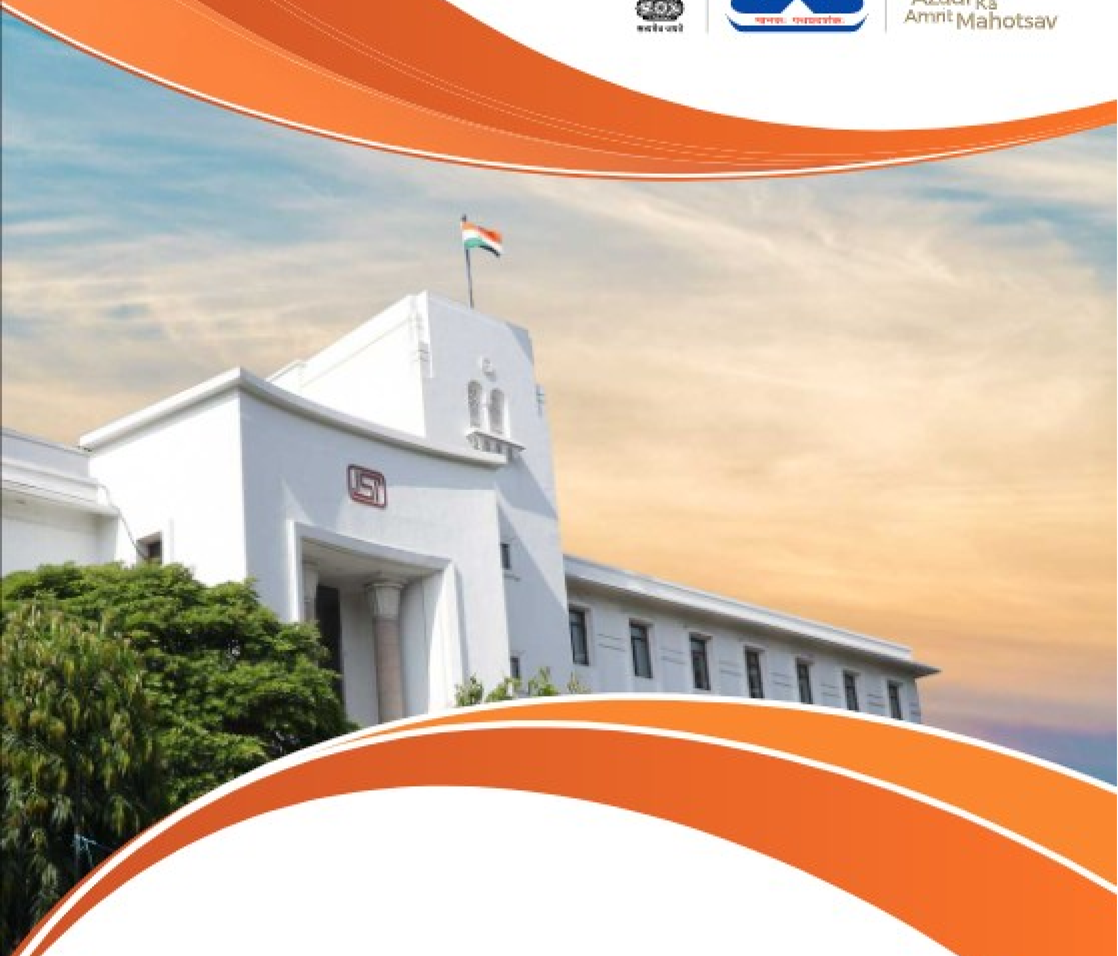


INDIAN STANDARDS ON MECHANICAL TESTING OF METALS

BUREAU OF INDIAN STANDARDS
Ministry of Consumer Affairs,
Food and Public Distribution,
Government of India

भारतीय मानक ब्यूरो
उपभोक्ता मामले, खाद्य और
सार्वजनिक वितरण मंत्रालय,
भारत सरकार

INDIA
BIS-LOCATIONS

About BIS

Bureau of Indian Standards (BIS), the National Standards Body (NSB) of India was established under the BIS Act, 1986 and came into existence on 1 April 1987 assuming the functions of the erstwhile Indian Standards Institution (ISI). The ISI came into being on 6 January 1947. The BIS Act, 2016 came into force on 12 October 2017 superseding BIS Act 1986. BIS Act, 2016 provides for the establishment of a national standards body for the harmonious development of the activities of standardization, conformity assessment and quality assurance of goods, articles, processes, systems and services and for matters connected therewith or incidental thereto.

BIS through its core activities of standardization and conformity assessment, has been benefiting the national economy by providing safe, reliable and quality goods; minimizing health hazards to consumers; protecting the environment, promoting exports and imports substitutes; controlling over proliferation of varieties, etc. The standards and certification schemes of BIS apart from benefitting the consumers and industry also support various public policies especially in areas of product safety, consumer protection, food safety, environment protection, building and infrastructure development, etc.

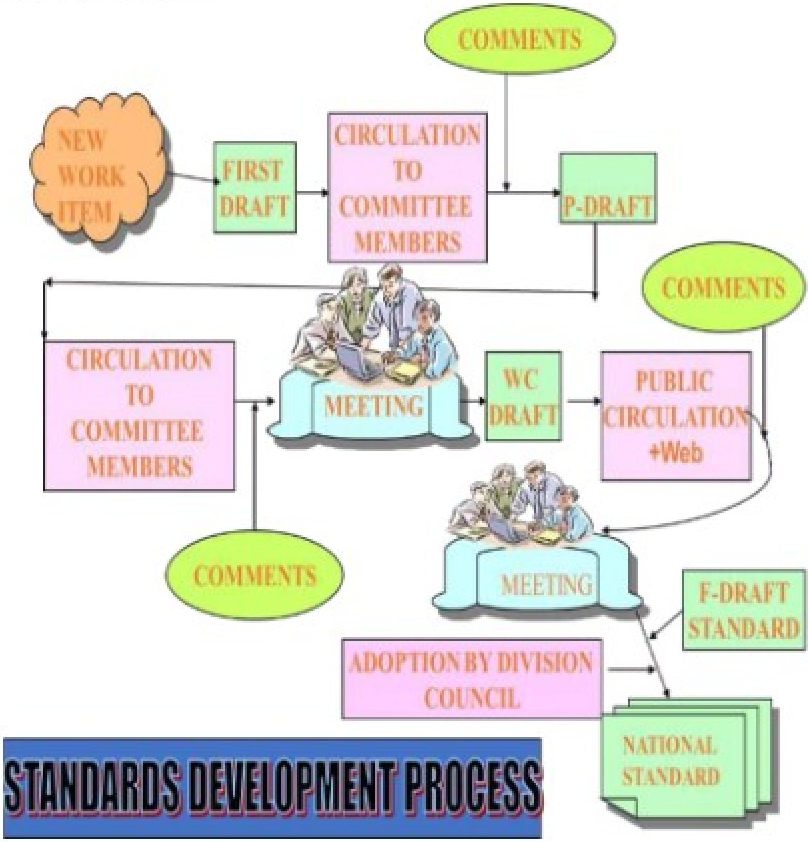
BIS also represents India in international standards bodies like International Organization for Standardization (ISO) and via the Indian National Committee in the International Electrotechnical Commission (IEC) and participates actively in the international standardization work undertaken in these bodies. BIS presents the national viewpoints on new areas taken up for international standardization and on various draft international standards during the process of development of these standards so that the country's interest is protected and reflected in these standards. This also enables the BIS technical committees to consider adoption of the International Standards as Indian Standards, with or without modifications, in order to enable our products and services to integrate with global trade and commerce.

STANDARD SETTING PROCESS OF BIS

The Indian Standards are developed by technical committees that are representative of various stakeholders having interest in the relevant subject of standardization under the scope of such committees through a process of consultation so that views of all are given due consideration and a consensus is evolved in formulating a standard.

The stakeholders involved in national standardization can broadly be categorized as industry, consumers/users, technologists (R&D and scientific institutions, academia, individual subject experts, etc) and government departments/regulators.

The process of standards development of BIS is aligned with accepted international best practices that are based on the core principles of openness, transparency, impartiality and consensus. The process begins with the identification of the standardization needs of the given sector or subject following which the development of the standard is taken up and planned by the relevant technical committee. Apart from consultation within the technical committees, draft standards are also open for public views/comments.



STANDARDS FORMULATION DEPARTMENTS OF BIS

There are 15 Technical Departments formulating standards in various subject areas. Corresponding to these departments 15 division councils exist. Each division council has several sectional committees working under it. The standards cover important segments of economy and help the industry in upgrading the quality of their goods and services.

METALLURGICAL ENGINEERING DEPARTMENT (MTD)

MTD is one of the 15 technical departments of BIS with the scope "Standardization in the field of metallurgy and metallurgical engineering including ferrous and non-ferrous metals, alloy and their products, ores and minerals, foundry, refractories and powder metallurgy, heat-treatment, corrosion protection, metallic and non-metallic coating (excluding paints, pigments and enamelling) and welding (excluding electrical welding equipment) and Nanomaterials and technologies".

MTDC is division council of MTD department.
The aspect wise breakup of the standards formulated by MTDC as on 15 September 2022 is given below:

Aspect	No. of Standards
Product Standards	726
Methods of Test	511
Codes of Practice	264
Terminology	56
Dimensions	47
System Standard	4
Safety Standard	6
Others	95
Total	1709

MTD, BIS is a 'P' member in 59 committees and 'O' Member in 30 committees of ISO.

