CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

OTTAWA

MINES BRANCH INVESTIGATION IR 61-139

# A COMPARISON OF THE TEST METHODS USED FOR THE BRINELL, DIAMOND PYRAMID (VICKERS), AND ROCKWELL HARDNESS TESTING OF METALS

(FURTHER TO MINES BRANCH INVESTIGATION REPORT IR 58-137, "A COMPARISON OF THE BRITISH, U. S. FEDERAL AND ASTM STANDARD AND TENTATIVE STANDARD TEST METHODS FOR THE BRINELL, DIAMOND PYRAMID AND ROCKWELL HARDNESS TESTING OF METALS")

by

P. J. TODKILL

PHYSICAL METALLURGY DIVISION



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Mines Branch Investigation Report IR 61-139

# A COMPARISON OF THE TEST METHODS USED FOR THE BRINELL, DIAMOND PYRAMID (VICKERS), AND ROCKWELL HARDNESS TESTING OF METALS

by

P. J. Todkill*

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## SUMMARY

In this report the International Organization for Standardization (ISO) Recommendations for the Brinell, Rockwell and Vickers Hardness Tests for Steel have been reproduced and compared with the corresponding British, U.S. Federal and ASTM Standard and Tentative Standard test methods for hardness testing of metals. This comparison has been made as a continuation of the survey of hardness test methods contained in Mines Branch Investigation Report IR 58-137, "A Comparison of the British, U.S. Federal and ASTM Standard and Tentative Standard Test Methods for the Brinell, Diamond Pyramid and Rockwell Hardness Testing of Metals".

These surveys have been conducted in order to provide a basis for discussion on the standardization of hardness test methods, a project within the scope of the Tripartite Committee on Standardization of Methods of Test of Ferrous Materials.

The comments received from the United States and the United Kingdom on the initial survey are contained in this report. One of these comments contains the suggestion that the ISO Recommendations be considered for adoption for A.B.C. standardization. However, as in the case of the previous report, the author has not drawn any conclusions as to which test method should be accepted as standard.

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# INTRODUCTION

In Mines Branch Investigation Report IR 58-137, dated August 30, 1958, a survey was made of the British, U. S. Federal and ASTM Standard and Tentative Standard test methods for the Brinell, Diamond Pyramid and Rockwell hardness testing of metals. This survey was made as part of the work of the Tripartite Committee of the armies of the United States, the United Kingdom, and Canada, on the Standardization of Methods of Test of Ferrous Materials, Category Nine, Project 6.7.1.

This investigation report has been prepared to extend this survey to include the International Organization for Standardization (ISO) Recommendations for the Brinell, Rockwell and Vickers Hardness Tests for Steel. The comments received from the United States and the United Kingdom on the initial survey have been reproduced in this report.

While some modifications have been made to the test method standards and tentative standards examined previously, these modifications have not been extensive and, hence, no attempt has been made to re-examine these standards.

The following ISO Recommendations have been reproduced in this report:

ISO Recommendation R79, 1st Edition, February 1959
Brinell Hardness Test for Steel

ISO Recommendation R81, 1st Edition, February 1959
Vickers Hardness Test for Steel

ISO Recommendation R80, 1st Edition, February 1959
Rockwell Hardness Test (B and C Scales) for Steel

Because these recommendations are confined to hardness tests for steel, they contain some limitations which are not found in the test methods compared previously. Hence, many of the differences found in the ISO recommendations and the corresponding test methods examined in the previous report are the result of the limitation in the scope of these ISO recommendations. Some of these differences are discussed below.

## BRINELL HARDNESS TEST

The ISO Recommendation R79, Brinell Hardness Test for Steel, states that the standard ball diameter is 10 mm. Therefore, in this respect, Recommendation R79 is in agreement with Federal Test Method No. 242 and ASTM Designation E10.

The only standard load given in R79 is 3000 kgf, whereas at least three standard loads are given in each of the test methods examined previously in Mines Branch Investigation Report IR 58-137. However, provision is made in R79 for the reporting of results when other loads and ball diameters are used.

In R79 it is stated that the standard duration of load is 10 to 15 sec. This minimum time of 10 sec is lower than that specified in the other test methods. This difference in length of time the test load is to be applied would not be expected to be significant in the case of tests conducted on steel.

## VICKERS HARDNESS TEST

ISO Recommendation R81, Vickers Hardness Test for Steel, is similar to the Diamond Pyramid Hardness test methods discussed in Mines Branch Investigation Report IR 58-137. However, R81 is somewhat less detailed than these other test methods; for example, the determination of the hardness of case-hardened specimens is not considered in R81.

