INDIAN STANDARDS ON POWDER METALLURGY

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


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BUREAU OF INDIAN STANDARDS

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.

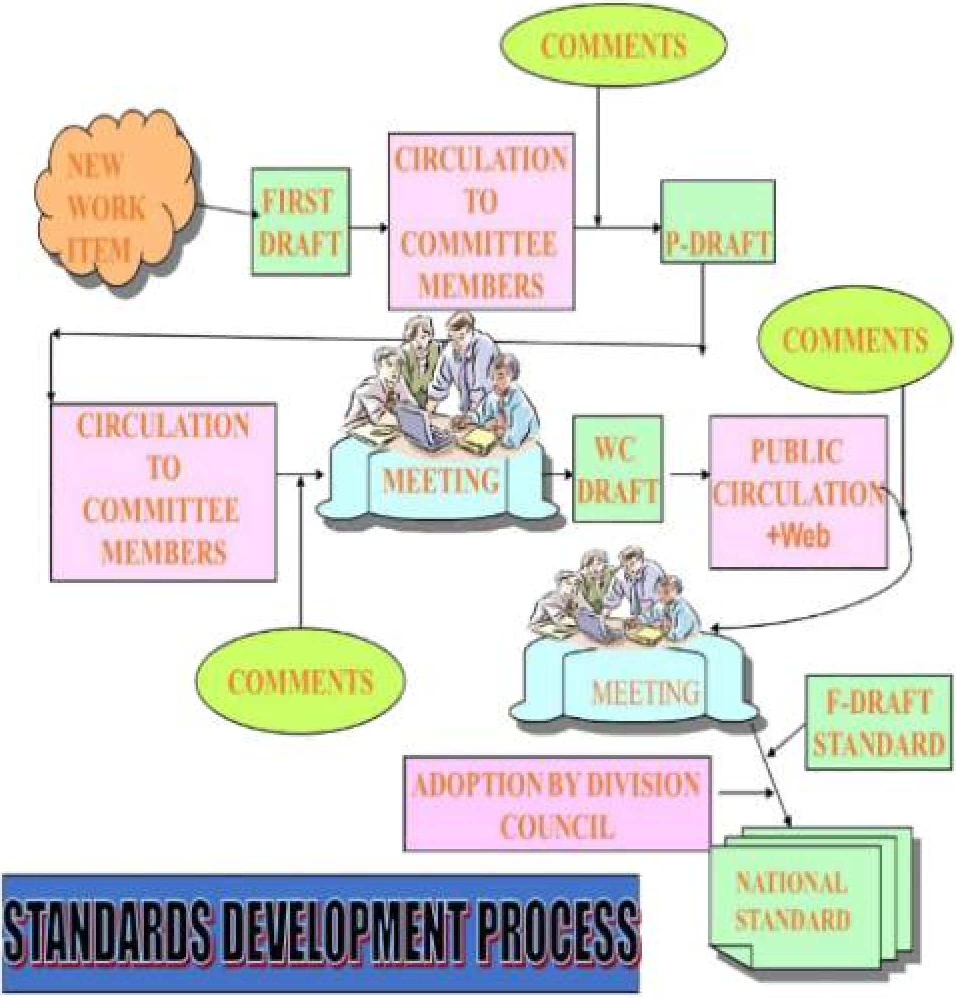
BIS also represents India in international standards bodies like International Organization for Standardization (ISO) and via the Indian National Committee in the International Electrotechnical Commission (IEC) and participates actively in the international standardization work undertaken in these bodies. 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

MTD 25: POWDER METALLURGICAL MATERIALS AND PRODUCTS SECTIONAL COMMITTEE

Scope: Standardization in the field of powder metallurgical materials

Liaison: ISO TC-119 (P): Powder Metallurgy ISO TC-119 SC-2 (O): Sampling and testing methods for powders (including powders for hardmetals) ISO TC-119 SC-3 (O): Sampling and testing methods for sintered metal materials (excluding hardmetals) ISO TC-119 SC-4 (O): Sampling and testing methods for hardmetals.

Total number of standards formulated by MTD 25 (Upto Oct 2022) : 63

Break up based on Aspect of standards:	Method of Test s	: 48
	Product Standards	: 13
	Code of Practice	: 1
	Terminology Standard	: 1

Standard on Terminology

Sl. No.	IS No. & Year	Title
1.	IS 5432 : 2022 ISO 3252 : 2019	Powder Metallurgy-Vocabulary

Code of Practice

Sl. No.	IS No. & Year	Title
1.	IS 11520 : 1985	Method for metallographic sample preparation of hardmetals

Products Standards

Sl. No.	IS No. & Year	Title
1.	IS 7505 : 1985	Specification for cobalt powder for hardmetals First Revision
2.	IS 7506 : 1987	Specification for nickel powder First Revision
3.	IS 7970 : 1987	Specification for tantalum powder for capacitors First Revision
4.	IS 8367 : 1993	Tin powder - Specification First Revision
5.	IS 8368 : 2010	Tungsten carbide powder for hardmetals - Specification Second Revision
6.	IS 8369 : 2010	Titanium carbide powder for hardmetals - Specification Second Revision

7.	IS 8370 : 2018	Iron powder for powder metallurgical applications First Revision
8.	IS 8392 : 1985	Specification for tungsten powder for hardmetals First Revision
9.	IS 8485 : 2018	Copper powder for powder metallurgical applications First Revision
10.	IS 10035 : 1993	Bronze powder for metallic filters - Specification First Revision
11.	IS 11110 : 1984	Specification for copper - Lead powder
12.	IS 11111 : 1984	Specification for leaded bronze powders
13.	IS 15585 : 2018/ ISO 5755 : 2012	Sintered metal materials - Specifications First Revision

Method of Tests

Sl. No.	IS No. & Year	Title
1	IS/ISO 4507 : 2000	Sintered ferrous materials carburized or carbonitrided - Determination and verification of case - Hardening depth by a micro - Hardness test
2	IS 4840 : 2022/ ISO 4490:2018	Metallic powders Determination of flow rate by means of a calibrated funnel Hall flowmeter
3	IS 4841 : 2022 / ISO 3369:2006	Impermeable sintered metal materials and hardmetals Determination of density
4	IS 4842 : 2018/ ISO 3327: 2009	Hardmetals - Determination of transverse ruputre strength Second Revision
5	IS 4848 : 2022/ ISO 3923-1: 2018	Metallic powders Determination of apparent density Funnel method
6	IS 4857 : 2020/ ISO 3927 : 2017	Metallic Powders Excluding Powders for Hardmetals Determination of Compressibility in Uniaxial Compression Fifth Revision
7	IS 5461 : 1984/ ISO 4497	Method for sieve analysis of metal powders First Revision
8	IS 5642 : 2014/ ISO 2738: 1999	Sintered metal materials excluding hardmetals - Permeable sintered metal materials - Determination of density oil content and open porosity Third Revision
9	IS 5644 (Part 1) : 1993/ ISO 4491-1:1989	Metallic powders - Determination of oxygen content by reduction methods Part 1 general guidelines Third Revision
10	IS 5644 (Part 2) : 2005/ ISO 4491-2:1997	Metallic powders - Determination of oxygen content by reduction methods Part 2 loss of mass on hydrogen reduction Hydrogen Loss Fourth Revision