❋ List of Technical Committees working under MTD

Under MTD, there are 20 Sectional Technical Committees working in various subject areas. List of committees with their scope is as follows:

Technical Committee Number	Technical Committee Name	SCOPE
MTD03	Mechanical Testing of Metals	Standardization in the field of mechanical testing of metals
MTD04	Alloy Steels and Forging	Standardization in the field of steel and wrought steel products including classification, designation and coding of steels
MTD06	Pig iron and Cast iron	Standardization in the field of pig iron, various types of cast iron castings
MTD07	Ores and Feed Stock for Aluminium Industry, its Metals/ Alloys and Products	Standardization in the field of Aluminium Ores and other feed stock for Aluminium industry and Standardization in the field of Aluminium Metals, their alloys and products
MTD08	Ores and Feed Stock for Copper Industry, its Metals/ Alloys and Products	Standardization in the field of copper ores and other feed stock for copper industry and standardization in the field of copper metals, their alloys and products
MTD09	Ores and Feed Stock for Non-Ferrous (Excluding Aluminium and Copper) Industry, their Metals/ Alloys and Products	Standardization in the field of Non-Ferrous Ores and other feed stock for Non-Ferrous Industry and Standardization in the field of Non-Ferrous Metals, their alloys and products. (Excluding Standardization in the field of Ores and Feed Stock for Aluminium and Copper Industry and their Metals, Alloys and Products)
MTD10	Precious Metals	Standardization in the field of precious metals
MTD11	Welding General and its Applications	Standardization in the field of welding fundamentals, consumables, equipments (other than electrical), testing, training, safety etc. and all welding processes including joining, surfacing, repairing and thermal cutting, soldering, brazing, friction welding, explosive, ultrasonic welding, beam welding (laser and

		electron beam), etc
MTD13	Ores and Feed Stock for Iron and Steel Industry	Standardization in the field of Ferrous ores, Ferro Alloys, Sponge Iron/Direct Reduced Iron and other Metallic additions/Feedstock used in the Iron and Steel making Industry
MTD14	Foundry and Steel Castings	Standardization in the field of foundry materials, foundry practices and steel castings
MTD15	Refractories	Standardization in the field of refractories
MTD16	Alloy Steels and Forging	Standardization in the field of alloy & special steels and forging, including classification, designation and coding of related steels
MTD19	Steel Tubes, Pipes and Fittings	Standardization in the field of steel tubes, pipes and fittings including classification, designation and coding of steel tubes
MTD21	Non-Destructive Testing	Standardization in the field of non-destructive testing
MTD22	Metallography and Heat-Treatment	Standardization in the field of metallography and heat-treatment of ferrous and non-ferrous metals and alloys
MTD24	Corrosion Protection and Finishes	Standardization in the field of corrosion, passivation and protection of metals, metal products in different applications, characteristics of protective and decorative metallic coatings, anodic oxide coatings, applied by electrolysis, hot dipping, thermal spraying, chemical means their testing and inspection methods
MTD25	Powder Metallurgical materials and Products	Standardization in the field of powder metallurgical materials
MTD26	Industrial Fuel-Fired Furnaces	Standardization in the field of industrial fuel fired furnaces
MTD33	Nanotechnologies	Standardization in the field of Nanomaterials and Nanotechnologies
MTD34	Methods of Chemical Analysis of Metals	Standardization in the field of chemical/instrumental analysis of ferrous, non-ferrous metals, ores and other raw materials

Mechanical Testing of Metals

- Mechanical testing of metals sectional committee, MTD 3 is one of the 20 sectional committees working under MTDC with the scope "Standardization in the field of mechanical testing of metals".
- This committee has formulated total **105** standards. Complete list of standards formulated by this committee has been placed below.

Sl No.	IS No.	Title
1	IS 1403 (Part 1) : 1993 ISO 7799:1985	Metallic materials sheet and strip 3 mm thick or less reverse bend test
2	IS 1499 : 1977	Method for charpy impact test U - notch for metals (First Revision)
3	IS 1500 (Part 1) : 2019 ISO 6506-1 : 2014	Metallic materials - brinell hardness test part 1 test method fifth revision
4	IS 1500 (Part 2) : 2013 ISO 6506-2 : 2017	Metallic materials -- brinell hardness test -- part 2 verification and calibration of testing machines
5	IS 1500 (Part 3) : 2019 ISO 6506-3 : 2014	Metallic materials - brinell hardness test part 3 calibration of reference blocks fifth revision
6	IS 1500 (Part 4) : 2019 ISO 6506-4 : 2014	Metallic materials - brinell hardness test part 4 table of hardness values fifth revision
7	IS 1501 (Part 1) : 2020 ISO 6507-1:2018	Metallic materials vickers hardness test part 1 test method fifth revision
8	IS 1501 (Part 2) : 2020 ISO 6507-2 : 2018	Metallic materials vickers hardness test part 2 verification and calibration of testing machines fifth revision
9	IS 1501 (Part 3) : 2020 ISO 6507-3 : 2018	Metallic materials vickers hardness test part 3 calibration of reference blocks fifth revision
10	IS 1501 (Part 4) : 2020 ISO 6507-4 : 2018	Metallic materials vickers hardness test part 4 tables of hardness values fifth revision
11	IS 1586 (Part 1) : 2018 ISO 6508-1 : 2016	Metallic materials - rockwell hardness test part 1 test method fifth revision

12	IS 1586 (Part 2) : 2018 ISO 6508-2:2015	Metallic materials - rockwell hardness test part 2 verification and calibration of testing machines and indenters fifth revision
13	IS 1586 (Part 3) : 2012 ISO 6508-3:2015	Metallic materials - rockwell hardness test part 3 calibration of reference blocks
14	IS 1598 : 1977	Method for izod impact test of metals (First Revision)
15	IS 1599 : 2019 ISO 7438 : 2016	Metallic materials - bend test fourth revision
16	IS 1608 (Part 1) : 2018 ISO 6892-1 : 2019	Metallic materials - tensile testing - part 1 method of test at room temperature
17	IS 1608 (Part 2) : 2020 ISO 6892-2:2018	Metallic materials - tensile testing part 2 method of test at elevated temperature fourth revision
18	IS 1608 (Part 3) : 2018 6892-3:2015	Metallic materials - tensile testing part 3 method of test at low temperature
19	IS 1716 : 1985	Method for reverse bend test for metallic wire (Second Revision)
20	IS 1717 : 2018 ISO 7800 : 2012	Metallic materials - wire - simple torsion test fourth revision
21	IS 1755 : 2018 ISO 7802:2013	Metallic materials - wire - wrapping test (Second Revision)
22	IS 1757 (Part 1) : 2020 ISO 148-1:2016	Metallic materials charpy pendulum impact test part 1 test method fourth revision
23	IS 1757 (Part 2) : 2020 ISO 148-2 : 2016	Metallic materials - charpy pendulum impact test part 2 verification of testing machines fourth revision
24	IS 1757 (Part 3) : 2020 ISO 148-3:2016	Metallic materials - charpy pendulum impact test part 3 preparation and characterization of charpy v-notch test pieces for indirect verification of pendulum impact machines fourth revision
25	IS 1828 (Part 1) : 2015 ISO 7500-1 : 2018	Metallic materials - calibration and verification of static uniaxial testing machines - part 1 tension compression testing machines - calibration and verification of the force-measuring system
26	IS 1828 (Part 2) : 2015 ISO 7500-2:2006	Metallic materials - verification of static uniaxial testing machines part 2 tension creep testing machines - verification of the applied force (First Revision)

27	IS 2328 : 2018 ISO 8492:2013	Metallic materials - tube - flattening test third revision
28	IS 2329 : 2005 ISO 8491:1998	Metallic materials - tube in full section - bend test (Second Revision)
29	IS 2330 : 2011 ISO 8494 : 2013	Metallic materials - tube - flanging test
30	IS 2335 : 2005 ISO 8493:1998	Metallic materials - tube – drift expanding test (Second Revision)
31	IS 2854 : 1990	Determination of young s modulus tangent modulus and chord modulus - test method
32	IS 2855 : 1991	Thermostat metals - determinantion of flexivity (First Revision)
33	IS 3394 : 1985	Method for accelerated life test of electrical resistance alloys for heating elements (First Revision)
34	IS 3407 (Part 1) : 1983	Method for creep testing of steel at elevated temperatures part 1 tensile creep testing (First Revision)
35	IS 3407 (Part 2) : 1983	Method for creep testing of steel at elevated temperatures part 2 tensile creep stress rupture testing (First Revision)
36	IS 3410 : 1993	Metallic materials - determination of linear thermal expansion (First Revision)
37	IS 3711 : 2020 ISO 377:2017	Steel and steel products location and preparation of samples and test pieces for mechanical testing third revision
38	IS 3766 : 1977	Method for calibration of pendulum impact testing machines for testing metals (First Revision)
39	IS 3803 (Part 1) : 1989 ISO 2566-1 : 1984	Steel - conversion of elongation values part 1 carbon and low alloy steels (Second Revision)
40	IS 3803 (Part 2) : 1989 ISO 2566-2 : 1984	Steel - conversion of elongation values part 2 austenitic steels (Second Revision)
41	IS 4169 : 2014 ISO 376 : 2011	Metallic materials - calibration of force proving instruments used for the verification of uniaxial testing machines (Second Revision)
42	IS 4258 : 2018 ISO 18265 : 2013	Metallic materials - conversion of hardness values third revision
43	IS 5069 : 2018 ISO 23718	Metallic materials - mechanical testing - vocabulary (Second Revision)
44	IS 5070 : 1985	Method for beam unnotched impact test for grey cast iron (First Revision)

45	IS 5074 : 1969	Method of axial load fatigue testing of steel
46	IS 5075 : 1985	Method of rotating bar bending fatigue testing of metals (First Revision)
47	IS 5242 : 1979	Method of test for determining shear strength of metals (First Revision)
48	IS 6243 : 1985	Method of hydrogen embrittlement test for copper (First Revision)
49	IS 6885 (Part 1) : 2020 ISO 4545-1:2017	Metallic materials knoop hardness test part 1 test method (Second Revision)
50	IS 6885 (Part 2) : 2020 ISO 4545-2:2017	Metallic materials knoop hardness test part 2 verification and calibration of testing machines (Second Revision)
51	IS 6885 (Part 3) : 2020 ISO 4545-3:2017	Metallic materials knoop hardness test part 3 calibration of reference blocks (Second Revision)
52	IS 6885 (Part 4) : 2020 ISO 4545-4:2017	Metallic materials knoop hardness test part 4 tables of hardness values (Second Revision)
53	IS 6886 : 1973	Method of dynamic force calibration of axial load fatigue testing machines by means of a strain gauge technique
54	IS 7096 : 1981	Method for scleroscope hardness testing of metallic materials (First Revision)
55	IS 7172 : 1984	Method for verification of scleroscope hardness testing machines (First Revision)
56	IS 8632 : 1977	Method for identification of test piece axes
57	IS 10166 : 1982	Method for calibration of standardized test block for verification of scleroscope hardness testing equipments
58	IS 10167 : 1982	Method for upsetting test on metallic materials
59	IS 10175 : 2018 ISO 20482 : 2013	Metallic materials - sheet and strip - erichsen cupping test third revision
60	IS 10180 : 1982	Method for plane strain fracture toughness testing of metals
61	IS 10181 : 1982	Method for determination of magnetic permeability of iron and steel
62	IS 10623 : 1983	Drop weight tear test on ferritic steels and line pipe
63	IS 10636 (Part 1) : 1983	Methods for measurement of abrasive wear properties of metallic material part 1 test method for gouging abrasion resistance jaw crusher test