It is stated in R81 that the standard test load is 30 kgf, although it is also mentioned that loads within the range 5 to 100 kgf

may be used. This load range is the same as given in British Standard 427 but differs from the load range 1 g to 120 kg given in Federal Method No. 244 and ASTM Designation E92.

In R81 it is stated that the radius of curvature of curved surfaces to be tested should be not less than 5 mm. The other test methods mentioned above suggest that the surface on which the impression is to be made should be flat.

## ROCKWELL HARDNESS TEST

The ISO Recommendation R80, Rockwell Hardness Test for Steel, is limited in scope to the B and C scales. Aside from this limitation, R80 is similar in many respects to British Standard 891. Hence, many of the remarks, made in Mines Branch Investigation Report IR 58-137, concerning the differences between this British Standard and both the Federal and ASTM test methods could be applied to Recommendation R80. However, unlike B.S. 891, Recommendation R80 recognizes tests performed on curved surfaces providing the radius of curvature of the surface to be tested is not less than 2.5 mm. Also, since in R80 the total load is composed of an initial load and an additional load, the remarks made in Mines Branch Investigation Report IR 58-137 concerning

the difference in the definition of the term Major Load do not apply.

The ISO Recommendation R80 and the ASTM E 18 test method differ with respect to the recommended minimum thickness for sheet metals and the time of application of load for Rockwell tests on metals which exhibit plastic flow. It may be concluded that the ISO Recommendation is directed at obtaining technically accurate hardness values, whereas, the ASTM test method is designed to give reproducible, commercially useful values which are readily determined in production testing.

ISO RECOMMENDATION R79
BRINELL HARDNESS TEST FOR STEEL
1st Edition
February 1959

## 1. PRINCIPLE OF TEST

The test consists in forcing a steel ball of diameter D, under a load F, into the test piece and measuring the diameter d of the indentation left in the surface after the removal of the load.

The Brinell hardness HB is the quotient of the test load F (expressed in kilogrammes-force) by the curved surface area of the indentation (expressed in square millimetres) which is assumed to be spherical and of diameter D.

## 2. SYMBOLS AND DESIGNATION

| No. | Symbol | Designation |
|---|---|---|
| 1 | D | Diameter of the ball, in millimetres |
| 2 | F | Test load, in kilogrammes-force |
| 3 | d | Diameter of indentation, in millimetres |
| 4 | HB | Brinell Hardness $= \frac{\text{test load}}{\text{surface area of indentation}} = \frac{2F}{\pi D(D-\sqrt{D^2-d^2})}$ |
| 5 | h | Depth of indentation, in millimetres |

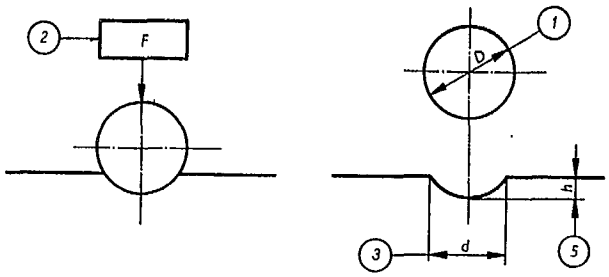
REMARKS

Scope is not stated although title shows that R79 applies to steel only.

DEFINITION

The Principle of Test in R79 corresponds to definitions found in Federal Method 242 and ASTM E 10 (pages 10 and 11, Mines Branch Investigation Report IR 58-137).

R79 (cont'd)




NOTE

The Brinell Hardness is denoted by the symbol HB for standard test conditions, that is:

ball diameter 10 mm
load 3000 kgf
duration of loading 10 to 15 sec

For other conditions, the symbol HB is supplemented by an index indicating the test conditions in the following order:

diameter of ball
load,
duration of loading.

Example: HB 5/750/20
= Brinell hardness measured with a ball of 5 mm diameter and with a load of 750 kgf applied for 20 sec.

REMARKS (cont'd)

See remarks page 15
Mines Branch Investigation Report IR 58-137.

R79 (cont'd)

3. TESTING EQUIPMENT

3.1 The nominal diameter of the ball should be not less than 1 mm unless otherwise specified. No diameter of the ball should differ from the nominal diameter by more than the following:

| Diameter of ball Millimetres | Tolerance Millimetres |
|---|---|
| from 1 to 3 | ± 0.0035 |
| over 3 to 6 | ± 0.004 |
| over 6 to 10 | ± 0.0045 |

3.2 The ball is of hardened steel with a hardness of at least 850 HV (taking into account the curvature of the ball, when testing); it should be polished and free from surface defects. Any ball showing any deformation after the test greater than the tolerance specified under clause 3.1 above, or any surface defect should be rejected and the corresponding test discarded.