11	IS 5644 (Part 3) : 2005/ ISO 4491-3:1997	Metallic powders - Determination of oxygen content by reduction methods Part 3 hydrogen - Reducible oxygen Fourth Revision
12	IS 5644 (Part 4) : 2018/ ISO 4491-4 : 2013	Metallic powders - Determination of oxygen content by reduction methods Part 4 total oxygen by reduction - Extraction Fourth Revision
13	IS 5652 (Part 1) : 1993/ ISO 3738-1:1982	Hardmetals - Rockwell hardness test Scale A Part 1 test method Second Revision
14	IS 6492 : 2020/ ISO 3954 : 2007	Powders for Powder Metallurgical Purposes Sampling First Revision
15	IS 7438 : 2022/ ISO 4496:2017	Metallic powders Determination of acid-insoluble content in iron copper tin and bronze powders
16	IS 7512 : 2006/ ISO 10070	Method for the determination of average particle size of metal powders by fisher sub-sieve sizer First Revision
17	IS 8871 : 2018/ ISO 3953:1993	Metallic powders - Determination of tap density Third Revision
18	IS 8876 : 1978	Method for determination of residue on chlorination of tungsten metal powder
19	IS 10385 : 2019/ ISO 2739 : 2012	Sintered metal bushings - Determination of radial crushing strength First Revision
20	IS 11506 : 2019/ ISO 13944 : 2012	Lubricated metal-powder mixes - Determination of lubricant content - Modified Soxhlet extraction method
21	IS 11518 : 1985/ ISO 3326	Method for determination of The Magnetization coercivity in hardmetals
22	IS 11627 : 1986/ ISO 3923-2	Method for determination of apparent density of metallic powders by scott volumeter
23	IS 11959 : 1987	Method for metallographic determination of microstructure in hardmetals
24	IS 11960 : 1987/ ISO 4499	Method for metallographic determination of apparent porosity and uncombined carbon in hard metals
25	IS 12279 : 2005/ ISO 3325:1996	Sintered metal materials excluding hardmetals - Determination of transverse rupture strength First Revision
26	IS 12286 : 1988/ ISO 28080:2011	Method for determination of abrasive wear resistance of hardmetals
27	IS 12473 (Part 1) : 1988/ ISO 7627-1	Chemical analysis of hardmetals by flame atomic absorption spectrometry Part 1 general requirements
28	IS 12473 (Part 2) : 1988/ ISO 7627-2	Chemical Analysis of Hardmetals by Flame Atomic Absorption Spectrometry - Part 2 Determination of Calcium Potassium Magnesium and Sodium in Contents from 0
29	IS 12473 (Part 3) : 1988/ ISO 7627-3	Chemical analysis of hardmetals by flame atomic absorption spectrometry Part 3 determination of cobalt iron manganese and nickel in contents from 0 01 to 0 5 percent M m
30	IS 12473 (Part 4) : 1988/ ISO 7627-4	Chemical analysis of hardmetals by flame atomic absorption spectrometry Part 4 determination of molybdenum titanium and vanadium in contents from 0 01 to 0 5 percent M m

31	IS 12473 (Part 5) : 1988/ ISO 7627-5	Chemical analysis of hardmetals by flame atomic absorption spectrometry Part 5 determination of cobalt iron manganese molybdenum nickel titanium and vanadium in contents from 0 5 to 2 percent M m
32	IS 12473 (Part 6) : 1988/ ISO 7627-6	Chemical analysis of hardmetals by flame atomic absorption spectrometry Part 6 determination of chromium in contents from 0 01 to 2 percent M m
33	IS 12483 : 1988/ ISO 4501	Determination of titanium in hardmetals by spectrophotometric method
34	IS 12513 : 1988/ ISO 3909	Determination of cobalt in hardmetals by potentiometric method
35	IS 12539 : 2022/ ISO 3907:2009	Hardmetals Determination of total carbon Gravimetric method
36	IS 12548 : 2022/ ISO 3908:2009	Hardmetals Determination of insoluble free carbon Gravimetric method
37	IS 12570 : 2022/ ISO 4492:2017	Metallic powders excluding powders for hardmetals Determination of dimensional changes associated with compacting and sintering
38	IS 12571 : 1988/ ISO 3995	Method for determination of green strength by transverse rupture of rectangular compacts of metallic powder
39	IS 12783 : 1989	Hardmetals - Vickers hardness test
40	IS 13780 : 2020/ 4506 : 2018	Hardmetals Compression Test First Revision
41	IS 13781 : 1993/ ISO 4003:1977	Permeable sintered metal materials - Determination of bubble test pore size
42	IS 13782 : 1993/ ISO 4022:1987	Permeable sintered metal materials - Determination of fluid perme ability
43	IS 13803 : 1993/ ISO 3312:1987	Sintered metal materials and hardmetals - Determination of young modulus
44	IS 15554 : 2018/ ISO 2740:1999	Sintered metal materials excluding hardmetals - Tensile test pieces First Revision
45	IS 15567 : 2020/ ISO 3928 : 2016	Sintered Metal Materials Excluding Hardmetals Fatigue Test Pieces First Revision
46	IS 15574 : 2022/ ISO 5754:2017	Sintered metal materials excluding hardmetals Unnotched impact test piece
47	IS 15703 : 2018/ ISO 4498:2005	Sintered metal materials excluding hardmetals - Determination of apparent hardness and microhardness First Revision
48	IS 17074 : 2019/ ISO 13517	Metallic powders - Determination of flow rate by means of a calibrated funnel Gustavsson Flowmeter

Terminology Standard

IS 5432: 2022 / ISO 3252: 2019

Powder Metallurgy-Vocabulary

Scope	This standard is an adoption of international ISO standard and the document defines terms relating to powder metallurgy. Powder metallurgy is the branch of metallurgy which relates to the manufacture of metallic powders, or of articles made from such powders with or without the addition of non-metallic powders, by the application of forming and sintering processes.
Terminology	The standard defines terms classified alphabetically under the following main headings: — powders;- 88 terms are defined — forming;- 94 terms are defined — sintering and characteristics of sintered materials;- 74 terms — post-sintering treatments;- 16 terms Examples of some of the defined terms — powder metallurgy materials. 1. **Alloyed Powder** - metal powder consisting of at least two constituents that are partially or completely alloyed with each other. 2. **Angle of Repose** - basal angle of a pile formed by a powder when freely poured under specified conditions on to a horizontal surface. 3. **Apparent Density** - mass per unit volume of a powder obtained following specific methods. Note 1 to entry: For example, ISO 3923-1 related to free-flowing powders and ISO 3923-2 related to non-free-flowing powders.