64	IS 10636 (Part 2) : 1983	Method for measurement of abrasive wear properties of metallic material part 2 test method for high stress abrasion
65	IS 10636 (Part 3) : 1983	Methods for measurement of abrasive wear properties of metallic material part 3 test methods for low stress abrasion
66	IS 11083 : 1984	Method for evaluation of friction and wear properties of materials against steel surface
67	IS 11240 : 1985	Method for falling weight test on metallic materials
68	IS 11999 : 2007 ISO 10113:2020	Metallic materials sheet and strip determination of plastic strain ratio
69	IS 12260 : 2018 ISO 8495 : 2013	Metallic materials - tube - ring - expanding test (First Revision)
70	IS 12261 : 1987	Method for reverse torsion test for metallic wire
71	IS 12278 : 2018 ISO 8496 : 2013	Metallic materials - tube - ring tensile test (Second Revision)
72	IS 12514 : 1988	Method for torsional stress fatigue testing
73	IS 12872 : 2011 ISO 9513 : 2012	Metallic materials - calibration of extensometer systems used in uniaxial testing (Second Revision)
74	IS 13237 : 1991	Metallic foil - tension testing
75	IS 13838 : 1993	Mechanical testing of metals - determination of poisson s rates
76	IS 15420 : 2003	Metallic materials - charpy pendulum impact test - preparation and characterization of charpy v reference test pieces for verification of test machines
77	IS 15756 : 2007 ISO 10275:2020	Metallic materials - sheet and strip - determination of tensile strain hardening exponent
78	IS 16842 : 2018 ISO 12108 : 2018	Metallic materials - fatigue testing - fatigue crack growth method
79	IS 16843 : 2018 ISO 12111:2011	Metallic materials - fatigue testing - strain - controlled thermo mechanical fatigue testing method
80	IS 17143 : 2019 ISO 1352 : 2011	Metallic materials - torque - controlled fatigue testing
81	IS 17144 (Part 1) : 2019 ISO 14577-1 : 2015	Metallic materials - instrumented indentation test for hardness and materials parameters part 1 test method
82	IS 17144 (Part 2) : 2019 ISO 14577-2 : 2015	Metallic materials - instrumented indentation test for hardness and materials parameters part 2 verification and calibration of testing machines

83	IS 17144 (Part 3) : 2019 ISO 14577-3 : 2015	Metallic materials - instrumented indentation test for hardness and materials parameters part 3 calibration of reference blocks
84	IS 17144 (Part 4) : 2019 ISO 14577-4 : 2016	Metallic materials - instrumented indentation test for hardness and materials parameters part 4 test method for metallic and non - metallic coatings
85	IS 17145 (Part 1) : 2019 ISO 12110-1 : 2013	Metallic materials - fatigue testing - variable amplitude fatigue testing part 1 general principles test method and reporting requirements
86	IS 17145 (Part 2) : 2019 ISO 12110-2 : 2013	Metallic materials - fatigue testing - variable amplitude fatigue testing part 2 cycle counting and related data reduction methods
87	IS 17146 (Part 1) : 2019 ISO 12004-1 : 2008	Metallic materials - sheet and strip - determination of forming - limit curves part 1 measurement and application of forming - limit diagrams in the press shop
88	IS 17146 (Part 2) : 2019 ISO 12004-2 : 2008	Metallic materials - sheet and strip - determination of forming - limit curves part 2 determination of forming - limit curves in the laboratory
89	IS 17147 : 2019 ISO 12107 : 2012	Metallic materials - fatigue testing - statistical planning and analysis of data
90	IS 17149 (Part 1) : 2019 ISO 16859-1 : 2015	Metallic materials - leeb hardness test part 1 test method
91	IS 17149 (Part 2) : 2019 ISO 16859-2 : 2015	Metallic materials - leeb hardness test part 2 verification and calibration of the testing devices
92	IS 17149 (Part 3) : 2019 ISO 16859-3 : 2015	Metallic materials - leeb hardness test part 3 calibration of reference test blocks
93	IS 17151 : 2019 ISO 12135 : 2016	Metallic materials - unified method of test for the determination of quasistatic fracture toughness
94	IS 17413 (Part 1) : 2020 ISO 26203-1:2018	Metallic materials - tensile testing at high strain rates part 1 elastic- bar-type systems
95	IS 17413 (Part 2) : 2020 26203-2:2011	Metallic materials - tensile testing at high strain rates part 2 servo- hydraulic and other systems
96	IS 17414 : 2020 ISO 16630:2017	Metallic materials sheet and strip hole expanding test

97	IS 17415 : 2020 ISO 18338:2015	Metallic materials - torsion test at ambient temperature
98	IS 17416 : 2020 ISO 14556 : 2015	Metallic materials - charpy V- notch pendulum impact test - instrumented test method
99	IS 17417 (Part 1) : 2020 ISO 4965-1:2012	Metallic materials - dynamic force calibration for uniaxial fatigue testing part 1 testing systems
100	IS 17417 (Part 2) : 2020 ISO 4965-2:2012	Metallic materials - dynamic force calibration for uniaxial fatigue testing part 2 dynamic calibration device DCD instrumentation
101	IS 17418 : 2020 ISO 16842 : 2014	Metallic materials - sheet and strip – biaxial tensile testing method using a cruciform test piece
102	IS 17419 : 2020 ISO 17340:2014	Metallic materials - ductility testing - high speed compression test for porous and cellular metals
103	IS 17679 : 2021 ISO 15653:2018	Metallic materials - method of test for the determination of quasistatic fracture toughness of welds
104	IS 17795 : 2022 ISO 204:2018	Metallic materials- uniaxial creep testing in tension - method of test
105	IS 17915 : 2022 ISO 20032 : 2013	Method for evaluation of tensile properties of metallic superplastic materials

Some of the important standards formulated by this committee are explained in brief in this handbook.

IS 1608/ISO 6892 -METALLIC MATERIALS - TENSILE TESTING

This standard has three parts:

1. Part 1 Method of test at room temperature.

Scope: This part of IS 1608/ISO 6892 specifies the method for tensile testing of metallic materials and defines the mechanical properties which can be determined at room temperature.

2. Part 2 Method of Test at Elevated Temperature

Scope: This part of IS 1608/ISO 6892 specifies a method of tensile testing of metallic materials at temperatures higher than room temperature

3. Part 3 method of test at low temperature

Scope: This part of IS 1608/ISO 6892 specifies a method of tensile testing of metallic materials at temperatures between +10 °C and -196 °C

- IMPORTANT DEFINITIONS

Gauge length: Length of the parallel portion of the test piece on which elongation is measured at any moment during the test.

Elongation: Increase in the original gauge length at any moment during the test.

Strain rate: Increase of strain, measured with an extensometer, in extensometer gauge length, per time.

Stress: At any moment during the test, force divided by the original cross-sectional area, So, of the test piece.

Maximum force: Highest force that the test piece withstands during the test after the beginning of work-hardening.

Tensile strength: Stress corresponding to the maximum force.

Yield strength: When the metallic material exhibits a yield phenomenon, stress corresponding to the point reached during the test at which plastic deformation occurs without any increase in the force.

Upper yield strength: Maximum value of stress prior to the first decrease in force.

Lower yield strength: Lowest value of stress during plastic yielding, ignoring any initial transient effects.

Modulus of elasticity: Quotient of change of stress ΔR and change of percentage extension Δe in the range of evaluation multiplied by 100%.

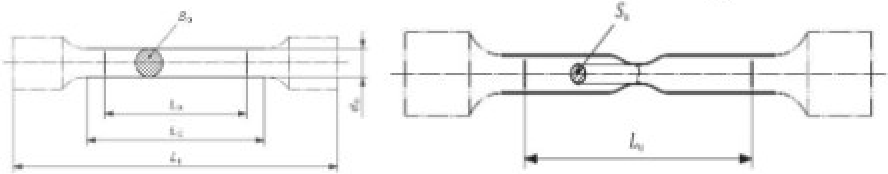
- PRINCIPLE

The test involves straining a test piece by tensile force, generally to fracture, for the determination of one or more of the mechanical properties.