4. TEST REQUIREMENTS

4.1 The test is carried out at ambient temperature, unless otherwise specified.

4.2 The ball is placed against the surface of the test piece. Pressure is gradually applied to the ball normal to the surface without sudden shocks until the test load is attained. The test load is maintained for 10 to 15 sec.

4.3 The test should be carried out on a surface which is sufficiently smooth and even to permit the accurate determination of the diameter of the indentation. It should be free from

REMARKS (cont'd)

R79 (cont'd)

oxide scale and foreign matter. Care should be taken in preparing the surface to avoid any change in condition, for example, due to heating or cold working.

4.4 The test piece should be placed on a rigid support. The contact surfaces should be clean and free from foreign matter (scale, oil, dirt, etc.). It is important that the test piece lies firmly on the support so that displacement cannot occur during the test.

4.5 The applied load, expressed in kilogrammes-force, should be equal to 30 times the square of the diameter of the ball, expressed in millimetres, i.e. $F = 30D^2$. The tolerance on the load should be $\pm$ 1.0%.

4.6 The thickness of the test piece should be not less than 8 times the depth of indentation h. No deformation should be visible at the back of the test piece after test.

$$\text{Depth of indentation} = \frac{F}{\pi D \times HB}$$

4.7 As a general rule, the distance from the centre of the indentation to the edge of the test piece should be at least 2-1/2 times the diameter of the indentation and the distance between the centres of two adjacent indentations should be at least 4 times the diameter of the indentation. The test is carried out in such a way that nothing occurs to falsify the test result (such as bulging at the edge or distortion of the test piece).

REMARKS (cont'd)

See pages 12 and 17 of Mines Branch Investigation Report IR 58-137.

R79 (cont'd)

4.8 The diameter of each indentation is measured in two directions at right angles and the mean value of the two readings is used for the purpose of determining the Brinell hardness. The measuring microscope or other measuring device should be capable of measuring the diameter of indentations to an accuracy of ± 0.25% of the diameter of the ball.

NOTES

1. It is recommended that the Brinell test as herein defined be not used for materials with a Brinell hardness exceeding 450. For harder steels, a test with a harder penetrator, tungsten carbide, diamond, etc., may be substituted, but the hardness value would then be on a different series.

2. There is no general process for converting accurately Brinell hardness into other scales of hardness or tensile strength. These conversions therefore should be avoided, except for special cases where a reliable basis for the conversion has been obtained by comparison tests.

REMARKS (cont'd)

See remarks on page 13 of Mines Branch Investigation Report IR 58-137.

ISO RECOMMENDATION R81
VICKERS HARDNESS TEST FOR STEEL
1st Edition
February 1959

REMARKS

Scope is not stated although title indicates that R81 applies only to steel.

## 1. PRINCIPLE OF TEST

The test consists in forcing a penetrator, in the form of a right pyramid with a square base and specified angle between opposite faces at the vertex under a load F, into the metal, and measuring the diagonal d of the indentation left in the surface after the removal of the load.

The Vickers hardness is the quotient of the test load F (expressed in kilogrammes-force) by the sloping area (expressed in square millimetres) of the indentation, considered as a right pyramid with a square base, of diagonal d, and having at the vertex the same angle as the penetrator.

DEFINITION

The Principle of Test in R81 corresponds to definitions contained in B.S.247, Federal Method 244 and ASTM E92.

## 2. SYMBOLS AND DESIGNATION

| No. | Symbol | Designation |
|---|---|---|
| 1 | - | Angle at the vertex of the pyramidal penetrator (136°) |
| 2 | F | Test load, in kilogrammes-force |
| 3 | d | Arithmetic mean of the two diagonals d1 and d2 |
| 4 | HV | Vickers hardness $= \frac{\text{test load}}{\text{area of indentation}}$ $= \frac{2F \sin \frac{136°}{2}}{d^2}$ $= 1.854 \frac{F}{d^2}$ (approx) |

R81 (cont'd)

REMARKS (cont'd)

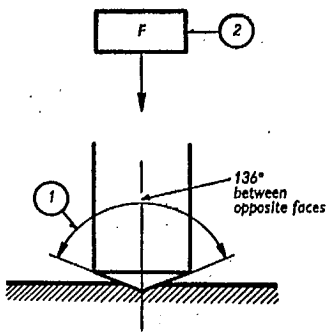



FIG. 1

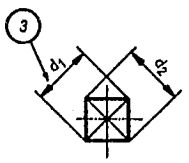



FIG. 2

NOTE

The symbol HV is supplemented by an index indicating the load and the duration of loading, when the latter differs from 10 to 15 sec, which is the normal time.

Example: HV30 = Vickers hardness, measured under a load of 30 kgf, applied for 10 to 15 sec;

HV30/20 = Vickers hardness, measured under a load of 30 kgf, applied for 20 sec.

