INTERNATIONAL STANDARD

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6507-1

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Metallic materials — Vickers hardness test —

Part 1:
Test method

Matériaux métalliques — Essai de dureté Vickers —
Partie 1: Méthode d'essai

ISO 6507-1:1997(E)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 6507-1 was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 3, *Hardness testing*.

This second edition of ISO 6507-1 cancels and replaces ISO 6507-1:1982, ISO 6507-2:1983, ISO 6507-3:1989, ISO 409-1:1982, ISO 409-2:1983 and ISO/DIS 409-3:1992 as follows:

— Combination of the three different International Standards for the ranges of the test force (ISO 6507-1:1982, ISO 6507-2:1983, ISO 6507-3:1989) into this part of ISO 6507.

— Integration of the tables for the calculation of Vickers hardness values for uses in tests made on flat surfaces (ISO 409-1:1982, ISO 409-2:1983 and ISO/DIS 409-3:1992) as annex C of this part of ISO 6507.

— The test method is specified for lengths of indentation diagonals between 0,020 mm and 1,400 mm.

— If the difference between the lengths of the two indentation diagonals is greater than 5 %, this is stated in the test report.

— Addition of a new clause 8 concerning the uncertainty of the test results.

— Addition of a new informative annex D "Monitoring the uncertainty of the hardness testing machines by the users".

ISO 6507 consists of the following parts, under the general title *Metallic materials — Vickers hardness test*:

— *Part 1: Test method*

— *Part 2: Verification of testing machines*

— *Part 3: Calibration of reference blocks*

Annexes A, B and C form an integral part of this part of ISO 6507. Annexes D and E are for information only.

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Metallic materials — Vickers hardness test —

Part 1:
Test method

1 Scope

This part of ISO 6507 specifies the method of Vickers hardness test for the three different ranges of test force for metallic materials (see table 1).

Table 1

Ranges of test force, F N	Hardness symbol	Previous designation (ISO 6507-1:1982)
$F \geqslant 49{,}03$	$\geqslant$ HV 5	Vickers hardness test
$1{,}961 \leqslant F < 49{,}03$	HV 0,2 to < HV 5	Low load Vickers hardness test
$0{,}098\,07 \leqslant F < 1{,}961$	HV 0,01 to < HV 0,2	Vickers microhardness test

The Vickers hardness test is specified in this part of ISO 6507 for lengths of indentation diagonals between 0,020 mm and 1,400 mm.

The force values in this part of ISO 6507 were calculated from kilogram force values. They were introduced before the SI-system was adopted. It was decided to keep the values based on the old units for this edition, but for the next revision it will be necessary to consider the advantage of introducing rounded values of test force and the consequence on the hardness scales.

NOTE —   In general, decreasing the test force increases the scatter of results of the measurements. This is particularly true for low-force Vickers hardness tests and Vickers microhardness tests where the principal limitation will arise in the measurement of the diagonals of the indentation. For Vickers microhardness, the accuracy of determination of the mean diagonal length is unlikely to be better than ± 0,001 mm (see annex E).

For specific materials and/or products, particular International Standards exist.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this part of ISO 6507. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this part of ISO 6507 are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 6507-2:1997, *Metallic materials — Vickers hardness test — Part 2: Verification of testing machines.*

3 Principle

A diamond indenter in the form of a right pyramid with a square base and with a specified angle between opposite faces at the vertex is forced into the surface of a test piece followed by measurement of the diagonal length of the indentation left in the surface after removal of the test force, F (see figure 1).