- SPECIMEN SHAPE AND DIMENSIONS
- Preferred test pieces have a direct relationship between the original gauge length, L_o, and the original cross-sectional area, S_o, expressed by the formula $L_o = k\sqrt{S_0}$ where K is coefficient of proportionality, internationally adopted value for k is 5.65.
- When the cross-sectional area of the test piece is too small for this requirement to be met with, k =5.65 a higher value (preferably 11.3) or a non-proportional test.
- For non-proportional test pieces, the original gauge length, L_o, is independent of the original cross-sectional area, S_o.
- Types of test pieces according to product type

Type of product

Sheets – Plates – Flats **Wire – Bars – Sections**

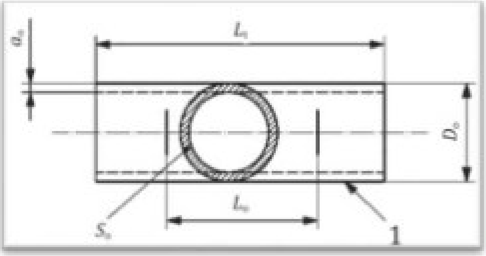


a) Before test b) After test

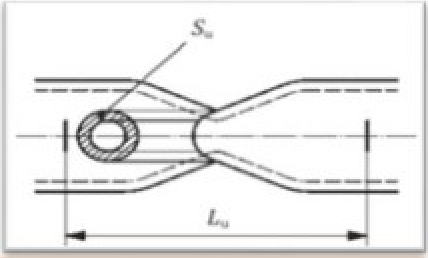
Fig. Machined test piece of round cross section

Table -Typical test piece dimensions for circular cross section test piece

Coefficient of proportionality k	Diameter d (mm)	Original gauge length $L_0 = k\sqrt{S_0}$ (mm)	Minimum parallel length L_c (mm)
5.65	20	100	110
	14	70	77
	10	50	55
	5	25	28



a) Before Testing



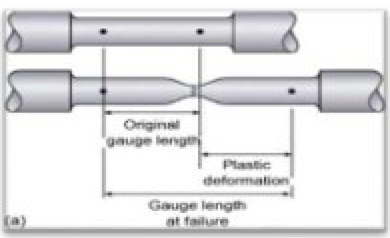
b) After Testing

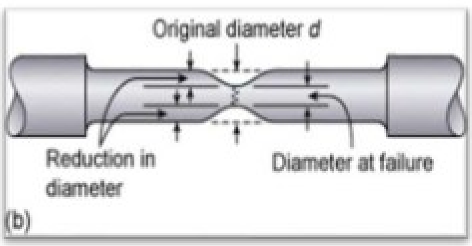
Fig. Test piece comprising of a length of a tube

Following three different non-proportional test piece geometries are widely used

Test piece type	Width b_0	Original Gauge length L_0	Parallel length L_c		Fee length b/w the grips for parallel sided test piece
			Minimum	Recommended	
1	12.5± 1	50	57	75	87.5
2	20 ± 1	80	90	120	140
3	25 ± 1	50	60	-	Not defined

Some real-life examples of common tensile test specimens:





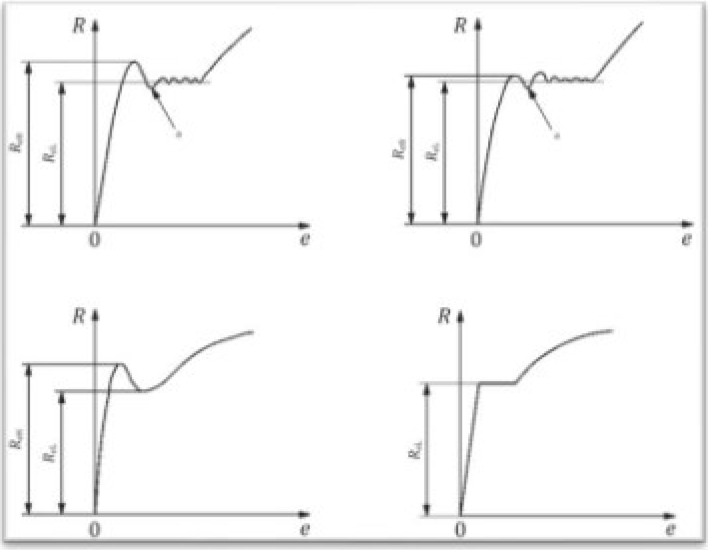


Fig. Examples of upper and lower yield strengths for different types of curve

- TEST REPORT

The test report shall contain at least the following information, unless otherwise agreed by the parties concerned:

a) Identification of the test piece;

b) Specified material, if known;

c) Type of test piece;

d) Location and direction of sampling of test pieces, if known;

e) Testing control mode(s) and testing rate(s) or testing rate range(s)

f) Test results —Results should be rounded to the following precisions or better, if not otherwise specified in product standards:

— Percentage yield point extension values, Ae, to the nearest 0.1 %;

— All other percentage extension and elongation values to the nearest 0.5 %;

—Percentage reduction of area, Z, to the nearest 1 %.

IS 1500 /ISO 6506 - METALLIC MATERIALS - BRINELL HARDNESS TEST

This standard has four parts:

1. Part 1 Test method

Scope: This part of IS 1500 /ISO 6506 specifies the method for the Brinell hardness test for metallic materials. It is applicable to both fixed location and portable hardness testing machines.

2. Part 2 Verification and calibration of testing machines

Scope: This part of IS 1500 /ISO 6506 specifies methods of direct and indirect verification of testing machines used for determining Brinell hardness in accordance with ISO 6506-1 and also specifies when these two types of verification have to be performed.

3. Part 3 Calibration of reference blocks

Scope: This part of part of IS 1500 /ISO 6506 specifies a method for the calibration of reference blocks to be used in the indirect verification of Brinell hardness testing machines as described in IS 1500 (Part 2). The procedures necessary to ensure metrological traceability of the calibration machine are also specified.

4. Part 4 Table of hardness values

Scope: This part of IS 1500 /ISO 6506 gives a table of the Brinell hardness values for use in tests on flat surfaces.

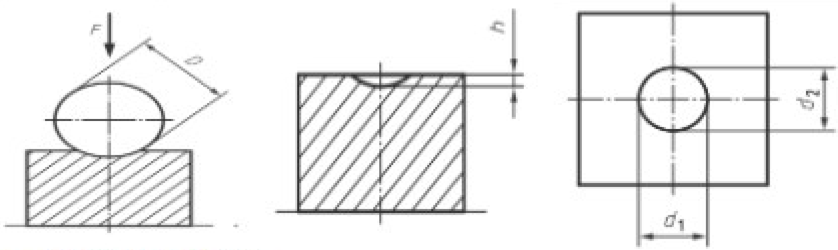
- PRINCIPLE

• An indenter (tungsten carbide composite ball with diameter, *D*) is forced into the surface of a test piece and, after removal of the force, *F*, the diameter of the indentation, *d*, left in the surface is measured.

• The Brinell hardness is proportional to the quotient obtained by dividing the test force by the curved surface area of the indentation. The indentation is assumed to take the shape of the unloaded ball indenter, and its surface area is calculated from the mean indentation diameter and the ball diameter, using the formula given in Table.

Table – Symbols and definition

Symbol	Definition
D	Diameter of the ball
F	Test force
d	Mean diameter of the indentation $d = \frac{d_1+d_2}{2}$
	Indentation diameters measured at approximately 90°
d_1, d_2	Depth of indentation $h = \frac{D}{2}\left(1 - \sqrt{1 - \frac{d^2}{D^2}}\right)$
h	
HBW	Brinell Hardenss $= constant\ x \frac{Test\ Force}{Idealized\ Surface\ area\ of\ indentation} = 0.102 \text{ x } \frac{2F}{\pi D^2\left(1-\sqrt{1-\frac{d^2}{D^2}}\right)}$
$0.102xF/D^2$	Force – diameter index



- NOMENCLATURE

Hardness values are designation as follows: e.g. 600 HBW 1/30/20

600	Brinell Hardness Value
HBW	Hardness Symbol
1	Ball Diameter in mm
30	Approximate kgf equivalent of applied test force where 30kgf= 2942N
20	Duration time of test force (20s) if not within specified range (10s to 15s)

- TEST PIECE

• The test shall be carried out on a surface which is smooth and even, free from oxide scale, foreign matter, and, in particular, free from lubricants.

• The test piece shall have a surface finish that will allow an accurate measurement of the diameter of the indentation.

NOTE- For indentations made with the smaller ball indenters, it might be necessary to polish or lap the surface prior to making the indentation.

• Preparation shall be carried out in such a way that any alteration of the surface, for example, due to excessive heating or cold working, is minimized.

• The thickness of the test piece shall be at least eight times the depth of indentation. Values for the minimum thickness of the test piece in relation to the mean diameter of indentation are to be referred from Annex B of IS 1500 part 1.

Visible deformation at the back of the test piece can indicate that the test piece is too thin.

- PROCEDURE
- The test force should be chosen so that the diameter of the indentation, d, lies between the values 0.24 D and 0.6 D. If the diameter of the indentation lies outside these limits, the ratio of indentation diameter to indenter diameter (d/D) shall be stated in the test report.
- Bring the indenter into contact with the test surface and apply the test force in a direction perpendicular to the surface; without shock, vibration, or overrun, until the applied force attains the specified value. The time from the initial application of force to the time the full test force is reached shall be 7^{+1}_{-5} s. Maintain the test force for 14^{+1}_{-4} s. For certain materials, where a longer duration of the test force is required, this time shall be applied with a tolerance of ±2 s.
- The distance from the edge of the test piece to the centre of each indentation shall be a minimum of two and a half times the mean indentation diameter. The distance between the centres of two adjacent indentations shall be at least three times the mean indentation diameter.
- For manual measuring systems, measure the diameter of each indentation in two directions approximately perpendicular to each other. The arithmetic mean of the two readings shall be taken for the calculation of the Brinell hardness.

Fig. Real Life Images of Brinell Hardness indenter

IS 1586/ISO 6508 METALLIC MATERIALS - ROCKWELL HARDNESS TEST

This standard has three parts:

1. Part 1 Test method

Scope: This part of IS 1586/ISO 6508 specifies the method for Rockwell regular and Rockwell superficial hardness tests for scales A, B, C, D, E, F, G, H, K, 15N, 30N, 45N, 15T, 30T, and 45T for metallic materials and is applicable to stationary and portable hardness testing machines.

2. Part 2 Verification and calibration of testing machines and indenters

Scope: This part of IS 1586/ISO 6508 specifies two separate methods of verification of testing machines (direct and indirect) for determining Rockwell hardness in accordance with ISO 6508-1:2015, together with a method for verifying Rockwell hardness indenters.

3. Part 3 Calibration of reference blocks

Scope: This part of IS 1586/ISO 6508 specifies a method for the calibration of reference blocks to be used for the indirect and daily verification of Rockwell hardness testing machines, as specified in IS 1586 (Part 2)

- PRINCIPLE

An indenter of specified size, shape, and material is forced into the surface of a test specimen under two force levels using the specific conditions.

The specified preliminary force is applied, and the initial indentation depth is measured, followed by the application and removal of a specified additional force, returning to the preliminary force.

The final indentation depth is then measured, and the Rockwell hardness value is derived from the difference, h, in final and initial indentation depths and the two constants N and S.