R81 (cont'd)

3. TESTING EQUIPMENT

REMARKS (cont'd)

3.1 The penetrator consists of a right diamond with a square base. The angle at the vertex, between opposite faces of the indenter is 136° ± 0.5°.

3.1.1 All four faces of the indenter are equally inclined to the axis of the indenter (within 0.5°) and meet in a point, i.e. any line of junction between opposite faces is less than 0.002 mm in length. A common form of point, when examined under high magnification, is shown in Figure 3. The limiting length of 0.002 mm is shown in the same figure.

3.1.2 The penetrator should be well polished and free from cracks or other surface defects.

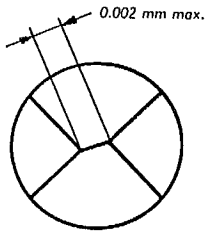



Figure 3.

R81 (cont'd)

4. TEST REQUIREMENTS

4.1 The test is carried out at ambient temperature, unless otherwise specified.

4.2 The penetrator, when normal to and in contact with the surface to be tested, is forced, without shock or vibration, into this surface until the applied load attains the specified value. This load is maintained for 10 to 15 sec.

4.3 The test should be carried out on a surface to be tested which is sufficiently smooth and even to permit the accurate determination of the diagonal of the indentation. It should be free from oxide scale and foreign matter. Care should be taken in preparing the surface to avoid any change in condition, e.g. due to heating or cold working.

4.4. The radius of curvature of curved surfaces to be tested should be not less than 5 mm. The testing of curved surfaces with smaller radii should be the subject of special agreement.

4.5 The test piece should be placed on a rigid support. The contact surfaces should be clean and free from foreign matter (scale, oil, dirt, etc.). It is important that the test piece lies firmly on the support so that displacement cannot occur during the test.

4.6 The thickness of the test piece or of the layer under test should be at least 1.2 times the diagonal of the indentation. No deformation should be visible at the back of the test piece after the test.

REMARKS (cont'd)

RADIUS OF CURVATURE
B.S. 427, Federal Method 244 and ASTM E92, indicate that surface should be flat.

B.S. 247, Federal Method 244, ASTM E92. The thickness of the specimen shall be at least 1-1/2 times the length of the diagonal.

R81 (cont'd)

4.7 The distance from the centre of any indentation to the edge of the test piece or the edge of any other indentation should be not less than 2-1/2 times the diagonal of the indentation.

4.8 The standard test load is 30 kgf. It is possible to use larger or smaller loads, provided that the loads are within the range of 5 to 100 kgf. The tolerance on the test load should be ± 1.0%.

4.9 The measuring microscope or other measuring device should be capable of reading the diagonal of the indentation to an accuracy of ± 0.001 mm for indentation diagonals of less than 0.2 mm and to an accuracy of ± 0.002 mm for indentation diagonals of 0.2 mm and over. The arithmetic mean of the length of the two diagonals of the indentation is taken for the calculation of the Vickers hardness.

4.10 The satisfactory condition of the penetrator should be verified frequently. Any irregularities in the shape of the indentation may indicate poor conditions of the penetrator. If the examination of the penetrator confirms this, then the test should be rejected.

NOTES

1. There is no general process for converting accurately Vickers hardness into other scales of hardness or tensile strength. These conversions therefore, should be avoided, except for special cases where a reliable basis for the conversion has been obtained by comparison tests.

REMARKS (cont'd)

See remarks under Apparatus, page 23, Mines Branch Investigation Report IR 58-137.

R 81 (cont'd)

2. It should be noted that for anisotropic materials, such as those which have been heavily cold worked, there will be a difference between the lengths of the two diagonals of the indentation. The specification for the product may indicate limits for such differences.

ISO RECOMMENDATION R80
ROCKWELL HARDNESS TEST
(B and C Scales)
for Steel
1st Edition
February 1959

REMARKS

Scope is not stated although title limits R80 to steel and the B and C scales.

## 1. PRINCIPLE OF TEST

The test consists in forcing a penetrator of standard type (cone or ball) into the surface of a test piece in two operations and measuring the permanent increase e of the depth of indentation of this penetrator under conditions defined later.

The unit of measurement for e is 0.002 mm, from which a number, known as the Rockwell hardness, is deduced.

DEFINITION

The Principle of Test as stated in R80 corresponds to definitions contained in Federal Method 243 and ASTM E18.