Code of Practice

IS 11520: 1985
Method for metallographic sample preparation of hardmetals

Scope	This standard prescribes a method for preparing hardmetal samples for metallographic examination.
Main clauses of standard	The standard has clauses on selection and preparation of sample **Selection of specimen** Hardmetals are very often in the form of relatively small pieces; it is possible to select and mount the entire piece in such a manner as to permit examination of the entire cross section. When pieces are too large for this, however, they should be sectioned, using a diamond cut off wheel, to allow viewing as much of a representative cross section as possible. For micrograph the area selected should represent, as nearlyas possible, the entire cross section. **Preparation of Specimen** **1. Mounting** —where possible, specimens should be mounted in a plastic material such as phenol-formaldehyde or poly-methyl methacrylate to facilitate polishing without rounding the edges. Large specimens may be polished without mounting. When specimens are too large they may be sectioned using a diamond cut-off wheel or they may be fractured (appropriate safety precautions should be taken while fracturing specimens). The area selected for examination should represent, as nearly as possible, the entire cross section. **2. Rough Grinding** — the surface to be examined may be ground flat on a surface grinder with a resin-bonded diamond wheel (100 to 220 grit) operated at 25 to 28 m/s. After the surface is flat, several clean-up passes are required; the maximum depth of cut is 13 µm per pass and cupious amounts of coolant are used. **3. Polishing** — Polishing is done in three steps using diamond powder or paste on a synthetic short-napped cloth (the reverse side of photographic paper). When automatic polishing equipment is used, a resin-bonded diamond disk may be substituted in the roughing lap. For manual polishing, speeds of 500 to 600 rpm are used, automatic polishing generally requires speeds of 100 to 200 rpm.

Product Standards

IS 7505: 1985 -Specification for cobalt powder for hardmetals

Scope	This standard covers the requirements of cobalt powder used in the manufacture of hard metals.
Requirements	1. **Manufacturing:** cobalt powder shall be manufactured by hydrogen reduction process. 2. **Chemical composition:** Cobalt content shall have a minimum of 98.7%. 3. **Particle size:** shall be within 1 to 3 µm.
Testing	1. **Chemical analysis:** The methods of chemical analysis shall be as agreed to between the purchaser and the manufacturer. 2. **Particle Size:** The average particle size shall be determined in accordance with IS 7512: 1974. 3. **Sampling**: The sampling of powders for conducting all the tests shall be done in accordance with IS 6492: 1972.

IS 7506: 1987-Specification for nickel powder

Scope	This standard specifies the requirements of nickel powder used for the manufacture of heavy alloys and hard metals.
Requirements	1. **Manufacturing:** As agreed between manufacturer and purchaser. 2. **Chemical composition:** Nickel powder shall have a minimum of 99. min. 3. **Particle Size: :** shall be within 2 to 7 µm.
Testing	1. **Chemical analysis:** The methods of chemical analysis shall be as agreed to between the purchaser and the manufacturer. 2. **Particle Size** - The average particle size shall be determined in accordance with IS 7512: 1974. 3. **Sampling** - The sampling of powder for conducting chemical analysis and particle size determination shall be in accordance with IS 6492: 1972

IS 7970: 1987-Specification for tantalum powder for capacitors

Scope	This standard specifies the requirements of tantalum powder used in the manufacture of capacitors.
Requirements	1. **Manufacturing:** As agreed between manufacturer and purchaser. 2. **Chemical composition:** a. Grade 1: Powder (Sodium Reduced) meant for high capacitance devices at low voltage (< 25 V) b. Grade 2: Powder (Electron beam refined, Hydride-Dehydride) meant for high reliability capacitance ratings (25 – 125 V). 3. **Particle Size:** Avg. particle size: a. Grade 1 (2.5 to 3.5 µm) b. Grade 2 (5.5 to 8.5 µm)
Testing	1. **Chemical analysis:** The methods of chemical analysis shall be as agreed to between the purchaser and the manufacturer. 2. **Particle Size** - The average particle size shall be determined in accordance with IS 7512: 1974. 3. **Sampling** - The sampling of powder for conducting chemical analysis and particle size determination shall be in accordance with IS 6492: 1972

IS 8367: 1993-Tin powder - Specification

Scope	This standard covers the requirements for granular tin powders for powder metallurgical applications.
Requirements	1. **Manufacturing:** Tin powder may be manufactured from ingots conforming to IS 26:1992 'Tin ingot-specifications'. 2. **Chemical composition:** Tin powder shall have a minimum 99.0 percent. 3. **Particle size:** There shall be three grades and maximum particle size for each grade when determined in accordance with IS 5461 : 1984 shall be as follows: a. Grade A – 180 micron b. Grade B – 125 micron c. Grade C – 90 micron
Physical Properties	1. **Apparent Density**: • The apparent density for all the grades of powder shall be at least 2.7g/cm³ but not more than 4.2 g/cm³.

	• The apparent density shall be determined in accordance with IS 4848:1981 or IS 10441:1991. **2. Flow Rate:** • The flow rate shall be as agreed to between the purchaser and the manufacturer. • The flow rate shall be determined in accordance with IS 4840:1984.
Testing	**1. Chemical analysis:** The chemical analysis of tin powder shall be carried out by the methods specified in IS 1940:1969. **2. Sampling:** The sampling of powder for conducting various tests shall be done in accordance with IS 6492:1972.

IS 8368:2010 Tungsten carbide powder for hardmetals - Specification

Scope	This standard specifies the requirements of tungsten carbide powder used for the manufacture of hard metals.
Requirements	**1. Manufacturing:** As agreed between manufacturer and purchaser. **2. Chemical composition:** Tungsten carbide powder shall have a carbon content 6.1% min., all other elemental content 1% max. and Tungsten is reminder. **3. Particle Size:** The particle size shall be as agreed to between the purchaser and the manufacturer.
Testing	**1. Chemical analysis:** The chemical composition of tungsten carbide powder shall be done by the method specified in IS 12473 (Parts 1 to 6), IS 12539 and IS 12548 or any other established instrument/chemical method as agreed to between the purchaser and the manufacturer. **2. Particle Size:** The average particle size of tungsten carbide powder shall be determined in accordance with IS 7512. **3. Sampling**: The sampling of powder for conducting chemical analysis and particle size determination shall be done in accordance with IS 6492.