• Rockwell hardness = $N - \frac{h}{S}$

N – Full range constant S – Scaling constant (mm) h – Permanent depth of indentation under preliminary test force after removal of additional test force (permanent indentation depth) (mm)

Table- Rockwell regular scales

Rockwell Regular hardness scale	Hardness symbol Unit	Type of indenter	Preliminary force F_0	Total force F	Scaling Constant S	Full Range Constant N	Applicable range of application (Rockwell Regular hardness scales)
A	HRA	Diamond cone	98,07 N	588,4 N	0,002 mm	100	20 HRA to 95 HRA
B	HRBW	Ball 1,587 5 mm	98,07 N	980,7 N	0,002 mm	130	10 HRBW to 100 HRBW
C	HRC	Diamond cone	98,07 N	1,471 kN	0,002 mm	100	20 HRC[a] to 70 HRC
D	HRD	Diamond cone	98,07 N	980,7 N	0,002 mm	100	40 HRD to 77 HRD
E	HREW	Ball 3,175 mm	98,07 N	980,7 N	0,002 mm	130	70 HREW to 100 HREW
F	HRFW	Ball 1,587 5 mm	98,07 N	588,4 N	0,002 mm	130	60 HRFW to 100 HRFW
G	HRGW	Ball 1,587 5 mm	98,07 N	1,471 kN	0,002 mm	130	30 HRGW to 94 HRGW
H	HRHW	Ball 3,175 mm	98,07 N	588,4 N	0,002 mm	130	80 HRHW to 100 HRHW
K	HRKW	Ball 3,175 mm	98,07 N	1,471 kN	0,002 mm	130	40 HRKW to 100 HRKW

[a] The applicable range of application can be extended to 10 HRC if the surfaces of the diamond cone and spherical tip are polished for a penetration depth of at least 0,4 mm

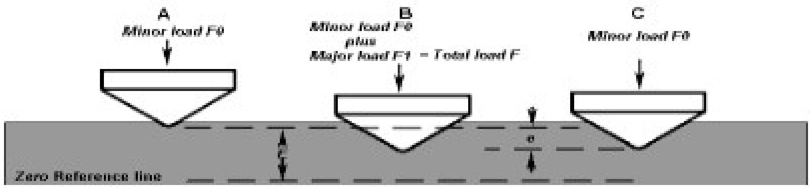
- Nomenclature

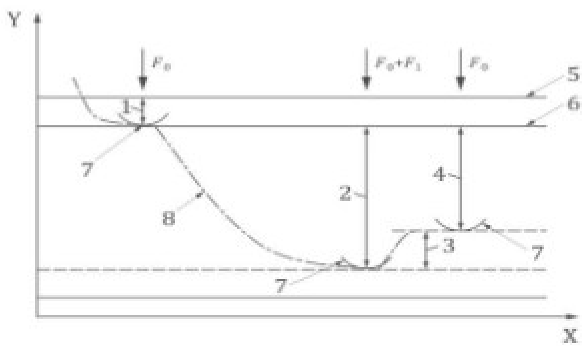
Hardness values are designation as follows: 80 HRBW

80	Rockwell hardness value
HR	Rockwell Hardness Symbol
B	Rockwell scale symbol
W	Indication of type of ball used W= Tungsten Carbide Composite

Table – Symbols and abbreviated terms

Symbol/ Abbreviated term	Definition
F_0	Preliminary test force
F_1	Additional test force (total force minus preliminary force)
F	Total test force
S	Scaling constant, specific to the scale
N	Full range constant, specific to the scale
h	Permanent depth of indentation under preliminary test force after removal additional test force (permanent indentation depth)
HRA **HRC** **HRD**	Rockwell Regular hardness = $100 - \frac{h}{0.002}$
HRBW **HREW** **HRFW** **HRGW** **HRHW** **HRKW**	Rockwell Regular hardness = $130 - \frac{h}{0.002}$
HRN **HRTW**	Rockwell Superficial hardness = $100 - \frac{h}{0.001}$





Key

X Time

Y Indenter position

1 Indentation depth by preliminary force, F_0

2 Indentation depth by additional test force, F_1

3 Elastic recovery just after removal of additional test force, F_1

F_0 Preliminary test force

4 Permanent indentation depth, h

5 Purface of specimen

6 Reference planes for measurement

7 Position of indenter

8 Indentation depth vs. time curve

F_1 Additional test force

Fig. Rockwell Principle Diagram

- TEST PIECE

• 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 specified otherwise in product or materials standards.

• An exception is made for reactive metals, such as titanium, which might 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

• The thickness of the test piece, or of the layer under test (minimum values are given in Annex B), shall be at least 10 times the permanent indentation depth for diamond indenters and 15 times the permanent indentation depth for ball indenters, unless it can be demonstrated that the use of a thinner test piece does not affect the measured hardness value. In general, 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.

- PROCEDURE

•Temperature requirement of 10 °C to 35 °C.

• The daily verification as defined in standard shall be performed before the first test of each day for each scale to be used.

• The test piece shall be placed on a rigid support and supported in such a manner that the surface to be indented is in a plane normal to the axis.

• Bring the indenter into contact with the test surface and apply the preliminary test force, F_0, without shock, vibration, oscillation, or overload. The preliminary force application time should not exceed 2 s. The duration of the preliminary test force, F_0, shall be 3^{+1}_{-2} s.

• Measure the initial indentation depth.

• Apply the additional force F_1 without shock, vibration, oscillation, or overload to increase the force from F_0 to the total force, F.

• The total test force, F, shall be maintained for a duration of 5^{+1}_{-3} s. Remove the additional test force, F_1, and while the preliminary test force, F_0, is maintained, after 4^{+1}_{-3} s, the final reading shall be made.

• Measure the final indentation depth while the preliminary test force is applied.

• The distance between the centres of two adjacent indentations shall be at least three times the diameter of the indentation. The distance from the centre of any indentation to an edge of the test piece shall be at least two and a half time the diameter of the indentation.

- **TEST REPORT**

The laboratory shall record at least the following information and that information shall be included in the test report, unless agreed by the parties concerned:

a) all details necessary for the complete identification of the test piece, including the curvature of the test surface;

b) the test temperature, if it is not within the limits of 10 °C to 35 °C;

c) the hardness result in the format defined in standard;

d) details of any occurrence which might have affected the result;

e) the actual extended total force duration time used, if greater than the 6 seconds allowed by the tolerances;

f) the date the test was performed;

Fig. Real Life images of Rockwell indenter

IS 6885/ISO 4545 METALLIC MATERIALS — KNOOP HARDNESS TEST

This standard has four parts:

1. Part 1 Test method

Scope: This document specifies the Knoop hardness test method for metallic materials for test forces from 0.009807 N to 19.613 N. The Knoop hardness test is specified in this document for lengths of indentation diagonals ≥ 0.020 mm. Using this method to determine Knoop hardness from smaller indentations is outside the scope of this document as results would suffer from large uncertainties due to the limitations of optical measurement and imperfections in tip geometry. IS 17144 (Part 1)/ ISO 14577-1 allows the determination of hardness from smaller indentations.

2. Part 2 Verification and Calibration of Testing Machines

Scope: This document specifies the method of verification and calibration of testing machines for determining Knoop hardness for metallic materials in accordance with IS 6885 (Part 1)/ ISO 4545-1. A direct method of verification and calibration is specified for the testing machine, indenter, and the diagonal length measuring system. An indirect verification method using reference blocks is specified for the overall checking of the machine.

3. Part 3 Calibration of reference blocks

Scope: This document specifies the method for the calibration of reference blocks to be used for the indirect verification of Knoop hardness testing machines as specified in IS 6885 (Part 2) / ISO 4545-2. The method is applicable only for indentations with long diagonals ≥ 0.020 mm

4. Part 4 Tables of Hardness Values

Scope: This document gives a table for the calculation of Knoop hardness values for use in tests carried out in accordance with IS 6885 (Part 1) / ISO 4545-1.

- PRINCIPLE

A diamond indenter, in the form of a rhombic-based pyramid with angles, α and β, between opposite edges respectively equal to 172.5° and 130° at the vertex, is forced into the surface of a test piece followed by measurement of the long diagonal, d, of the indentation remaining in the surface after removal of the test force, F

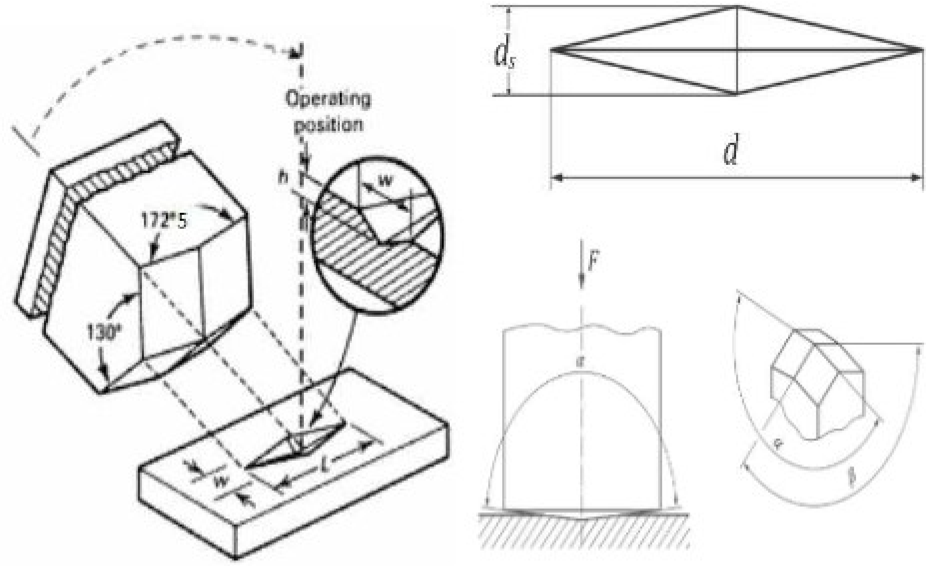


Fig. Principle of test and indenter geometry

Table -Symbols and designations

Symbol	Designation
F	Test force, in newtons (N)
d	Length of the long diagonal, in mm
d_s	Length of the short diagonal, in mm
α	Angle between the opposite edges of the long diagonal at the vertex of the diamond pyramid indenter (nominally 172.5°)
β	Angle between the opposite edges of the short diagonal at the vertex of the diamond pyramid (nominally 130°)
V	Magnification of the measuring system
c	Indenter constant, relating projected area of the indentation to the square of the length of the long diagonal Indenter constant, $c = \frac{\tan\frac{\beta}{2}}{2\tan\frac{\alpha}{2}}$, for nominal angles α and β, c is approx. 0.07028

HK	Knoop hardness $= \frac{Test\ force\ (kgf)}{Projected\ area\ of\ indentation\ (mm^2)} = \frac{1}{g_n} \times \frac{Test\ force\ (kgf)}{Projected\ area\ of\ indentation\ (mm^2)} = \frac{1}{g_n} \times \frac{F}{cd^2}$ For the nominal indenter constant c ≈ 0.07028 Knoop hardness = $1.451 \times \frac{F}{d^2}$

- Nomenclature

Hardness values are designation as follows: e.g. 640 HK 0.1/20

640	Knoop hardness value
HK	Hardness Symbol
0.1	Approximate kgf equivalent value of applied test force
20	Duration of test force (20 s) if not within the specified range (10 s to 15s)

- TEST PIECE

• The test shall be carried out on a polished surface, which is smooth and even, free from oxide scale and foreign matter and, in particular, 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.

