of magnitude.

13.2.2 Repeatability:

13.2.2.1 The repeatability of the testing machine under the particular verification conditions is determined by the following quantity:

$$R_5 - R_1 \tag{1}$$

13.2.2.2 The repeatability of the testing machine verified is considered satisfactory if it satisfies the conditions given in Table 20.

13.2.3 Error:

13.2.3.1 The error of the testing machine under the particular verification conditions is expressed by the following quantity:

$$\bar{R} - R \tag{2}$$

where:

$$\bar{R} = \frac{R_1 + R_2 + \dots + R_5}{5}, \text{ and}$$

R = stated hardness of the standardized test block used.

TABLE 20 Repeatability of Machines

Range of Standardized Hardness Test Blocks	The Repeatability ^A of the Machine Shall Be Not Greater Than:
<i>Rockwell C Scale:</i>	
25 to 30	2.0
35 to 55	1.5
59 to 65	1.0
<i>Rockwell B Scale:</i>	
40 to 59	2.5
60 to 79	2.0
80 to 100	2.0
<i>Rockwell 30N Scale:</i>	
40 to 50	2.0
55 to 73	1.5
75 to 80	1.0
<i>Rockwell 30T Scale:</i>	
43 to 56	2.5
57 to 70, incl	2.0
Over 70 to 82	2.0

^A The repeatability of machines on Rockwell or Rockwell superficial hardness scales other than those given in Table 20 shall be the equivalent converted difference in hardness for those scales, except for the 15N and 15T scales. In the case of the 15N and 15T scales, the repeatability shall be no greater than 1.0 for all ranges.

Example—At C 60, typical readings of a series of indentations might range from 59 to 60, 59.5 to 60.5, 60 to 61, etc. Thus, converted A-scale values corresponding to C 59 to 60 (see Table II of Hardness Conversion Tables E 140) would be A 80.7 to 81.2 and the repeatability for the A-scale would be 0.5.

13.2.3.2 The mean hardness value for the five tests shall not differ from the mean corresponding to the hardness of the standardized test block by more than the tolerance of the latter (shown in Table 21).

13.3 It should be understood that hardness test blocks, diamond indentors, and machine designs vary between manufacturers and that if all parameters are met under 13.1, it is possible that change of one or more of the parameters may be needed to meet indirect verification on test blocks. Consult manufacturer's instructions on the proper method to make corrections *within the tolerances specified in this test method*.

13.4 *Time Interval Between Verifications*—It is recommended that testing machines be verified annually or more frequently if required. In no case shall the time interval between verifications exceed 18 months.

13.5 Verification Report:

13.5.1 The verification report shall include the following information:

- 13.5.1.1 Reference to this ASTM Test Method,
- 13.5.1.2 Method of verification (direct or indirect),
- 13.5.1.3 Identification data of the hardness testing machine,
- 13.5.1.4 Means of verification (test blocks, elastic proving devices, etc.)
- 13.5.1.5 The Rockwell hardness scale(s) verified,
- 13.5.1.6 The result obtained,

TABLE 21 Tolerance Values for Standardized Test Blocks

Nominal Hardness of Standardized Test Block	Tolerance Values of the Test Block Shall Not Be Greater Than
<i>C Scale</i> ^A	
60 and Greater	±0.5
Below 60	±1.0
<i>A Scale</i>	
80 and Greater	±0.5
Below 80 to 60.5, incl	±1.0
<i>15N Scale</i>	
90 and Greater	±0.7
Below 90 to 69.4, incl	±1.0
<i>30N Scale</i>	
77.5 and Greater	±0.7
Below 77.5 to 41.5, incl	±1.0
<i>45N Scale</i>	
66.5 and Greater	±0.7
Below 66.5 to 19.6, incl	±1.0
<i>B Scale</i> ^B	
45 and Greater	±1.0
Below 45 to 1.5, incl	±1.5
<i>F Scale</i>	
99.6 to 57.0, incl	±1.0
<i>15T Scale</i>	
75.3 and Greater	±1.0
Below 75.3 to 60.5, incl	±1.5
<i>30T Scale</i>	
46.2 and Greater	±1.0
Below 46.2 to 15.0, incl	±1.5
<i>45T Scale</i>	
17.6 and Greater	±1.0
Below 17.6 to 1.0, incl	±1.5

^A All other scales on steel blocks of the equivalent converted values are as follows: 70.0 HRC to 60.0 HRC = ±0.5 and 59.9 HRC to 20.0 HRC = ±1.0.

^B All other scales on brass blocks of the equivalent converted values are as follows: 100.0 HRB to 1.0 HRB = ±1.0.