IS 8369 : 2010-Titanium carbide powder for hardmetals - Specification

Scope	This standard specifies the requirements of titanium carbide powder used for the manufacture of hard metals.
Requirements	1. **Manufacturing:** As agreed between manufacturer and purchaser. 2. **Chemical composition:** Titanium carbide powder shall have a carbon content 19% min., oxygen 1% max., all other elemental content 1% max. and Titanium is reminder. 3. **Particle Size:** The particle size shall be as agreed to between the purchaser and the manufacturer.
Testing	1. **Chemical analysis:** The chemical composition of titanium carbide powder shall be done by the method specified in IS 12473 (Parts 1 to 6), IS 12539 and IS 12548 or any other established instrument/chemical method as agreed to between the purchaser and the manufacturer. 2. **Particle Size:** The average particle size of titanium carbide powder shall be determined in accordance with IS 7512. 3. **Sampling:** The sampling of powder for conducting chemical analysis and particle size determination shall be done in accordance with IS 6492.

IS 8370 : 2018-Iron powder for powder metallurgical applications

Scope	This standard covers the requirements for iron powder for use in the manufacture of sintered bearings and parts.
Requirements	1. **Manufacturing:** As agreed between manufacturer and purchaser. 2. **Chemical composition:** The material shall be of two grades, namely Grade 1 (acid insolubles 0.2% max.) and Grade 2(acid insolubles 0.2% max.). 3. **Particle Size:** The particle size between –45 and +150 microns the value shall be as agreed to between the purchaser and the manufacturer.

Physical Properties	1. **Apparent Density:** The apparent density of different grades of material when tested in accordance with IS 4848 shall be as given below: <table><tr><th>*Grade*</th><th>*Apparent Density* g/cm³</th></tr><tr><td>1</td><td>2.4 to 2.7</td></tr><tr><td>2</td><td>2.7 to 3.0</td></tr></table> 2. **Flow Rate:** The flow rate of Grades 1 and 2 material when determined in accordance with IS 4840 shall not be more than 32 s/50 g. 3. **Compressibility:** Unlubricated powder when pressed with a pressure of 400 N/mm^2 in accordance with IS 4857 shall a minimum 6.2 g/cm^3, green density.
Testing	1. **Chemical analysis:** The methods of chemical analysis shall be as agreed to between the purchaser and the manufacturer. 2. **Acid-Insoluble Content:** The acid insolubles shall be determined in accordance with IS 7438. 3. **Sampling:** The sampling of powders for conducting the various tests shall be done in accordance with IS 6492.

IS 8392 : 1985-Specification for tungsten powder for hardmetals

Scope	This standard covers the requirements of tungsten powder used for manufacturing hard metals.
Requirements	1. **Manufacturing:** The powder shall be manufactured by hydrogen reduction process. 2. **Chemical composition:** The material shall contain minimum tungsten content of 99.50%. 3. **Particle Size:** Avg. particle size shall be within 0.5 µm to 20 µm.
Testing	1. **Chemical analysis:** The method of chemical analysis shall be as agreed to between the purchaser and the manufacturer. 2. **Particle Size:** The average particle size shall be determined in accordance with IS 7512:1974.

	3. Sampling: The sampling of powders for conducting all the tests shall be done in accordance with IS 6492:1972.

IS 8485 : 2018-Copper powder for powder metallurgical applications

Scope	This standard covers the requirements for copper powder for use in the powder metallurgical application.
Requirements	**1. Manufacturing:** As agreed between manufacturer and purchaser. **2. Chemical composition:** Copper powder shall have a minimum copper 98.5, min percent.
Physical Properties	1. The apparent density of both the grades powder when tested in accordance with IS 4848 shall be between 2.5 and 3.0 g/cm³. Any apparent density requirement outside this range shall be specifically agreed to between the purchaser and the manufacturer. 2. **Flow Rate:** The flow rate of the powder shall tested in accordance with IS 4840. The time taken for 50g of the powder to flow through the orifice shall be as follows: a) For Grade 1 — less than 32 s b) For Grade 2 — less than 40 s **3. Compressibility:** Unlubricated powder when pressed with a pressure of 400 N/mm² in accordance with IS 4857 shall attain a green density of 7.2 g/cm³, *Min.*
Testing	1. **Chemical analysis:** The copper shall be determined as per the procedure given in Annex A. 2. **Sampling:** The sampling of powders for conducting the various tests shall be done in accordance with IS 6492.

IS 10035 : 1993-Bronze powder for metallic filters - Specification

Scope	This standard covers the requirements of bronze powder for use in the manufacture of metallic filters.

Requirements	1. **Manufacture**: Powder may be manufactured by atomization or any other process. 2. **Chemical composition:** Tin (9.5% - 11.5%), other elements 3% max. and copper reminder. 3. **Particle size:** Size distribution shall be mutually agreed upon between the purchaser and the manufacturer. The sieve analysis of the material shall be carried out in accordance with IS 5461: 1984.
Physical Properties and Testing	1. **Apparent Density-** The apparent density of the powder when determined in accordance with IS 4848:1981 or IS 10441:1991 shall be not less the 4.0 g/cm^3. 2. **Flow Rate** – Flow rate shall be as agreed to between the purchaser and the manufacturer. It shall be determined in accordance with IS 4840:1984. 3. **Particles Shape** – Particle shape shall be spherical or near spherical. a) **Sampling:** Sampling of powder for conducting various tests shall be done in accordance with 6492:1992. b) **The hydrogen loss:** shall be determined in accordance with IS 5644 (Part 2): 1993

IS 11110 : 1984-Specification for copper - Lead powder

Scope	This standard covers the requirements for copper-lead alloy powder for use in the manufacture of bimetallic bearings and bushes
Requirements	1. **Manufacture**: Powder may be manufactured by atomization or any other process. 2. **Chemical composition:** Lead powder shall have a maximum Lead 25 to 35 %, other elements 2% max., and Copper reminder.
Physical Properties	1. **Apparent Density -** The apparent density of the powder when tested in accordance with IS 4848:1981 shall be between 4.0 and 6.0 g/cm^8.

	2. **Flow Rate** - The flow rate of powder shall be tested in accordance with IS 4840:1984". The time taken for 50 g of the powder to flow through the orifice shall be less than 25 seconds.
Testing	1. **Sieve analysis:** The sieve analysis of material shall be as agreed to between the purchaser and the manufacturer. 2. **Sampling:** The sampling of powders for conducting in accordance with IS 6492:1972.
General Applications	Lead-Free Bronze Powders are used in the manufacture of steel-backed bearings (or bi-metal strip) for large engine bearings (automotive, agricultural vehicles, marine engines, etc.) where lead (Pb)- replacement is a necessity and where higher hardness/wear resistance may also be needed, depending upon the end-application.