• The thickness of the test piece, or of the layer under test, shall be at least 1/3 times the length of the diagonal length of the indentation. No deformation shall be visible at the back of the test piece after the test.

- PROCEDURE

• If the test is carried out at a temperature outside 10 °C to 35 °C range, it shall be noted in the test report. Test carried out under controlled conditions shall be made at a temperature of (23 ± 5) °C.

• Periodic verification shall be done for each test force used.

• The indenter shall be brought into contact with the test surface and the test force shall be applied in a direction perpendicular to the surface, without shock, vibration, or overload, 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 be 7^{+1}_{-5} s.
• The indenter shall contact the test piece at a velocity of ≤ 0.070 mm/s

• The duration of the test force shall be $14^{+1}_{-4}\ s$, except for tests on materials whose time-dependent properties would make this an unsuitable range.

• The length of the long diagonal shall be measured and used for the calculation of the knop hardness. For all tests, the perimeter of the indentation shall be clearly defined in the field of view of the microscope. Magnifications should be selected so that the diagonal can be enlarged to greater than 25 %, but less than 75 % of the maximum possible optical field of view.

Minimum distance for Knoop indentations

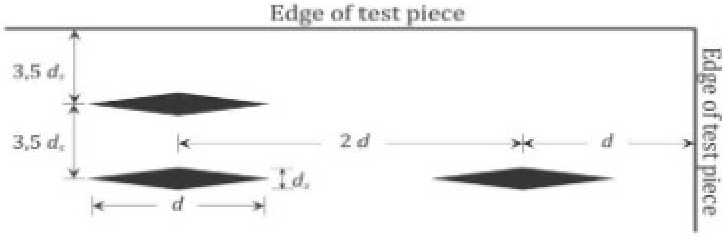


Fig. Minimum distance for Knoop indentations

- TEST REPORT

• The test report shall include the following information, unless otherwise agreed by the parties concerned:

b) All information necessary for identification of the test piece;

c) The date of the test;

d) The hardness result obtained in HK, reported in the format defined in clause 5.2 of the standard;

e) All operations not specified in this document, or regarded as optional;

f) The details of the temperature of the test, if it is outside the ambient range specified in 8.1;

h) Where conversion to another hardness scale is also performed, the basis and method of this conversion any circumstances that affected the results;

IS 1501 /ISO 6507- METALLIC MATERIALS — VICKERS HARDNESS TEST

This standard has four parts:

1. Part 1 Test method

Scope: This document specifies the Vickers hardness test method for the three different ranges of test force for metallic materials including hard metals and other cemented carbides.

2. Part 2 Verification and Calibration of Testing Machines

Scope: This document specifies the method of verification and calibration of testing machines for determining Knoop hardness for metallic materials in accordance with IS 6885 (Part 1) / ISO 4545-1. A direct method of verification and calibration is specified for the testing machine, indenter, and the diagonal length measuring system. An indirect verification method using reference blocks is specified for the overall checking of the machine.

3. Part 3 Calibration of reference blocks

Scope: This document specifies the method for the calibration of reference blocks to be used for the indirect verification of Knoop hardness testing machines as specified in IS 6885 (Part 2) / ISO 4545-2. The method is applicable only for indentations with long diagonals ≥0.020 mm

4. Part 4 Tables of Hardness Values

Scope: This document gives a table for the calculation of Knoop hardness values for use in tests carried out in accordance with IS 6885 (Part 1) / ISO 4545-1.

- 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.

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

• Geometry of indenter, the measured angles between the opposite faces at the vertex of the diamond pyramid shall be within the range 136° ± 0.5° (α = 136° ± 0.5°)

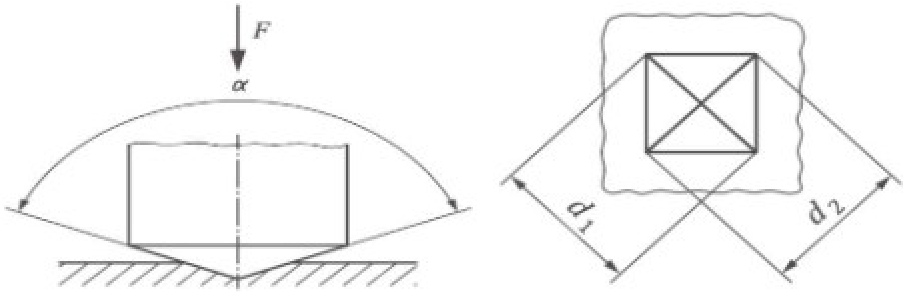


Fig. Principle of the test, geometry of indenter and Vickers indentation

- Nomenclature

Hardness values are designation as follows: 640 HV 30/20

640	Vickers hardness value
HV	Hardness Symbol
30	Approximate kgf equivalent value of applied test force where (30 kgf=294.2 N)
20	Duration of test force (20 s) if not within the specified range (10s to 15s)

- TEST PIECE

• 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 as defined in Annex A of the standard.

• No deformation shall be visible at the back of the test piece after the test. The thickness of a hard metal test piece shall be at least 1 mm.

- PROCEDURE

• If the test is carried out at a temperature outside 10°C 35°C range, it shall be noted in the test report. Test carried out under controlled condition shall be made at a temperature of (23 ± 5) °C.

• Periodic verification shall be done for each test force used.

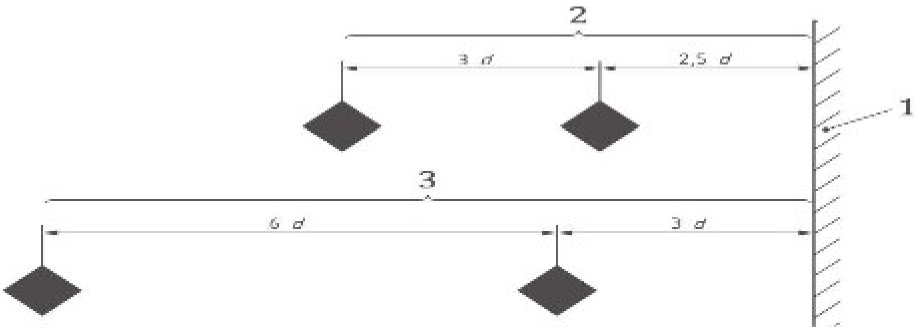
• The indenter shall be brought into contact with the test surface and the test force shall be applied in a direction perpendicular to the surface, without shock, vibration or overload until the applied force attains the specified value. The time from the initial application of the force until the full test force is reached shall be 7^{+1}_{-5} s

• For the Vickers hardness range and low-force Vickers hardness range and low-force Vickers hardness range tests, the indenter shall contact the test piece at a velocity of ≤ 0.2 mm/s. For micro-hardness tests, the indenter shall contact the test piece at a velocity of ≤ 0.070 mm/s

• The duration of the test force shall be 14^{+1}_{-4},, except for test on materials whose time-dependent properties would make this an unsuitable range.

• The length of the long diamond shall be measured and used of the calculation of the Knoop hardness. For all tests, the perimeter of the indentation shall be clearly defined in the field of view of the microscope. Magnification should be selected so that the diagonal can be enlarged to greater that 25%, but less than 75% of the maximum possible optical field of view.

Minimum distance between adjacent indentations:



Key

1 Edge of test piece
2 Steel, copper and copper alloys
3 Light metals, lead and tin and their alloys

Fig. Minimum distance for Vickers indentations

Measurement of the diagonal length

• The lengths of the two diagonals shall be measured. The arithmetical mean of the two readings shall be taken for the calculation of the Vickers hardness. For all tests, the perimeter of the indentation shall be clearly defined in the field of view of the microscope.

$$d = \frac{d_1 + d_2}{2}$$

• Magnifications should be selected so that the diagonal can be enlarged to greater than 25%, but less than 75% of the maximum possible optical field of view.

- TEST REPORT

The test report shall include the following information unless otherwise agreed by the parties concerned:

a) A reference to this document, i.e., ISO 6507-1;

b) All information necessary for identification of the test piece;

c) The date of the test;

d) The hardness result obtained in HV, reported in the format defined in clause 5.2 of the standard;

e) All operations not specified in this document or regarded as optional;

f) Details of any circumstances that affected the results;

g) The temperature of the test, if it is outside the ambient range specified in clause 8.1 of the standard;

h) Where conversion to another hardness scale is also performed, the basis and method of this conversion.

Fig. Real Life Image of Vickers Hardness Indenter

IS 1757 /ISO 148 METALLIC MATERIALS — CHARPY PENDULUM IMPACT TEST

This standard has three parts:

1. Part 1 Test method

Scope: This part of IS 1757 / ISO 148 specifies the Charpy (V-notch and U-notch) pendulum impact test method for determining the energy absorbed in an impact test of metallic materials.