R 80 (cont'd)

2. SYMBOLS AND DESIGNATIONS

REMARKS (cont'd)

Table 1. - Test with diamond cone (Rockwell C)

| No. | Symbol | Designation |
|---|---|---|
| 1 | - | Angle at the tip of the diamond cone (120°) |
| 2 | - | Radius of curvature at the tip of the cone (0.20 mm) |
| 3 | $F_o$ | Preliminary load = 10 kgf |
| 4 | $F_1$ | Additional load = 140 kgf |
| 5 | F | Total Load = $F_o + F_1$ = 10 + 140 = 150 kgf |
| 6 | - | Depth of indentation under preliminary load before application of additional load |
| 7 | - | Increase in depth of indentation under additional load |
| 8 | e | Permanent increase of depth of indentation under preliminary load after removal of additional load, the increase being expressed in units of 0.002 mm |
| 9 | HRC | Rockwell hardness C = 100-e |

R80 (cont'd) REMARKS (cont'd)

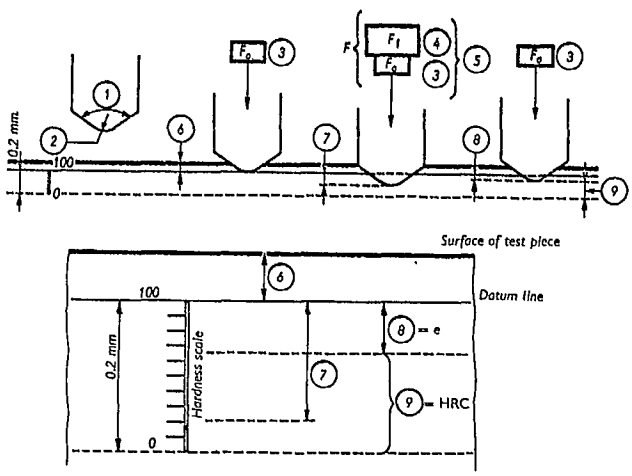



FIG. 1

R 80 (cont'd)

Table 2. - Test with steel ball (Rockwell B)

| No. | Symbol | Designation |
|---|---|---|
| 1 | D | Diameter of ball (1.5875 mm or 1/16 in.) |
| 3 | Fo | Preliminary load = 10 kgf |
| 4 | $F_1$ | Additional load = 90 kgf |
| 5 | F | Total load = Fo + $F_1$ = 10 + 90 = 100 kgf |
| 6 | - | Depth of indentation under preliminary load before application of additional load |
| 7 | - | Increase in depth of indentation under additional load |
| 8 | e | Permanent increase of depth of indentation under preliminary load after removal of additional load, the increase being expressed in units of 0.002 mm |
| 9 | HRB | Rockwell hardness B = 130-e |

REMARKS (cont'd)

R80 (cont'd)

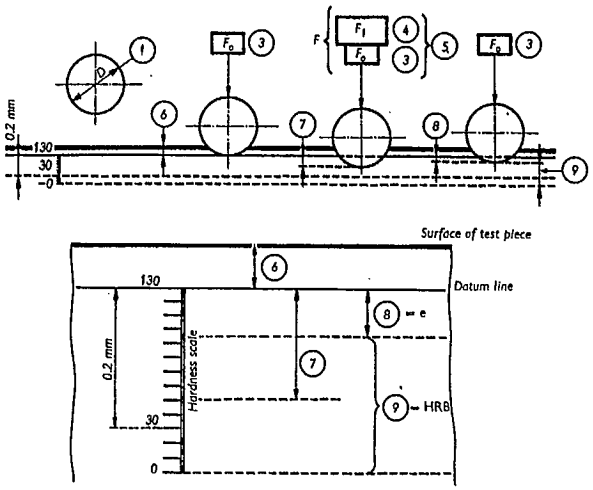



FIG. 2

3. TESTING EQUIPMENT

3.1 The conical penetrator is a diamond in the form of a right circular cone with a rounded tip. The diamond cone has an included angle of 120° ± 0.5° and its axis is in line with the axis of the penetrator within a tolerance of 0.5°. The tip of the cone is rounded to a radius of 0.20 mm and the contour of the tip of the cone should not depart from the nominal contour by more than 0.002 mm. The surface of the cone blends in a truly tangential

REMARKS (cont'd)

R80 (cont'd)

REMARKS (cont'd)

manner with the surface of the sphere (see Note 2)

3.1.1 The penetrator should be free from cracks or other surface defects.

3.2 The ball penetrator is a hardened and polished steel ball having a diameter of 1.5875 mm (1/16 in.). No diameter of the ball should differ from the nominal diameter by more than $\pm$ 0.0035 mm.

3.2.1 The ball is of hardened steel with a hardness of at least 850 HV (taking into account the curvature of the ball, when testing); it should be polished and free from surface defects. Any ball showing any deformation after the test greater than the tolerance specified under clause 3.2 above or any surface defect should be rejected and the corresponding test discarded.