IS 11111 : 1984-Specification for leaded bronze powders

Scope	This standard covers the requirements for leaded bronze alloy powder for use in the manufacture of bimetallic bearings and bushes.
Requirements	1. **Manufacture**: Powder may be manufactured by atomization or any other method. 2. **Chemical Composition**: Leaded bronze powder shall have a maximum lead (8 to 11%), Tin (9-11%), total other elements (1.5% max) and Copper reminder.
Physical Properties	1. **Apparent Density:** The apparent density of the powder when tested in accordance with IS 4848: 1981 shall be between 4.0 and 6.0 g/cm^8. 2. **Flow Rate**: The flow rate of powder shall be tested in accordance with IS 4840: 1984. The time taken for 50 g of the powder to flow through the orifice shall be less than 25 seconds.
Testing	1. **Sieve Analysis:** The sieve analysis of material shall be as agreed to between the purchaser and the manufacturer. 2. **The hydrogen loss:** shall be determined as per the procedure given in IS 5644: 1981 by reducing the sample at 600 ± 10°C for 10 minutes in a current of hydrogen. 3. **Sampling:** The sampling of powders for conducting various tests shall be done in accordance with IS 6492: 1972.

IS 15585 : 2018 / ISO 5755 : 2012-Sintered metal materials - Specifications

Scope	This International Standard specifies the requirements for the chemical composition and the mechanical and physical properties of sintered metal materials used for bearings and structural parts. When selecting powder metallurgical (PM) materials, it should be taken into account that the properties depend not only on the chemical composition and density, but also on the production methods. The properties of sintered materials giving satisfactory service in particular applications may not necessarily be the same as those of wrought or cast materials that might otherwise be used. Therefore, liaison with prospective suppliers is recommended.
Requirements	**1. Chemical Composition**: The chemical composition and mechanical properties are given in Tables 1 to 18. The liquid lubricant content of materials for bearings, impregnated with liquid lubricant, shall be not less than 90 % of the measured open porosity. **2.** Designations: Designations shall be in accordance with Annex A.
Testing	**1. Chemical analysis:** The chemical composition table for each material lists the principal elements by minimum and maximum mass percentage before any additional process, such as oil impregnation, resin impregnation or steam treatment, has taken place. "Other elements" may include minor amounts of elements added for specific purposes and is reported as a maximum percentage. **2. Tensile properties:** The ultimate tensile strength and the yield strength shall be determined in accordance with ISO 2740 and ISO 6892-1. **3. Radial crushing strength:** The radial crushing strength shall be determined in accordance with ISO 2739. The wall thicknesses of test pieces to be used shall be in the range covered by ISO 2795. **4.** Impact energy: The impact energy shall be determined in accordance with ISO 5754. **5.** Other tests

Method of Tests

IS/ISO 4507 : 2000 / ISO 4507:2000 - Sintered ferrous materials carburized or carbonitrided - Determination and verification of case - Hardening depth by a micro - Hardness test

Scope	This International Standard specifies methods for determining the case-hardening depth of carburized or carbonitrided sintered ferrous materials by micro-hardness measurement. The methods are adapted to materials having porosity and only apply to quenched materials.
Apparatus	**1.** Vickers or Knoop micro-hardness testing machine, capable of applying a predetermined load of 0.980 7 N(HV 0.1) to an accuracy of ±1 % **2.** Measuring instrument, capable of measuring the diagonals of the indentation to an accuracy of ± 0.5 pm
Procedure	**1.** Preparation of sample: The surface on which the measurement is to be made shall be polished to a smoothness sufficient to permit correct measurements of the micro-hardness indentation. Method A — Determination of case-hardening depth Method B — Inspection test for case-hardening depth
Test Report	**1.** All details necessary for identification of the test sample (with details of heat treatment, if necessary); **2.** the area of the part on which the tests were carried out; **3.** the method used (method A, method A modified or method B) and the specified value of hardness corresponding to case-hardening depth; **4.** the result obtained;

IS 4840 : 2022 / ISO 4490:2018-Metallic powders Determination of flow rate by means of a calibrated funnel Hall flowmeter

Scope	This document specifies a method for determining the flow rate of metallic powders, including powders for hard metals, by means of a calibrated funnel (Hall flowmeter). The method is applicable only to powders which flow freely through the specified test orifice.

Apparatus	1. **Calibrated funnel,** the dimensions of which are shown in Figure 1. The funnel shall be made of a non-magnetic, corrosion-resistant metallic material with sufficient wall thickness and hardness to withstand distortion and excessive wear. 2. **Balance of sufficient capacity**, capable of weighing the test portion to an accuracy of ±0.05 g. 3. **Timing device**, capable of measuring the elapsed time to an accuracy of ±0.1 s. 4. **Reference grit**, a reference powder1) used for calibration of the funnel, shall be used.
Sampling	1. **General -** In general, the powder shall be tested in the as-received condition. In certain cases, and after agreement between the supplier and user, the powder may be dried. However, if the powder is susceptible to oxidation, the drying shall take place in a vacuum or in inert gas. If the powder contains volatile substances, it shall not be dried. 2. **Test sample weight-** The mass of the test sample shall be at least 200 g. 3. **Test portion weight-** Immediately before the test, weigh out a 50 g ± 0,1 g test portion 4. **Number of test portions-** The determination shall be carried out on three test portions.
Procedure	1. Transfer the test portion to the funnel, keeping the discharge orifice properly closed, for example with a dry finger or a mechanical shutter. Take care that the stem of the funnel is filled with powder. 2. Start the timing device (5.4) when the orifice is opened and stop it at the instant when the last of the powder leaves the orifice. 3. Record the elapsed time measured to the nearest 0.1 s.

IS 4841 : 2022 / ISO 3369:2006-Impermeable sintered metal materials and hardmetals Determination of density

Scope	This Standard specifies a method of determining the density of impermeable sintered metal materials and hardmetals. NOTE: For the determination of density of permeable sintered metal materials, see ISO 2738:1999, Sintered metal materials, excluding hardmetals — Permeable sintered metal materials — Determination of density, oil content and open porosity.
Apparatus and materials	**1.** **Precision balance**, having a capacity which will permit readings within ± 0.1 mg, on weighings up to 10 g and ± 0.001 % above 10 g. The weights shall be calibrated and have a density of not less than 7 g/cm^3. **2.** **Arrangement of racks or a suspension wire,** according to Figures 1 and 2. In each case, the suspension wire shall have a maximum diameter of 0.25 mm. A heavier gauge wire shall only be used if this is necessary to support the test piece. **3.** **Vessel**, for the weighing liquid. For test pieces of volume less than 10 cm 3 the vessel shall be dimensioned so that, when the test piece is lowered into the liquid, the rise in liquid level is less than 2.5 mm **4.** **Distilled or deionized and preferably degassed water**, to which 1 or 2 drops of a wetting agent have been added.
Procedure	**1.** Place the test piece in the upper rack (Figure 1) or pan (Figure 2). The lower rack shall be completely immersed and the suspension wire shall be hanging freely from the pan and partially immersed in the liquid. Remove all air bubbles and weigh the test piece (m1). **2.** Place the test piece on the lower rack (Figure 1) or suspend it by means of the wire (Figure 2). Lower the test piece into the vessel containing the liquid so that only the suspension wire breaks the surface of the liquid. Remove all air bubbles and weigh. **3.** Weighings up to 10 g shall be read to 0.1 mg, and weighings above 10 g shall be read to 0.001 %.