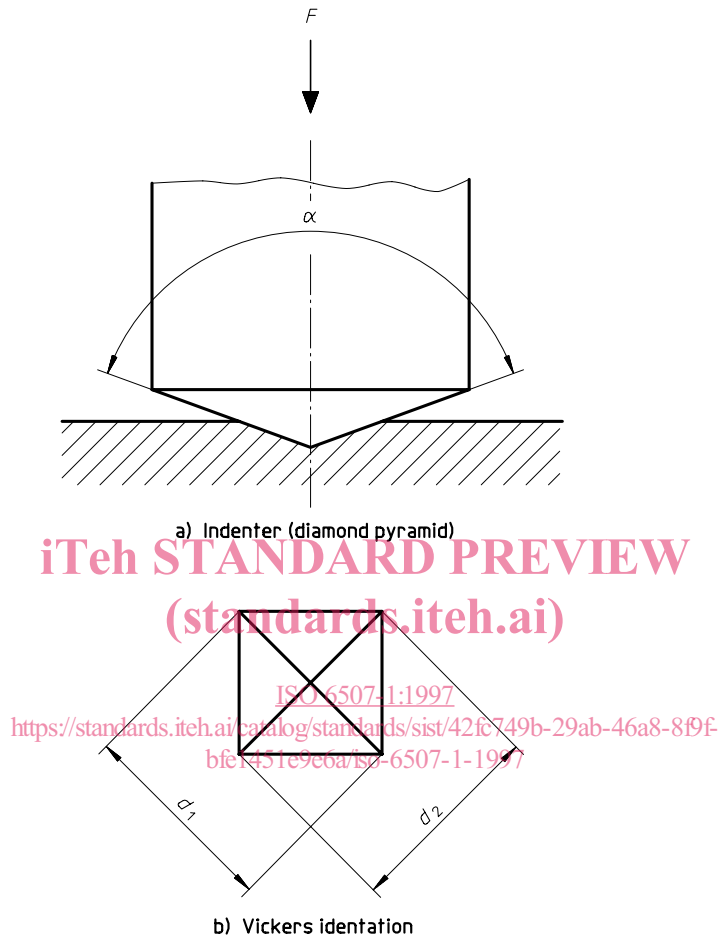a) Indenter (diamond pyramid)

b) Vickers identation

Figure 1 — Principle of the test

The Vickers hardness is proportional to the quotient obtained by dividing the test force by the sloping area of the indentation which is assumed to be a right pyramid with a square base, and having at the vertex the same angle as the indenter.

4 Symbols and designations

4.1 See table 2 and figure 1.

Table 2

Symbol	Designation
α	Angle between the opposite faces at the vertex of the pyramidal indenter (136°)
F	Test force, in newtons
d	Arithmetic mean, in millimeters, of the two diagonals length d_1 and d_2 (see figure 1)
HV	$$\text{Vickers hardness} = \text{Constant} \times \frac{\text{Test force}}{\text{Surface area of indentation}}$$ $$= 0{,}102 \; \frac{2F \sin\frac{136°}{2}}{d^2} \approx 0{,}189\,1 \; \frac{F}{d^2}$$

NOTE — $\text{Constant} = \dfrac{1}{g_n} = \dfrac{1}{9{,}806\,65} \approx 0{,}102$

4.2 The Vickers hardness is denoted by the symbol HV preceded by the hardness value followed by

   a) a number representing the test force (see table 3);

   b) the duration of loading, in seconds, if different from the time specified in 7.4.

EXAMPLES

640 HV 30 = Vickers hardness of 640 determined with a test force of 294,2 N applied for 10 s to 15 s.

640 HV 30/20 = Vickers hardness of 640 determined with a test force of 294,2 N applied for 20 s.

5 Testing machine

5.1 Testing machine, capable of applying a predetermined force or forces within the required range of test forces, in accordance with ISO 6507-2.

5.2 Indenter, a diamond in the shape of a right pyramid with a square base, as specified in ISO 6507-2.

5.3 Measuring device, as specified in ISO 6507-2.

NOTE — A suggested procedure for monitoring the uncertainty of the hardness testing machine by the users is given in annex D.

6 Test piece

6.1 The test shall be carried out on a surface which is smooth and even, free from oxide scale, foreign matter and, in particular, completely free from lubricants, unless otherwise specified in product standards. The finish of the surface shall permit accurate determination of the diagonal length of the indentation.

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

Due to the small depth of Vickers microhardness indentations, it is essential that special precautions are taken during preparation. It is recommended to use a polishing/electropolishing process which is suitable for the material parameters.

6.3 The thickness of the test piece or of the layer under test shall be at least 1,5 times the diagonal length of the indentation (see annex A).

No deformation shall be visible at the back of the test piece after the test.

6.4 For tests on curved surfaces, the corrections given in annex B, tables B.1 to B.6 shall be applied.

6.5 For test pieces of small cross-section or of irregular shape, it may be necessary to provide some form of additional support.

7 Procedure

7.1 In general, the test is carried out at ambient temperature within the limits of 10 °C to 35 °C. Tests carried out under controlled conditions shall be made at a temperature of (23 ± 5) °C.