2. Part 2 Verification of Testing Machines

Scope: This part of IS 1757 / ISO 148 covers the verification of pendulum-type impact testing machines, in terms of their constructional elements, their overall performance and the accuracy of the results they produce. It is applicable to machines with 2 mm or 8 mm strikers used for pendulum impact tests carried out, for instance, in accordance with IS 1757 (Part 1) / ISO 148-1.

3. Part 3 Preparation and characterization of Charpy V-notch test pieces for indirect verification of pendulum impact machines

Scope: This part of IS 1757 / ISO 148 specifies the requirements, preparation and methods for qualifying test pieces used for the indirect verification of pendulum impact testing machines in accordance with IS 1757 (Part 2) / ISO 148-2.

It specifies notched test pieces with nominal dimensions identical to those specified in IS 1757 (Part 1) / ISO 148-1; however, the tolerances are more stringent.

- PRINCIPLE OF TEST

• This test consists of breaking a notched test piece with a single blow from a swinging pendulum, under the conditions defined in Clauses 6, 7 and 8 of the standard.

• The notch in the test piece has a specified geometry and is located in the middle between two supports, opposite to the location which is impacted in the test. The energy absorbed in the impact test, the lateral expansion and the shear fracture appearance are normally determined.

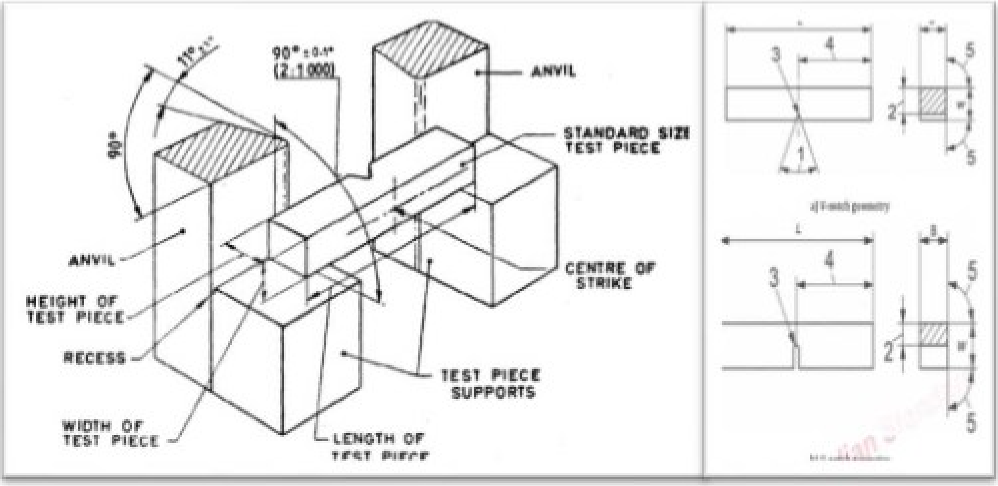


Fig. Test piece terminology showing configuration of test piece supports and anvils of a pendulum impact testing machine

- TEST REPORT

❖ **Mandatory information**

The test report shall contain the following information or, when agreed by the customer, it shall be possible to retrieve this information based on a traceable coding of the test report by the test laboratory:

a) Reference to this part of ISO 148, i.e. ISO 148-1

b) Identification o f the test piece (e.g. type of steel and cast number)

c) Size of the test piece, if other than the standard test piece

d) Temperature of the test or the conditioning temperature of the test specimens

e) Absorbed energy, KV2, KV8, KU2, or KU8, as appropriate

f) Whether the specimen, or the majority of specimens in a group of specimens were broken (not required for material acceptance tests);

g) Any abnormalities that could have affected the test.

IS 1598 METHOD FOR IZOD IMPACT TEST OF METALS

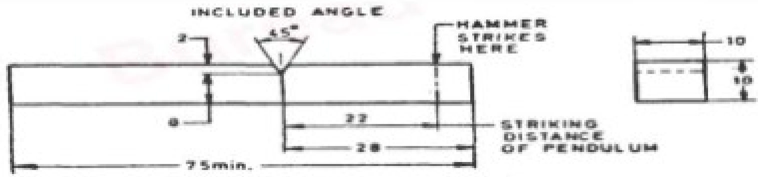
- SCOPE:

This standard prescribes the method of conducting Izod impact test on metals.

- PRINCIPLE OF TEST:

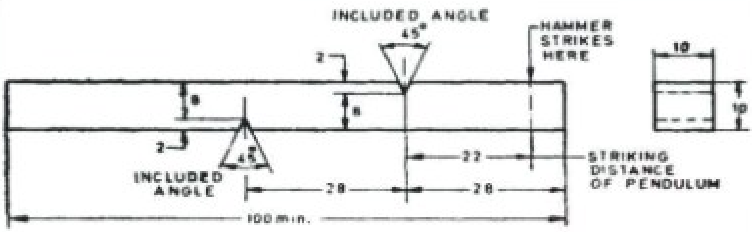
The test consists of breaking by one blow from a swinging hammer, under specified conditions, a notched test piece, gripped vertically with the bottom of the notch in the same plane as the upper face of the grips. the blow is struck at a fixed position on the face having the notch. The energy absorbed is determined.

- TEST PIECE



All dimensions in millimetres.

FIG. 1 SINGLE-NOTCH SQUARE TEST PIECE



All dimensions in millimetres.

FIG. 3 TWO-NOTCH SQUARE TEST PIECE

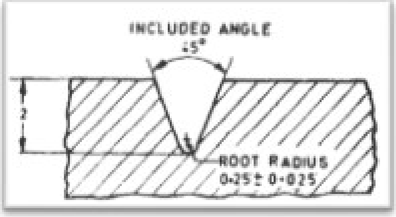
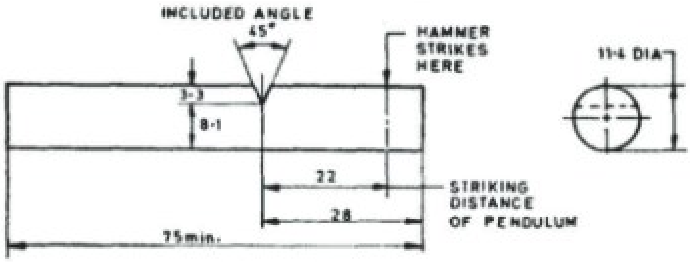


Fig. Enlarged view of notch for square test piece



All dimensions in millimetres.

FIG. 5 SINGLE-NOTCH ROUND TEST PIECE

- Testing Requirements

• The longitudinal axis of the test piece shall lie in the plane of swing of the centre of gravity of the hammer.

• The notch shall be positioned so that its plane of symmetry coincides with the top face of the grips.

• The notch shall be .at right angles to the plane of swing of the centre of gravity of the hammer. This is ensured by form of the test pieces and method of grip. The test piece shall be gripped tightly in the anvil grips.

• During testing of the two- and three-notch test pieces the material remaining for testing after each test shall be examined to ensure that the correct length of test piece is available above the next notch and any undesirable deformed metal shall be removed to ensure that the form and length of the test piece are correct before further testing.

• Unless otherwise stated in the relevant material specification, an impact test shall consist of three specimens taken from a single test coupon or test location, the average value of which shall comply with the specified minimum, but in no case below either two-thirds of the specified minimum or 7 Joules whichever is greater. If more than one value is below the specified minimum, or if one value is below the greater of 7 joules or two-thirds of the specified minimum, a retest of three additional specimens shall be made, each of which should have a value equal to or exceeding the specified minimum.

IS 1599 / ISO 7438 - METALLIC MATERIALS - BEND TEST

- SCOPE:

• This Indian Standard specifies a method for determining the ability of metallic materials to undergo plastic deformation in bending.

• This standard applies to test pieces taken from metallic products, as specified in the relevant product standard. It is not applicable to certain materials or products, for example tubes in full section or welded joints, for which other standards exist.

- PRINCIPLE

• The bend test consists of submitting a test piece of round, square, rectangular or polygonal cross-section to plastic deformation by bending, without changing the direction of loading, until a specified angle of bend is reached.

• The axes of two legs of the test piece remain in a plane perpendicular to the axis of bending. In the case of a 180° bend, the two lateral surfaces may, depending on the requirements of the product standard, lie flat against each other or may be parallel at a specified distance, an insert being used to control this distance.

- Test Equipment:

• Bending device with two supports and a former (Figure 1)

• Bending device with a V-block and a former (Figure 2)

• Bending device with a clamp (Figure 3)

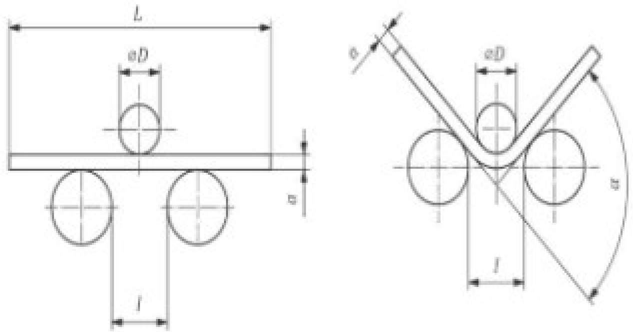


Figure 1 — Bending device with two supports and a former

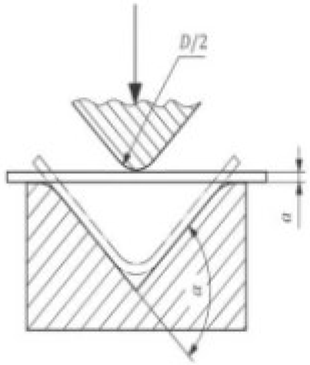
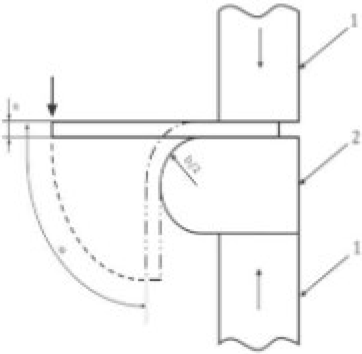


Figure 2 — Bending device with a V-block and a former



Key
1 clamp
2 former

Figure 1 — Bending device with a clamp

- TEST PIECE

1. General: Round, square, rectangular, or polygonal cross-section test pieces shall be used in the test. Any areas of the material affected by shearing or flame cutting and similar operations during sampling of test pieces shall be removed.