IS 4842 : 2018 / ISO 3327 : 2009-Hardmetals - Determination of transverse rupture strength

Scope	This International Standard specifies a method for the determination of the transverse rupture strength of hardmetals. This method is applicable to hardmetals of negligible ductility. If it is used for hardmetals showing significant plastic deformation before breaking, incorrect results may be obtained. In such cases, the method may be used for comparison purposes only.
Apparatus	1. **Device for applying a force,** capable of applying a uniformly increasing force with an accuracy of 1 % or better. 2. **Three cylinders (rollers),** of which two are freely lying support cylinders with a fixed distance between them and one is a freely lying force cylinder. The three cylinders shall be of equal diameter between 3.2 mm and 6 mm. 3. **A suitable protective guard,** surrounding the fixture for safety.
Procedure	1. Place a test piece flat and centrally on the support cylinders so that its length is perpendicular to the lengths of the support cylinders. In the case of a Type B test piece, place its width on the support cylinders. 2. Bring the force cylinder or ball gradually into contact with the test piece. The deviation of the line or the point of application of the force from the middle of the span shall not exceed 0,5 mm for Type A test pieces and 0,2 mm for Type B test pieces. 3. Increase the stress in the test piece at a uniform rate not exceeding 200N/(mm2·s). **NOTE:** This corresponds to a force increasing at a maximum rate of 1 600 N/s for Type B and Type C test pieces and 600 N/s for Type A test pieces.

IS 4848 : 2022 / ISO 3923-1: 2018 -Metallic powders Determination of apparent density Funnel method

Scope	This document specifies the funnel method for the determination of the apparent density of metallic powders under standardized conditions. The method is intended for metallic powders that flow freely through a 2.5 mm diameter orifice. It can, however, be used for powders that flow with difficulty through a 2.5 mm diameter orifice but flow through a 5 mm diameter orifice. Methods for the determination of the apparent density of powders that will not flow through a 5 mm diameter orifice are specified in ISO 3923-2[1].
Apparatus	**1.** **Funnels** accepted have the following properties: a) orifice of diameter 2.5 mm and a cone angle of 60°, Hall funnel according to ISO 4490; b) orifice of diameter 2.5 mm and a cone angle of 30°, Gustavsson funnel according to ISO 13517; **2.** **Cylindrical cup**, with a capacity of 25 cm3 ± 0.03 cm^3 and an internal diameter of 28 mm ± 0.5 mm. A cup with the same capacity and with an internal diameter of 30 mm ± 1 mm is also acceptable. 28 mm ± 0.5 mm is, however, the first option when new equipment is manufactured. The cup and funnels should be made of a non-magnetic, corrosion-resistant, metallic material with sufficient wall thickness and hardness to avoid distortion and excessive wear. The inner surfaces of the cup and funnels should be polished. **3.** **Balance**, of sufficient capacity, capable of weighing the test sample to an accuracy of ± 0,01 g.
Sample	**1.** The test sample shall be at least 100 cm^3 in volume to allow the determination to be carried out on three test portions. **2.** In general, the powder should be tested in the as-received condition. In certain instances, the powder may be dried. However, if the powder is susceptible to oxidation, the drying shall take place in a vacuum or in an inert gas. If the powder contains volatile substances, it shall not be dried.
Procedure	**1.** Pour the test portion of powder into one of the funnels with the 2,5 mm orifice and, from that, directly into the cylindrical cup, until this is completely filled and the powder flows over. Level the powder in one operation with a non-magnetic straight-edge without compressing it, and take care not to jar or vibrate the cup. **2.** If the powder does not flow through this funnel, use the funnel with the 5 mm orifice. If the powder still does not flow, it is acceptable to initiate flow by poking once with a 1 mm wire from the top of the funnel. The wire shall not enter the cup. **3.** Determine the mass of the powder to the nearest 0.01 g. **4.** Carry out the determinations on three test portions.

IS 4857 : 2020 / ISO 3927 : 2017-Metallic Powders Excluding Powders for Hardmetals Determination of Compressibility in Uniaxial Compression

Scope	This document specifies methods for measuring the extent to which a metallic powder is compacted when subjected to uniaxial compressive loading in a confining die under specified conditions. The method is not applicable to powders for hardmetals.
Apparatus	1. **Press:** capable of applying forces up to approximately 500 kN with a minimum accuracy of ± 1% and adjustable to permit an even increase of the force at a rate not higher than 50 kN/s. 2. **Scale**: capable of weighing at least 100 g and readable to 0,001 g. 3. **Micrometer:** or other suitable measuring device readable to 0.005 mm for measuring the dimensions of the compacts.
Procedure	1. **Cleaning of the die and punches:** Wipe the die cavity and the punches with soft and clean paper towelling soaked with an appropriate solvent such as acetone. Allow the solvent to evaporate. 2. **Compacting pressures:** For determining the compressibility curve of a powder at a series of pressures, it is recommended that the applied pressures 200 N/mm², 400 N/mm², 500 N/mm², 600 N/mm² and 800 N/mm² be used. If compressibility is to be determined at a single pressure only, it should preferably be measured at one of these pressures or by agreement between the parties concerned.

IS 5461 : 1984-Method for sieve analysis of metal powders

Scope	This standard prescribes the method for sieve analysis of dry unlubricated metallic powders. The method is not applicable to powders in which the morphology differs markedly from being equiaxial and the particle size wholly or mostly under 45 µm.
Terminology	For the purpose of this standard, the definitions given in IS 5432 shall apply.
Apparatus	1. **Sieves** - A set of standard sieves (see Table 1) conforming to IS 460 (Part 1):1978. 2. **Sieve Shaker** - A mechanically operated sieve shaker with following details may be used: a) Number of revolutions: 270-300/min b) Number of tapings: 140- 160/min c) Hammer mass: 3kg d) Amplitude: 30 mm e) Free falling height of 60 m f) hammer

	g) The sieve shaker shall be fitted with a plug to receive the impact of tapping device. 3. **Balance** - A balance having a sufficient capacity to weigh 100 g of powder to an accuracy of ±0.01 g.
Test Procedure	1. The group of sieves selected shall be assembled in consecutive order as to size of openings with the coarsest sieve at the top, the assembly being completed by a collecting pan below the bottom siever The test specimen shall be placed on the top sieve and this sieve closed with a cover. The sieve assembly shall then be fastened securely in a suitable mechanical sieve shaking device and the machine operated for a period of 15 minutes. 2. The screened fractions shall be removed from the nest of sieves by removing the coarsest sieve from the nest gently tapping its contents to one side and pouring them upon a glazed paper. Any material adhering to the bottom of the sieve and frame shall be brushed with a soft brush into the next finer sieve. The sieve just removed shall be tapped, upside down, on the paper containing the portion that had been retained on it. This fraction shall be weighed to the nearest 0.1 g. This process shall be repeated for each sieve in the nest and the fraction collected in the pan shall also be removed and weighed. The sum of the masses of all the fractions shall not be less than 99 percent of the mass of test specimen, and the difference between this sum and the mass of the test specimen shall be added to the mass of the fraction collected in the pan.