4. TEST REQUIREMENTS

4.1 The test is carried out at ambient temperature, unless otherwise specified.

4.2 The penetrator, when normal to, and in contact with the surface to be tested, is put, without sudden shock, under preliminary load:

$F_o = 10 \text{ kgf} \pm 0.2 \text{ kgf}$

Care should be taken that this load is not exceeded.

4.3 The dial of the indicator (depth gauge) is set at the initial position and the load increased, without sudden shock, within three to six seconds, by the value of the

See remarks, page 35, Mines Branch Investigation Report IR 58-137.

R80 (cont'd)

REMARKS (cont'd)

additional load:

$$F_1 = \begin{matrix} 140 \text{ kgf} \pm 0.7 \text{ kgf (cone)} \\ 90 \text{ kgf} \pm 0.45 \text{ kgf (ball)} \\ \text{(see Note 3)} \end{matrix}$$

thus obtaining a total load:

$$F = Fo + F_1 = \begin{matrix} 150 \text{ kgf} \pm 0.9 \text{ kgf (cone)}, \\ 100 \text{ kgf} \pm 0.65 \text{ kgf (ball)}. \end{matrix}$$

4.4 When the needle of the indicator (depth gauge) is steady, the additional load $F_1$ is removed so as to bring the load back to the preliminary load Fo.

4.5 The permanent increase of depth of indentation e is read off from the dial and the Rockwell hardness number deduced. The indicator (depth gauge) should be accurate to $\pm$ 0.5 of a scale unit, i.e. to $\pm$ 0.001 mm.

4.5.1 Most dial scales give a direct reading of the Rockwell hardness number.

4.6 The test should be carried out on a surface which is smooth and even, and free from oxide scale and foreign matter. Care should be taken in preparing the surface to avoid any change in condition, e.g. due to heating or cold working.

4.7 The radius of curvature of curved surfaces to be tested should be not less than 2.5 mm. The testing of curved surfaces with smaller radii should be the subject of special agreement.

See remarks page 41, Mines Branch Investigation Report IR 58-137.

4.8 The test piece should be placed on a rigid support. The contact surfaces should be clean and free from foreign matter (scale, oil, dirt, etc.). It is important that the test piece lies firmly on the support so that displacement cannot occur during the test.

R80 (cont'd)

4.8.1 After each change or removal and replacement of the penetrator or the support, it should be ascertained that the new penetrator (or the new support) is correctly mounted in its housing.

4.9 The thickness of the test piece or of the layer under test should be at least 8 times the permanent increase of depth e. No deformation should be visible at the back of the test piece after the test.

4.10 The distance between the centres of two adjacent indentations or from the centre of any indentation to the edge of the test piece should be at least 3 mm, unless otherwise agreed.

4.11 Throughout the test the apparatus should be protected from shock or vibration.

NOTES

1. There is no general process for converting accurately Rockwell hardness into other scales of hardness or tensile strength. These conversions therefore should be avoided, except for special cases where a reliable basis for the conversion has been obtained by comparison tests.

2. The form of the point and the size of the radius of the penetrator have an important effect on the Rockwell hardness number obtained. The anisotropy of diamonds makes difficult the machining of the penetrator to a precise symmetrical form.

REMARKS (cont'd)

See remarks page 41, Mines Branch Investigation Report IR 58-137.

See remarks page 43, Mines Branch Investigation Report IR 58-137.

R80 (cont'd)

3. Measurements made in accordance with this ISO Recommendation will probably be within ± 1 unit at 60 HRC; if results within ± 1-1/2 units are acceptable, the tolerance on the additional load $F_1$ may be increased to ± 1%.

Comments on Mines Branch Investigation Report IR 58-137 which were received from the United States and the United Kingdom are reproduced below:

"Directorate of Design and Development
Canadian Army Headquarters

Subject:- Tripartite Standardization, Category 9
Serial 9.6.7.1 - Methods of Test,
Ferrous Metals

1. Reference HQS 8939-6-7-1 (DD-ID) over DDD 9-0-P2, dated 17 Apr 59 requesting comments on the Canadian report:-

> "A comparison of the British, US Federal, and A.S.T.M. Standard and Tentative Standard test methods for the Brinell, Diamond Pyramid and Rockwell Hardness Testing of Metals".

2. The report reprints three sets of specifications together for ease of comparison, indicating the main differences between them, without offering any recommendations or proposals. It would have been helpful if the monitoring country had made proposals for unifying the specifications.

3. While the report is useful, it is considered that methods of hardness testing of metals are not of peculiarly Service interest but concern civilian users in industry etc., and therefore should be considered on a much broader basis.