7.2 The following test forces (see table 3) shall be used.

Table 3

Hardness test[1]		Low-force hardness test		Microhardness test[2]	
Hardness symbol	Nominal value of the test force F N	Hardness symbol	Nominal value of the test force F N	Hardness symbol	Nominal value of the test force F N
HV 5	49,03	HV 0,2	1,961	HV 0,01	0,098 07
HV 10	98,07	HV 0,3	2,942	HV 0,015	0,147 1
HV 20	196,1	HV 0,5	4,903	HV 0,02	0,196 1
HV 30	294,2	HV 1	9,807	HV 0,025	0,245 2
HV 50	490,3	HV 2	19,61	HV 0,05	0,490 3
HV 100	980,7	HV 3	29,42	HV 0,1	0,980 7
1) Nominal test forces greater than 980,7 N may be applied. 2) The test forces for the microhardness test are recommended.					

7.3 The test piece shall be placed on a rigid support. The support surfaces shall 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.

7.4 Bring the indenter into contact with the test surface and apply the test force in a direction perpendicular to the surface, without shock or vibration, until the applied force attains the specified value. The time from the initial application of the force until the full test force is reached shall not be less than 2 s nor greater than 8 s. For low-force hardness and microhardness tests, this time shall not exceed 10 s. For low-force hardness and microhardness tests, the approach speed of the indenter shall not exceed 0,2 mm/s.

The duration of the test force shall be 10 s to 15 s.

For particular materials, a longer time for maintaining the force is provided; this time shall be applied with a tolerance of ± 2 s.

7.5 Throughout the test, the testing machine shall be protected from shock or vibration.

7.6 The distance between the centre of any indentation and the edge of the test piece shall be at least 2,5 times the mean diagonal length of the indentation in the case of steel, copper and copper alloys and at least three times the mean diagonal length of the indentation in the case of light metals, lead and tin and their alloys.

The distance between the centres of two adjacent indentations shall be at least three times the mean diagonal length of the indentation in the case of steel, copper and copper alloys, and at least six times the mean diagonal length in the case of light metals, lead and tin and their alloys. If two adjacent indentations differ in size, the spacing shall be based on the mean diagonal length of the larger indentation.

7.7 Measure the lengths of the two diagonals. The arithmetical mean of the two readings shall be taken for the calculation of the Vickers hardness.

For flat surfaces, the difference between the lengths of two indentation diagonals should not be greater than 5 %. If the difference is greater, this shall be stated in the test report.

8 Uncertainty of the results

The uncertainty of results is dependent on various parameters which may be separated into two categories:

  a) parameters depending on the Vickers hardness testing machine (including the uncertainty of the verification of the testing machine and of the calibration of the reference blocks);

  b) parameters depending on the application of the test method (variation of the operating conditions).

NOTE —   In the absence of sufficient data on those parameters it is not possible, at present, to fix values of accuracy, but the uncertainty may approach approximately ± 10 % of the measured hardness values.

9 Test report

The test report shall include the following information:

    a) reference to this part of ISO 6507;

    b) all details necessary for identification of the test piece;

    c) the result obtained;

    d) all operations not specified by this part of ISO 6507, or regarded as optional;

    e) details of any occurrence which may have affected the results;

    f) the temperature of the test, if it is outside the range specified in 7.1.

NOTES

1   A strict comparison of hardness values is only possible at identical test forces.

2   There is no general process of accurately converting Vickers hardness into other scales of hardness or into tensile strength. Such conversions therefore should be avoided, unless a reliable basis for conversion can be obtained by comparison tests.

3   It should be noted that for anisotropic materials, for example those which have been heavily cold-worked, there will be a difference between the lengths of the two diagonals of the indentation. Where possible, the indentation should be made so that the diagonals are inclined at approximately 45° to the direction of cold-working. The specification for the product may indicate limits for the differences between the lengths of the two diagonals.

4   There is evidence that some materials may be sensitive to the rate of straining which causes small changes in the value of the yield stress. The corresponding effect on the termination of the formation of an indentation can make alterations in the hardness value.