IS 5642 : 2014 / ISO 2738 : 1999

Sintered metal materials excluding hardmetals - Permeable sintered metal materials - Determination of density oil content and open porosity

Scope	This international Standard specifies methods of determining the density, oil content and open porosity of permeable sintered metal materials. It applies in particular to porous metal bearings and to structural parts produced by pressing and sintering metal powders.
Apparatus	1. **Analytical balance**, of sufficient capacity and accurate to 0.01 %. 2. **Soxhlet extractor**, with oil solvent. 3. **Device for weighing the test piece in air and in liquid**. 4. **Vessel**, large enough to accommodate the test piece and the device (6.3) for weighing 5. **Apparatus for vacuum impregnation of the test piece with oil**. 6. **Impregnation oil**, of known density 7. **Thermometer**, accurate to ± 0.5 °C.
Terms and definitions	**For the purposes of this International Standard the following terms and definitions apply.** 1. **Density**: The density of the test piece may be expressed in two ways. 2. **Dry density**: the mass, after drying, divided by the volume.

	Fully impregnated density (wet density): The fully impregnated mass divided by the volume. 3. **Oil content**: The oil content of the test piece may be expressed in two ways. **Percentage by volume**: The volume of the oil divided by the volume of the test piece and multiplied by 100. **Percentage of the volume of the open porosity**: The volume of the oil divided by the volume of the open porosity and multiplied by 100.
Procedures	**1.** Determination of the initial mass of the test piece **2.** Determination of the mass of the dried test piece **3.** Impregnation with oil and surface coating **4.** Determination of the volume of the test piece

IS 5644 (Part 1):1993 / ISO 4491-1:1989 -Metallic powders - Determination of oxygen content by reduction methods Part 1 general guidelines

Scope	This part of IS0 4491 is-the first part of a series dealing with the determination of oxygen content in metallic powders by reduction methods. It gives general guidance to these methods, and gives some recommendations for the correct interpretation of the results obtained. The test methods are applicable generally to all powders of metals, alloys, carbides and mixtures thereof. The constituents of the powder shall be non-volatile under the conditions of test. The powder shall be free of lubricant or organic binder. However, there exist certain limitations which depend upon the nature of the analysed metal. These limitations are discussed in clause 4.
Sampling	For sampling of the powder the procedures given in IS0 3954:1977, Powders for powder metallurgical purposes – Sampling, are recommended. The powder shall be tested in the as-received condition. Metallic powders are frequently reactive substances with respect to air and moisture. Therefore, particular attention shall be given to adequate conditions for handling and storage of the test sample. The test portion shall be taken immediately prior to the analysis.
Implementation of methods for oxygen	**1.** Metals of oxides which are reducible by hydrogen ("H reducible") and which may possibly contain carbon, for example: Fe, Ni, Co, Cu, Ag, Sn, Pb, W, MO, Re.

determination by reduction	**2.** Any metal (containing carbon or not) When reduced totally by graphite (reduction-extraction method), the total oxygen content (0,) is measured.

IS 5644 (Part 2) : 2005 / ISO 4491-2:1997 -Metallic powders - Determination of oxygen content by reduction methods Part 2 loss of mass on hydrogen reduction Hydrogen Loss

Scope	This part of ISO 4491 specifies a method for the determination of the relative loss of mass with a metallic powder undergoes when heated in a stream of pure dry hydrogen under specified conditions. The purpose of this test is to evaluate a chemical powder characteristic which is of importance to the powder metallurgical industry. The test is not intended as a means for the determination of the content of specific elements. (See annex A and ISO 4491-1.) The test method is applicable to unalloyed, partially alloyed and completely alloyed powder of the metals Mad in table 1 (see 6.1). It is not applicable to lubricated powders or to mixtures of metal powders. The results can be influenced by the presence of reducible, oxidizable or volatile metals, metalloids or compounds (see annex A). The results obtained on such powders shall be used with caution and their interpretation shall be subject to agreement between supplier and user. This part of ISO 4491 shall be read in conjunction with ISO 4491-1.
Apparatus	**1. Laboratory balance**, of sufficient capacity, and capable of weighing to an accuracy of 0.1 mg **2. Electrically heated tubular furnace** **3. Supply unit for hydrogen and either nitrogen or argon**, with pressure gauges and flow meters to control the flow of gas. **4. Gas-tight tube,** of quartz or refractory material (for example dense alumina). **5. Totally enclosed thermocouple** **6. Boat,** preferably of high-alumina ceramic with a polished surface.
Procedure	**1.** The powder shall be tested in the as-received condition. **2.** The loss in mass shall be determined on two test portions. **3.** Heat the furnace (4.2), with the tube (4.3) inserted, to the temperature indicated in table 1. **4.** Weigh the boat (4.5) to the nearest 0.1 mg. **5.** Pass nitrogen (3.2) through the tube at a flow rate corresponding to a gas speed of at least 25 mm/s. **6.** Start up the flow of hydrogen (3.1).

	7. Allow the boat with the reduced test portion to cool in the nitrogen atmosphere to below 35 °C. 8. Weigh the boat with the reduced test portion to the nearest 0.1 mg.

IS 5644 (Part 3) : 2005 / ISO 4491-3:1997 -Metallic powders - Determination of oxygen content by reduction methods Part 3 hydrogen - Reducible oxygen