13.5.1.7 Date of verification and reference to the verifying agency, and

13.5.1.8 Signature of verifying agency representative.

14. Procedure for Periodic Checks by the User

14.1 Verification by the standardized test block method (13.2) is too lengthy for daily use. Instead, the following is recommended:

14.1.1 Make at least one routine check each day that the testing machine is used. See Part A of this test method.

14.1.2 Before making the check, make at least two preliminary indentations to ensure that the hardness testing machine is working freely and that the test block, indenter, and anvil are seated correctly. The results of these preliminary indentations should be ignored.

14.1.3 Make at least three hardness readings on a standardized hardness test block on the scale and at the hardness level at which the machine is being used. If the mean of these values falls within the tolerances marked on the standardized hardness test block, the machine may be regarded as satisfactory. If not, the machine should be verified as described in 13.2.



C. CALIBRATION OF STANDARDIZED TEST BLOCKS FOR MACHINES USED FOR ROCKWELL AND ROCKWELL SUPERFICIAL HARDNESS TESTING

15. Scope

15.1 Part C specifies a test method for the calibration of standardized blocks to be used in Rockwell hardness testing machines for the indirect verification of these machines as described in Part B.

16. Manufacture

16.1 The attention of the manufacturer of the block is drawn to the need to use a manufacturing process which will give the necessary homogeneity, stability of structure, and uniformity of surface hardness.

16.2 Each metal block to be standardized shall be of a thickness not less than 0.236 in. (6 mm).

16.3 The area of the test surface of the block shall not be more than 4 in.² (2581 mm²).

16.4 The standardized block shall be free of magnetism. It is recommended that the manufacturer ensure that the blocks, if of steel, have been demagnetized at the end of the manufacturing process.

16.5 The maximum deviation in flatness of the surfaces shall not exceed 0.0002 in. (0.005 mm).

16.6 The maximum error in parallelism shall not exceed 0.0002 in. per in. (mm per mm).

16.7 The test surface shall be free from scratches which interfere with the measurement of the indentation. The mean surface roughness (R_a) shall not exceed 12 μ in. (0.0003 mm) center line average.

16.8 The bottom surface shall have a fine ground finish.

16.9 To assure that material is not removed from the test surface, its thickness at the time of standardization (to the nearest ± 0.005 in. (0.1 mm)) shall be marked on the block or an identifying mark shall be made on the test surface. Resurfacing of a test block for reuse is not recommended; however, if a standard test block is reconditioned, the new test surface must be recalibrated in accordance with this section.

17. Standardizing Machine

17.1 In addition to fulfilling the general requirements specified in Sections 12 and 13, the standardizing machine shall also meet the following requirements:

17.1.1 The machine shall be verified directly. Direct verification involves the following:

17.1.1.1 Verification of the test force (see 13.1.1),

17.1.1.2 Verification of the indenter (see 13.1.2), and

17.1.1.3 Verification of the measuring device (see 13.1.3).

17.1.2 Each preliminary test force shall be correct to within ± 0.5 %. Each total test force shall be correct to within ± 0.25 %.

17.1.3 The verification of the shape of the indenter can be made by direct measurement or by measurement of its projection on a screen. The verification shall be made at not less than eight approximately equally spaced sections.

17.1.4 The diamond indenter shall have an included angle of $120^\circ \pm 0.1^\circ$.

17.1.5 The angle between the axis of the diamond indenter and the axis of the indenter holder (normal to the seating surface) shall not exceed 0.3° .

17.1.6 The tip of the diamond indenter shall be spherical with a mean radius of 0.200 ± 0.005 mm. In each measured section the radius shall not exceed 0.200 ± 0.007 mm and local deviations from a true radius shall not exceed 0.002 mm. The surface of the cone and spherical tip shall blend in a truly tangential manner.

17.1.7 The diameter of the indenter ball shall be within the tolerance of 0.001 mm.

17.1.8 The measuring device shall be capable of accurately measuring vertical displacements corresponding to ± 0.1 of a regular Rockwell unit and ± 0.1 for a superficial Rockwell unit.

18. Standardizing Procedure

18.1 The standardized test blocks shall be calibrated in a standardizing machine as described in Section 17 at a temperature of $73^\circ\text{F} \pm 5^\circ\text{F}$ ($23^\circ\text{C} \pm 2^\circ\text{C}$) using the general test procedure described in Part A.

18.2 The standardized test blocks shall be calibrated traceable to the national Rockwell standards maintained at NIST when primary standardized test blocks are available from NIST for the specific Rockwell scale.

19. Number of Indentations

19.1 In accordance with Part A of this test method, make at least five indentations on each standardized block, distributed uniformly over the block's surface.