6

Annex A

(normative)

Minimum thickness of the test piece in relation to the test force and to the hardness
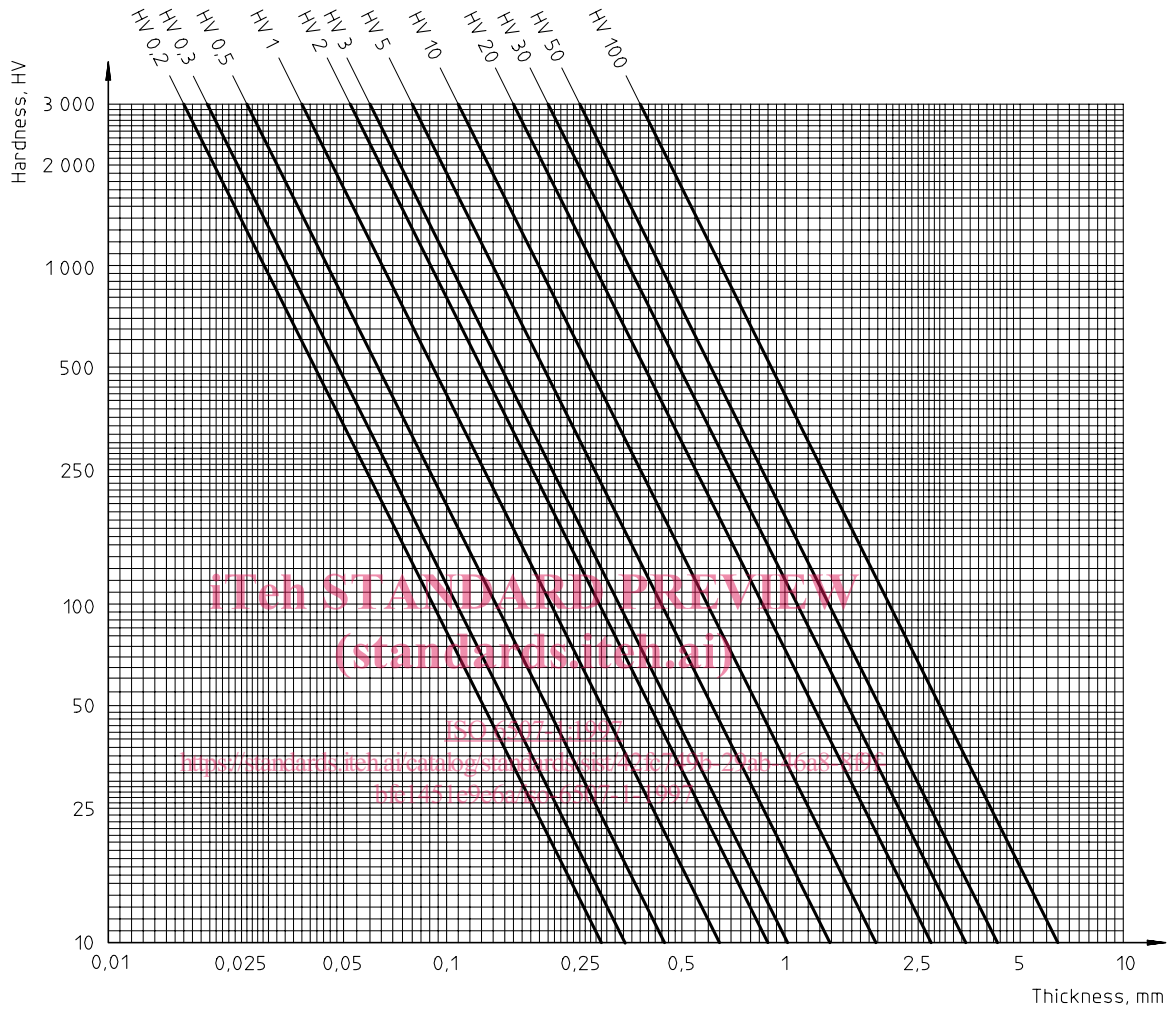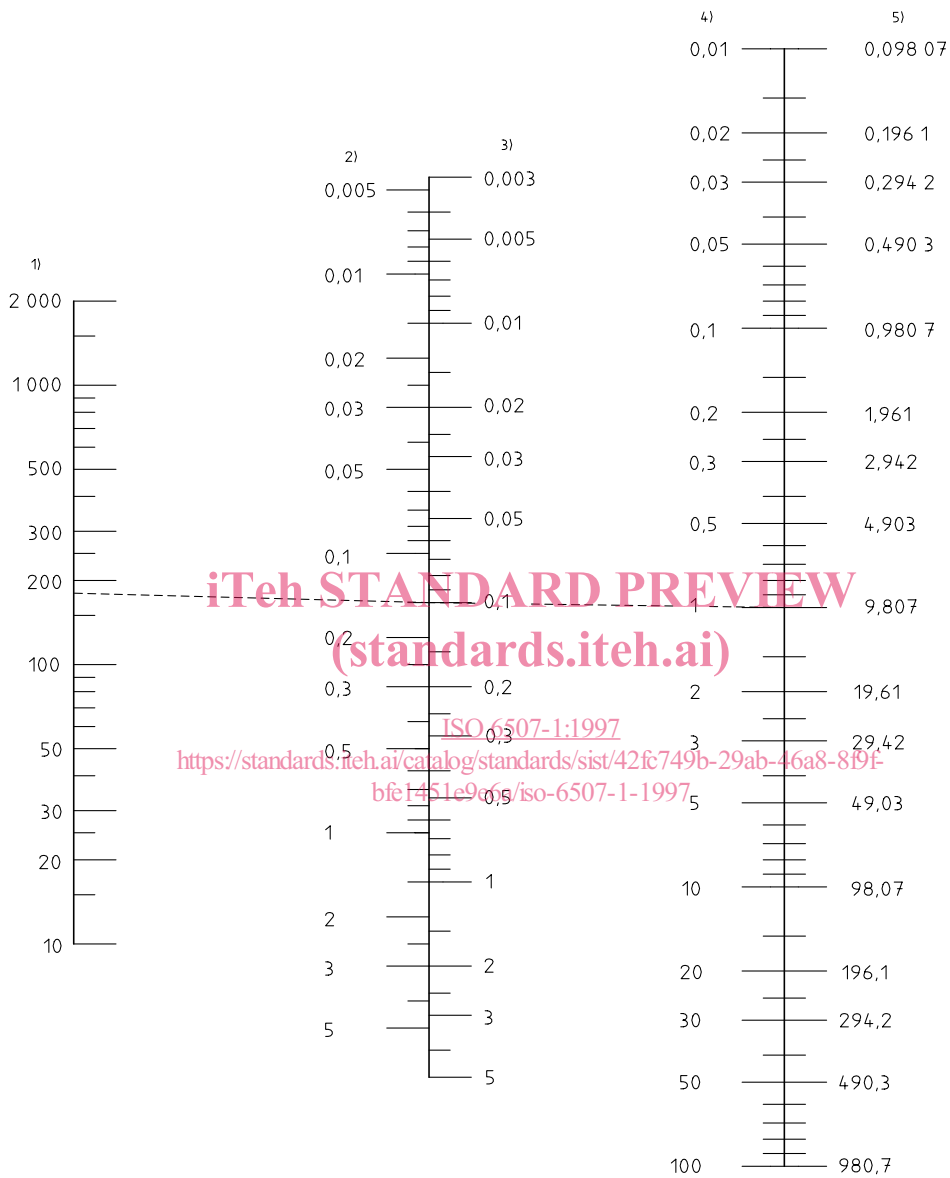