4. In this connection it is understood that ISO has made considerable investigations and ISO/TC17 "steel" have made a number of recommendations on methods of mechanical testing, including four on hardness testing, which are on their way to the ISO Council for acceptance as international recommendations. ISO TC's 26 "Copper", 79 "Light Metals" and 25 "Cast Iron" are using the steel recommendations and modifying them to suit their particular materials. Further, a committee to co-ordinate the recommendations of these ISO/TC's - ISO/METESCO "Co-ordinating Committee for Mechanical Testing" has been set up and will meet in London this autumn.

5. It is suggested that the ISO recommendations be considered for adoption for A.B.C. standardization.

(Sgd) J. C. White, Major
(for)
Brigadier
Senior Army Liaison Officer
United Kingdom Services Liaison Staff"

"Office of the Senior Standardization Representative
U.S. Army Standardization Group, Canada
c/o Directorate of Weapons and Development
Canadian Army Headquarters, Ottawa, Canada

Subject:- Method of Test - Ferrous Metals, Category 9, Serial No. 9-6-7-1

TO: Directorate of Design and Development
Army Headquarters, Ottawa

1. References:

a. Your Memorandum, HQS 8939-6-7-1 (DD-ID) dated 17 April 1959, subject as above.

b. Letter, LOG/E3-31728, Deputy Chief of Staff for Logistics, Department of the Army dated 20 August 1958, subject as above.

2. In accordance with your request for comment on the Canadian Department of Technical Surveys Report IR 58-137, Department of the Army has provided the following information:

a. This report points up the areas that need further discussion to bring about standardization between the parties concerned. The comparison has adequately pointed out all the differences existing among the test methods reviewed. Although the comparison was based on ASTM E 10-54T, since superseded by ASTM EMO-58T, and Federal Test Method Standard No. 151, superseded by an "a" revision, an examination of these newer documents shows no significant changes to the comparison.

b. The Department of the Army would be interested in reviewing any proposals for standardization of test methods which may develop from this report.

(Sgd) W. B.Roop, Major,
Infantry
(for)
John J. Kenney
Colonel, Artillery
Senior Standardization Representative
U.S. Army"

"FROM: Chief of Naval Material

TO: Deputy Chief of Staff for Logistics
Standards Branch, Procurement Division (LOG/E3)
Department of the Army

SUBJECT: Army Tripartite Standardization
Category 9, Serial No. 9.6.7.1
Methods of Test - Ferrous Metals

REF: (a) Department Army ltr LOG/E3-22022 of 3 Jun 1959 to CNM

1. The Department of the Navy was requested by reference (a) to review and provide official comment on Investigation Report IR 58-137, titled "A Comparison of the British, U.S. Federal and A.S.T.M. Standard and Tentative Standard Test Methods for the Brinell, Diamond Pyramid and Rockwell Hardness Testing of Metals". This report was prepared by the Canadian Department of Mines and Technical Surveys.

2. The report has been reviewed by cognizant Navy activities and is considered generally satisfactory to the Department of the Navy. However, it is suggested that the areas of Standardization should be limited to a minimum indentor load of 50 grams. Reason: At loads lighter than 50 grams, the effects of surface grain fragmentation during polishing, grain orientation, relative location of precipitates, and internal stress concentrations become dominant factors controlling the size of the test indentation. As these factors are often variable, they may induce a normal scatter of such degree that the indentor reading becomes insignificant. Under these conditions the correlation of such readings with hardness readings obtained with heavier indentor loads may be lost.

(Sgd) C. B. Gr.....
(for) C. B. Irwin
By Direction"

The following additional comments were received under date of 28 July, 1959, from Major J. C. White on behalf of Senior Army Liaison Officer, United Kingdom Services Liaison Staff:

Tripartite Standardization - Methods of Test
Ferrous Metals - Category 9.6.7.1.

"You recently requested the comments of all Inspectorates on a paper by Mr. P. J. Todkill of the Department of Mines and Technical Services, Ottawa, on British, U.S. Federal, and ASTM Standards on hardness testing. Your minute and enclosed paper

were passed on promptly to next addressee, but I regret that it has taken rather longer than anticipated to prepare reasoned comments on the lengthy paper.

In my opinion, Mr. Todkill was fully justified in commenting on the three Standards in respect of their application to both ferrous and non-ferrous metals. In all countries where Standards are used, those on mechanical testing cover both ferrous and non-ferrous applications, unless the particular test in question is applied only to one form. I think this fact should be drawn to the attention of the Tripartite Committee on Standardization of Methods of Test of Ferrous Materials.

My own comments, like Mr. Todkill's are on hardness testing, irrespective of application. I do not think it necessary at this stage to consider differences of lay-out or of terminology inevitable between standards produced by different Authors in different countries. There are, however, certain differences between the Standards which have technical implications, and which could cause differences of opinion, to be deplored, between representatives of the three countries here concerned. I have shown these differences on three appendices attached hereto.