20. Uniformity of Hardness

20.1 Let R_1, R_2, \dots, R_5 be the measured values in Rockwell units arranged in increasing order of magnitude.

20.2 The nonuniformity of the block under the particular conditions of standardization is characterized by $R_5 - R_1$.

20.3 The nonuniformity of the block must satisfy the conditions of Table 22.

21. Marking and Certification Requirements

21.1 Each standardized test block shall be marked with the following:

21.1.1 Arithmetic mean of the hardness values found in the standardizing test reported to the nearest tenth, for example: 66.3 HRC or 80.2 HRBW,

21.1.2 Tolerance value (see Table 21),

21.1.3 Name or mark of the supplier,

21.1.4 Unique serial number,

21.1.5 Name or mark of the calibrating agency if different from supplier,

21.1.6 Thickness of the block or an identifying mark on the test surface, and

21.1.7 *Year of Calibration*. It is sufficient that the year of calibration be incorporated into the serial number of the block.

21.2 All of the markings, except the official mark, should be placed outside of the test area or on the side of the block. When

TABLE 22 Maximum Nonuniformity of Standardized Test Blocks

Nominal Hardness of Standardized Test Block	Nonuniformity of the Test Block Shall Not Be Greater Than
<i>C Scale</i> ^A	
60 and Greater	0.5
Below 60	1.0
<i>A Scale</i>	
80 and Greater	0.5
Below 80 to 60.5, incl	1.0
<i>15N Scale</i>	
90 and Greater	0.7
Below 90 to 69.4, incl	1.0
<i>30N Scale</i>	
77.5 and Greater	0.7
Below 77.5 to 41.5, incl	1.0
<i>45N Scale</i>	
66.5 and Greater	0.7
Below 66.5 to 19.6, incl	1.0
<i>B Scale</i> ^B	
45 and Greater	1.0
Below 45 to 1.5, incl	1.5
<i>F Scale</i>	
99.6 to 57.0, incl	1.0
<i>15T Scale</i>	
75.3 and Greater	1.0
Below 75.3 to 60.5, incl	1.5
<i>30T Scale</i>	
46.2 and Greater	1.0
Below 46.2 to 15.0, incl	1.5
<i>45T Scale</i>	
17.6 and Greater	1.0
Below 17.6 to 1.0, incl	1.5

^A All other scales on steel blocks of the equivalent converted values are as follows: 70.0 HRC to 60.0 HRC = 0.5 and 59.9 HRC to 20.0 HRC = 1.0.

^B All other scales on brass blocks of the equivalent converted values are as follows: 100.0 HRB to 1.0 HRB = 1.0.

the markings are on the side of the block, the markings shall be upright when the test surface is the upper surface.

21.3 Each block shall be supplied with a certificate showing the results of the individual standardizing tests and the arithmetic mean of those tests, including the following:

- 21.3.1 Date of standardization,
- 21.3.2 Serial number of block, and
- 21.3.3 Name of manufacturer or mark of supplier.

22. Keywords

- 22.1 metallic; Rockwell Hardness

APPENDIX

(Nonmandatory Information)

X1. LIST OF ASTM SPECIFICATIONS GIVING HARDNESS VALUES CORRESPONDING TO TENSILE STRENGTH

X1.1 The following ASTM standards give approximate Rockwell hardness or Rockwell superficial hardness values corresponding to the tensile strength values specified for the

materials covered: Test Methods and Definitions A 370 and Specifications B 19, B 36, B 96, B 97, B 103, B 121/B 121 M, B 122/B 122 M, B 130, B 134, B 152, B 291, and B 370.

SUMMARY OF CHANGES

This section identifies the principal changes to this standard that have been incorporated since the last edition E 18-00. The numbering system used in this Summary reflects current numbering of this edition of E 18. Note—Most of the changes listed below resulted from the new addition of allowing the use of tungsten-carbide indenter balls.

- (1)Note 2 - added
- (2)Paragraph 3.1.2.1 - revised
- (3)Paragraph 3.1.2.2 - revised
- (4)Paragraph 3.1.2.3 - revised
- (5)Paragraph 3.1.3 - revised
- (6)Figure 2 caption - revised
- (7)Paragraph 5.1.1 - revised
- (8)Figure 4 caption - revised
- (9)Paragraph 5.3.1 - revised

- (10)Paragraph 5.3.3 - revised
- (11)Paragraph 6.1 - revised
- (12) Note 3 - renumbered
- (13) Paragraph 6.5 - revised
- (14)Note 4 - renumbered
- (15)Note 5 - renumbered
- (16)Note 6 - renumbered
- (17)Paragraph 9.1.3 - added
- (18) Paragraph 13.1.2.2 - revised



- (19)Note 7 - replaced and renumbered
- (20)Paragraph 13.1.2.2 (c) - revised
- (21)Table 18 footnote A - revised
- (22)Table 19 title - revised

- (23)Paragraph 17.1.7 - revised
- (24)Paragraph 21.1.1 - revised
- (25)SUMMARY OF CHANGES added.

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