Figure A.1 — Minimum thickness of the test piece in relation to the test force and to the hardness (HV 0,2 to HV 100)

The nomogram shown in figure A.2 has been designed for the minimum thickness of a test piece, assuming that the minimum thickness has to be 1,5 times the diagonal length of the indentation. The required thickness is given by the point of intersection of the minimum thickness scale and a line (shown dotted in the example in figure A.2) joining the test force (right-hand scale) with the hardness (left-hand scale).

1) Hardness value, HV
2) Minimum thickness, t, mm
3) Diagonal length, d, mm
4) Hardness symbol, HV
5) Test force F, N

**Figure A.2 — Nomogram designed for the minimum thickness of the test piece
(HV 0,01 to HV 100)**

Annex B
(normative)

Tables of correction factors for use in tests made on curved surfaces

B.1 Spherical surfaces

Tables B.1 and B.2 give the correction factors when tests are made on spherical surfaces.

The correction factors are tabulated in terms of the ratio of the mean diagonal d of the indentation to the diameter D of the sphere.

EXAMPLE

Convex sphere	D = 10 mm
Test force	F = 98,07 N
Mean diagonal of indentation	d = 0,150 mm

$$\frac{d}{D} = \frac{0,150}{10} = 0,015$$

Vickers hardness = $0,189\,1 \times \frac{98,07}{(0,15)^2}$ = 824 HV 10

Correction factor from table B.1, by interpolation = 0,983

Hardness of sphere = $824 \times 0,983$ = 810 HV 10

Table B.1 — Convex spherical surfaces

d/D	Correction factor	d/D	Correction factor
0,004	0,995	0,086	0,920
0,009	0,990	0,093	0,915
0,013	0,985	0,100	0,910
0,018	0,980	0,107	0,905
0,023	0,975	0,114	0,900
0,028	0,970	0,122	0,895
0,033	0,965	0,130	0,890
0,038	0,960	0,139	0,885
0,043	0,955	0,147	0,880
0,049	0,950	0,156	0,875
0,055	0,945	0,165	0,870
0,061	0,940	0,175	0,865
0,067	0,935	0,185	0,860
0,073	0,930	0,195	0,855
0,079	0,925	0,206	0,850

Table B.2 — Concave spherical surfaces

d/D	Correction factor	d/D	Correction factor
0,004	1,005	0,057	1,080
0,008	1,010	0,060	1,085
0,012	1.015	0,063	1,090
0,016	1,020	0,066	1,095
0,020	1,025	0,069	1,100
0,024	1,030	0,071	1,105
0,028	1,035	0,074	1,110
0,031	1,040	0,077	1,115
0,035	1,045	0,079	1,120
0,038	1,050	0,082	1,125
0,041	1,055	0,084	1,130
0,045	1,060	0,087	1,135
0,048	1,065	0,089	1,140
0,051	1,070	0,091	1,145
0,054	1,075	0,094	1,150

B.2 Cylindrical surfaces

Tables B.3 to B.6 give the correction factors when tests are made on cylindrical surfaces.

The correction factors are tabulated in terms of the ratio of the mean diagonal d of the indentation to the diameter D of the cylinder.

EXAMPLE

Concave cylinder, one diagonal of the
indentation parallel to axis $\qquad D = 5$ mm

Test force $\qquad F = 294,2$ N

Mean diagonal of indentation $\qquad d = 0,415$ mm

$$\frac{d}{D} = \frac{0,415}{5} = 0,083$$

Vickers hardness $= 0,189\ 1 \times \dfrac{294,2}{(0,415)^2} \qquad = 323$ HV 30

Correction factor from table B.6 $\qquad = 1,075$

Hardness of cylinder $= 323 \times 1,075 \qquad = 347$ HV 30

Table B.3 — Convex cylindrical surfaces - Diagonals at 45° to the axis

d/D	Correction factor	d/D	Correction factor
0,009	0,995	0,119	0,935
0,017	0,990	0,129	0,930
0,026	0,985	0,139	0,925
0,035	0,980	0,149	0,920
0,044	0,975	0,159	0,915
0,053	0,970	0,169	0,910
0,062	0,965	0,179	0,905
0,071	0,960	0,189	0,900
0,081	0,955	0,200	0,895
0,090	0,950		
0,100	0,945		
0,109	0,940		

Table B.4 — Concave cylindrical surfaces - Diagonals at 45° to the axis

d/D	Correction factor	d/D	Correction factor
0,009	1,005	0,127	1,080
0,017	1,010	0,134	1,085
0,025	1,015	0,141	1,090
0,034	1,020	0,148	1,095
0,042	1,025	0,155	1,100
0,050	1,030	0,162	1,105
0,058	1,035	0,169	1,110
0,066	1,040	0,176	1,115
0,074	1,045	0,183	1,120
0,082	1,050	0,189	1,125
0,089	1,055	0,196	1,130
0,097	1.060	0,203	1,135
0,104	1,065	0,209	1,140
0,112	1,070	0,216	1,145
0,119	1,075	0,222	1,150

Table B.5 — Convex cylindrical surfaces — One diagonal parallel to axis

d/D	Correction factor	d/D	Correction factor
0,009	0,995	0,085	0,965
0,019	0,990	0,104	0,960
0,029	0,985	0,126	0,955
0,041	0,980	0,153	0,950
0,054	0,975	0,189	0,945
0,068	0,970	0,243	0,940