I think all the listed differences could be resolved by discussion, to the advantage of all concerned."

PKT:vb

APPENDIX 1

Technical Differences Between Standards on Brinell Testing

| Subject | BS 240, Part 1, 1937<br>BS 240, Part 2, 1950 | U.S. Federal Method<br>242 - 1956 | A.S.T.M. Designation<br>E10 - 54T |
|---|---|---|---|
| Equipment General | Permits 1/2/5/10 mm balls and $P/D^2$ ratios of 1/5/10/30 as appropriate | Permits only 10 mm ball, but other sizes by agreement. $P/D^2$ ratio to be 30/15/5 | Permits only 10 mm ball, other sizes can be used but not as standard. $P/D^2$ ratio to be 30/15/5/2.5/1/25/1 |
| Equipment Accuracy | Testing machine ± 0.5%<br>Microscope ± 0.5% | Testing machine ± 1%<br>Microscope Unspecified | Testing machine Unspecified<br>Microscope Unspecified |
| Time of Load Application | 15 seconds | 15 seconds minimum | 15 seconds minimum |
| Direction of Load | Normal ± 0 | Normal ± 2° | Normal ± 2° |
| Test Specimens | Permits specimens less than 10 times depth of impression provided proper precautions taken | Specimen to be not less than 10 times depth of impression | Specimen to be not less than 10 times depth of impression |
| Specimen Thickness | Tables of minimum thickness for 4 sizes of ball | No such tables | Table of minimum thickness for one size of ball only |
| Readings | Two readings at right angles to each other required | Two readings at right angles to each other as required | One reading may be taken on other than standard tests, i.e. if ball other than 10 mm used |
| Interpretation of Readings | 12 Tables covering all possible combinations of load and ball | One Table covering 10 mm ball and 500/1500/3000 kg loads | One Table covering 10 mm ball and 500/1500/3000 kg loads |
| Calibration | No reference | No reference | Two possible methods given |

APPENDIX 2

Technical Differences Between Standards on Vickers Hardness Testing

| Subject | B.S. 427 1931 | U.S. Federal Method<br>244 - 1956 | A.S.T.M. Designation<br>E92 - 57 |
|---|---|---|---|
| Equipment General | Standard Loads<br>5/10/20/30/50/100/120 kg | Any load 1/120 kg permitted | Any load 1/120 kg permitted by implications |
| Diamond | 136° unlimited | 136° ± 1/2° | 136 ± 30 seconds |
| Time of Load Applications | 15 seconds | 15 seconds minimum | 15 seconds minimum |
| Testing of Case Hardened Parts | Reduce load until two equal adjacent readings obtained | Reduce load until two equal adjacent readings obtained | Only requires reporting of load used |
| Calibration | No reference | No reference | Method given |

APPENDIX 3

Technical Differences Between Standards of Rockwell Hardness Testing

| Subject | B.S. 891 1940 | U.S. Federal Method<br>244 - 1956 | A.S.T.M. Designation<br>E92 - 57 |
|---|---|---|---|
| Equipment General | Major load defined as difference between maximum and minimum used.<br>A/B/C scales only recommended<br>D/E/F/G/H scales for information | Major load defined as maximum used.<br>A/B/C/D/E/F/G/H/K scales recommended | Major load defined as maximum used.<br>A/B/C/D/E/F/G/H/K/L/M/P/R/S/V scales recommended |
| Equipment Accuracy | Load ± 0.5%<br>Measuring device ± 0.001 mm | Not specified | Not specified |
| Indentor | 120° ± 0.1° radius 0.20 mm<br>± 0.005 mm or 1/16 in. ball | Pyramid not specified<br>1/16 in. or 1/8 in. ball by implication | 120° with 0.2 mm radius 1/16 in., 1/8 in., 1/4 in. or 1/2 in. ball |
| Adjustment of Dashpot | No reference | 4/5 second travel with no specimen in machine | 4/5 second travel with no specimen in machine |
| Removal of Maximum Load | As soon as pointer steady | As soon as pointer steady | Within 2 seconds of motion stopping, or, immediately if no plastic flow and after agreed time if plastic flow |
| Test Specimens | Curved surface unacceptable | Down to 1/2 in. radius acceptable and below if correction applied | Provides two tables for correction of readings, implying that they are acceptable |
| Specimen Thickness | No bulge permitted | Bulge permitted if detail specification says so | Two tables of limiting thickness imply acceptability of bulge |
| Standard Test Block | Limits ± 1 for B30 or above,<br>± 2 for less than B30 | Not specified | Limits ± 1 for B30 or above,<br>± 1-1/2 for less than B30 |
| Superficial Hardness Testing | No reference | Permits | Describes and permits |