2. Edges of rectangular test pieces: The edges of rectangular test pieces shall be rounded to a radius not exceeding the following values:

    i. 3 mm, when the thickness of the test pieces is 50 mm or greater.

    ii. 1.5 mm, when the thickness of the test pieces is less than 50 mm and more than or equal to 10 mm (inclusive).

    iii. 1 mm when the thickness is less than 10 mm.

3. Width of the test piece:

a) The same as the product width, if the latter is equal to or less than 20 mm;

b) When the width of a product is more than 20 mm:

    i. (20 ± 5) mm for products of thickness less than 3 mm.

    ii. between 20 mm and 50 mm for products of thickness equal to or greater than 3 mm.

4. Thickness of the test piece: equal to the thickness of the product to be tested.

5. Length of the test piece: The length of the test piece depends on the thickness of the test piece and the test equipment used.

- PROCEDURE

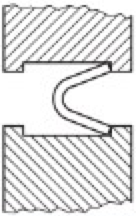


Fig. Bending the legs of the test piece

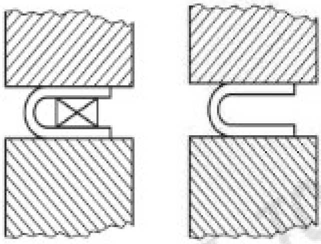


Fig. legs of the test piece parallel to each other

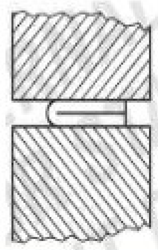


Fig. Legs of the test piece in direct contact

- TEST REPORT

The test report shall include the following information:

a) A reference to this Standard, i.e. IS1599/ISO 7438
b) Identification of the test piece (type of material, cast number, direction of the test piece axis relative to a product, etc.
c) Shape and dimensions of the test piece
d) Test method
e) Any deviation from this International Standard
f) Test result

IS 5075/ ISO 1143 Metallic materials — Rotating bar bending fatigue testing

- Scope

This document specifies the method for rotating bar bending fatigue testing of metallic materials. The tests are conducted at room temperature or elevated temperature in air, the specimen being rotated. Fatigue tests on notched specimens are not covered by this document, since the shape and size of notched specimens have not been standardized. However, fatigue test procedures described in this document can be applied to fatigue tests of notched specimens.

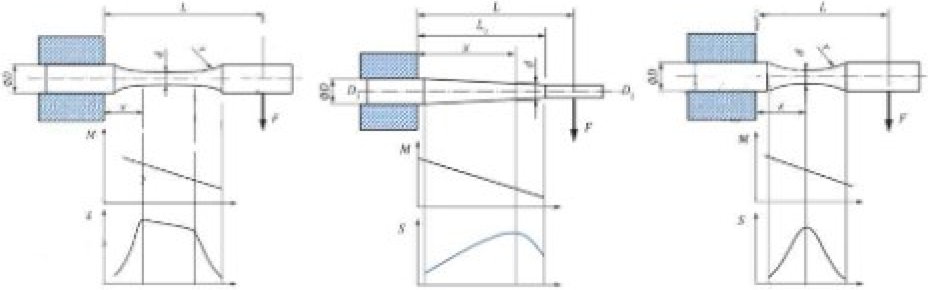
- Principle of test

Nominally identical specimens are used, each being rotated and subjected to a constant bending moment. The forces giving rise to the bending moment do not rotate. The specimen may be mounted as a cantilever, with single-point or two-point loading, or as a beam, with four-point loading. The test is continued until the specimen fails or until a pre-determined number of stress cycles have been achieved, a stress cycle corresponds to a complete rotation of the specimen.

Shape and size of specimen

Forms of the test section: the test section may be

Cylindrical with tangentially blending fillets at one or both ends, tapered or hourglass-type



(a) Cylindrical type (b) Tapered type (c) hourglass-type

Symbol	Description	Symbol	Description
D	Diameter of gripped or loaded end of specimen	r	Radius at ends of test section that starts transition from test diameter d
d	Diameter of specimen where stress is maximum	F	Applied force
M	Bending Moment	x	Distance along specimen axis from fixed bearing face to maximum stress plane
S	Stress	r	Radius at ends of test section that starts transition from test diameter d

A ratio of at least 2:1 between the cross-sectional areas of the gripping regions and the test portion of the specimen is recommended. The recommended values of 'd' are 6 mm, 7.5 mm and 9.5 mm

- Test procedure

Mounting the specimen: Each specimen shall be mounted in the test machine such that stresses at the test section (other than those imposed by the applied force) are avoided.

Application of force: The specific formula to calculate the force or the mass in bending conditions for a given stress is generally given in the user manual of the rotating bar bending machine.

Frequency selection: Tests are normally performed at a frequency between 15 Hz to 200 Hz. The frequency chosen shall be suitable for the particular combination of material, specimen and test machine.

End of test: The test is continued until specimen failure or until it has reached the required number of cycles (e.g. 107 or 108). Where the failure location is outside the specimen gauge length, the test result is considered invalid.

- Test report

The fatigue test report shall include the mandatory items that are listed below:

a) material tested and its metallurgical characteristics — reference can usually be made to the appropriate specifications to which the material was produced;

b) method of stressing and the type of machine used;

c) type, dimensions and surface condition of the specimen and the points of load application;

d) frequency of the stress cycles;

e) test temperatures and the temperature of the specimen if self-heating occurs (i.e. greater than 35 °C);

f) daily maximum and minimum values of air temperature and relative humidity;

g) criterion for the end of the test, i.e. its duration (e.g. 106, 107, 108 cycles), or complete failure of the specimen, or some other criterion;

h) any deviations from the required conditions during the test;

i) Test result

IS 10175 / ISO 20482 Metallic Materials — Sheet and Strip — Erichsen Cupping Test

- SCOPE:

This Standard specifies a standard test method for determining the ability of metallic sheets and strips having a thickness from 0.1 mm up to 2 mm and a width of 90 mm or greater to undergo plastic deformation in stretch forming.

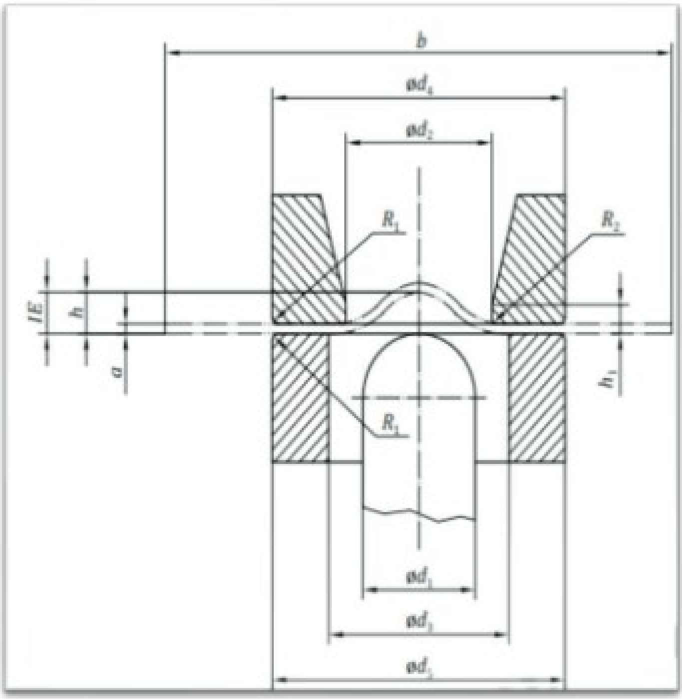


Fig. 1 — Schematic representation — Erichsen cupping index

- PRINCIPLE

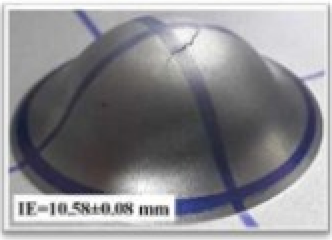
Forming an indentation by pressing a punch with a spherical end against a clamped test piece between a blank holder and a die until a through crack appears. The measured depth of the indentation is the result of the test based on the movement of the punch.

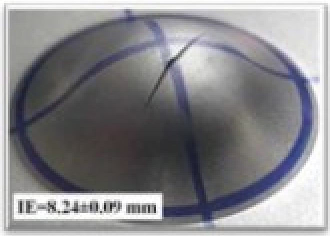
- TESTING EQUIPMENT

The construction of the machine shall be such that it is possible to observe the outside of the test piece during the test in order to be able to determine the instant when a through crack appears. In general, the commencement of rupture is accompanied by a drop in the force sustained by the test piece and sometimes by perceptible noise.

- TEST PIECE

The test piece shall be flat and of such dimensions that, for b > 90 mm, the centre of any indentation is not less than 45 mm from any edge of the test piece, and not less than 90 mm from the centre of the adjacent indentation. For narrow test pieces the centres of the indentations shall be in the centre of the test piece width and at least one strip width from the centre of an adjacent indentation.





- TEST REPORT

The test report shall include at least the following information:

a) a reference to this International Standard, i.e. ISO 20482;

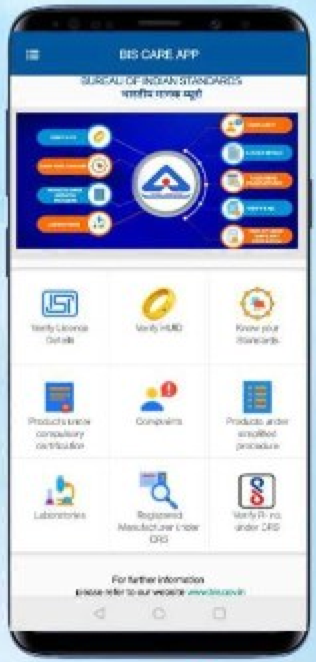
b) identity of the test piece (test piece orientation);

c) thickness of the test piece;

d) type of lubricant used;

e) appearance of test piece after rupture, if required;

f) value of the Erichsen cupping index, IE, single values if required.



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