Scope	This part of ISO 4491 specifies a method for the determination of the hydrogen-reducible oxygen content of metallic powder a containing 0,05% (m/m) to 3 % (m/m) oxygen. The method is applicable to unalloyed, partially alloyed or completely alloyed metal powders and also to mixtures of carbides and binder metal. It is not applicable to powders containing lubricants or organic binders. The method may be extended to powders containing carbon by the use of a special catalytic device. This part of ISO 4491 shall be read in conjunction with ISO 760 and ISO 4491-1.
Apparatus	1. **Hydrogen supply unit (A)**, fitted with a pressure-regulating valve, a flow control valve and a flow meter. 2. **Purifier (B),** for the hydrogen, containing a catalytic deoxidizer and a dryer. 3. **Nitrogen (or argon) supply unit (C),** fitted with a pressure-regulating valve, a flow control valve and a flow meter. 4. **Gas-selection valve** 5. **Reduction tube** 6. **Catalytic converter** 7. **Titration flask**
Procedure	1. Weigh, to the nearest 0.1 mg, a mass of test portion corresponding to the expected hydrogen-reducible oxygen content, as in&ated in table 1. 2. Test conditions: The reduction temperatures to be applied are shown in table 2. 3. WARNING — Do not stop the hydrogen flow whiie the tube is stiii hot, except when changing back to nitrogen. 4. Blank test: For each series of determinations, carry out a blank test on an empty boat (5.8), following the same procedures as used for the test portion. 5. **Determination:** a) Method 1: Ciosed-end reduction tube

	b) Method 2: open-ended reduction tube

IS 5644 (Part 4) : 2018 / ISO 4491-4 : 2013 - Metallic powders - Determination of oxygen content by reduction methods Part 4 total oxygen by reduction - Extraction

Scope	This part of ISO 4491 specifies a method for the determination of the total oxygen content of metallic powders by reduction-extraction at high temperature. By agreement, this method is also applicable to the determination of the total oxygen content of sintered metal materials. The method is applicable to all powders of metals, alloys, carbides, and mixtures thereof which are non-volatile under the test conditions. The sample may be in powder or compact form. The analysis is carried out on the powder as supplied, but the method is not applicable if the powder contains a lubricant or binder. If such substances are present, the method may be used only if they can first be completely removed by a method not affecting the oxygen content of the powder. This part of ISO 4491 is to be read in conjunction with ISO 4491-1
Apparatus and materials	The main elements of an apparatus suitable for determining the oxygen content of a metallic powder are the following: — crucibles, machined from high purity graphite; — a device to degas the graphite crucible at high temperature; — a device to introduce the test portion and degas it under inert gas or in vacuum at ambient temperature; — a device for gas extraction in accordance with a predetermined temperature cycle; — a purification train to remove water; — a measuring device for the determination of the carbon monoxide or carbon dioxide. The materials needed will depend on the type of equipment used, for example high purity inert gas (helium or argon). Calibration of the measuring device, when necessary, requires high purity gas, carbon monoxide, carbon dioxide, or certified metallic reference materials.
Procedure	1. **General:** For the reason given in the introduction, it is not possible to specify the conditions of oxygen determination for each of the various metals, alloys, and carbides to be analysed, and for each of the types of apparatus available. It should be noted that, especially when the reduction is carried out in the solid state and with continuous heating, the reaction may be slow and the time for complete reduction of the oxides will depend on the oxygen content. 2. **Blank test and calibration**: Generally, a blank test is carried out under the same conditions as those selected for the determination, but excluding the test portion. If necessary, the apparatus is calibrated, or verified to be in correct working order, in accordance with the manufacturer's instructions, generally using

	pure gases (carbon monoxide, carbon dioxide) or reference materials of certified oxygen content.

IS 5652 (Part 1) : 1993 / ISO 3738-1:1982-Hardmetals - Rockwell hardness test Scale A Part 1 Test method

Scope	This part of IS0 3736 specifies the Rockwell hardness test scale A) for hardmetals.
Apparatus	1. **Testing equipment,** such that the measurements can be made of 0.2 HRA or better. 2. **Diamond indenter,** as specified in ISO/R 716. A performance test of the indenter shall be carried out on a machine for which the force-application and depth-measuring device shall have been verified. At least five indentations shall be made on each of a series of five standard hardmetal test blocks. Calculate the mean hardness for each test block. Deter mine the difference between this mean hardness and the certified hardness of the block. Determine the arithmetical mean and the range of these five differences. If the average is not more than ± 0.3 HRA and the range is not more than 0.6 HRA, the indenter shall be accepted.
Procedure	1. The order of procedure shall be in accordance with ISO/R 80, with the following amendments. a) The first two readings after a new indenter has been mounted shall be disregarded. b) The speed of applying the additional force shall be limited so that the movement of the weights is completed in 6 to 8 s with no test piece on the testing equipment. c) The time of maintaining the additional force after the movement of the pointer has stopped shall not exceed 2 s. While maintaining the preliminary force, remove the additional force gradually within 2 s. d) The anvil should be chosen to ensure adequate support of the test piece. 2. Select a standard test block having a value closest to the expected hardness of the test piece. Determine the Rockwell A hardness at three points on the block. The average of the three readings shall be within + 0.5 HRA of the certified hardness of that block.

	3. Before determining the hardness, take an initial reading on the test piece. This reading shall be disregarded. Then determine the hardness on the test piece with at least three indentations made at random.

IS 6492 : 2020 / ISO 3954 : 2007-Powders for Powder Metallurgical Purposes Sampling First Revision

Scope	This International Standard specifies procedures for the sampling of powders for powder metallurgical purposes. It also covers the splitting of the sample into the quantity required for testing.
Terms and definitions	**1. Lot**: quantity of powder processed or produced under conditions that are presumed uniform. **2. Increment**: quantity of powder obtained by a sampling device at one time from a single lot. **3. Gross sample**: quantity of powder, adequate for the tests to be performed, consisting of all the increments taken from a single lot. **4. Composite sample**: blended entire gross sample or part thereof **NOTE 1** Alternatively, it may be obtained by splitting the lot. **NOTE 2** However it is obtained, it is essential that it be thoroughly blended.
Sampling	**1. General**: Increments shall be taken in such a manner that the composite sample represents the lot as accurately as possible. **NOTE** Demixing may occur at any time when a batch of powder is set in motion, for example when filling containers, emptying containers, during transportation or if subjected to vibration during storage. All the surfaces of a sampling device that come into contact with the powder shall be smooth and clean. **2. Sampling procedures** **a) General requirements**: The sampling procedure shall be such that the powder properties are not changed. Whenever possible, procedure 4.2.2 should be preferred over procedure. **b) Sampling during discharge in a continuous stream**: The dimensions of the sampling container at right angles to the stream of powder shall exceed the cross-section of the stream by an ample margin. They shall be large enough so that no overflow of powder occurs when collecting the sample. The sampling container shall be exposed to the powder stream and withdrawn in such a manner that all portions of the stream have an equal chance of entering it.

	NOTE: The gross sample thus obtained shall be blended by rotating for 10 to 15 revolutions at 15 rpm to 30 rpm in order to obtain the composite sample.

IS 7438:2022 / ISO 4496:2017 - Metallic powders Determination of acid-insoluble content in iron copper tin and bronze powders

Scope	This document specifies methods for determining, in iron, copper, tin and bronze powders, the approximate content of non-metallic materials which are insoluble in the ordinary mineral acids. The insoluble matter referred to is generally considered to be acid-insoluble silica and silicates, carbides, alumina, clays or other refractory oxides which are either present in the raw material from which the powders are manufactured or introduced during the manufacturing process.
Sampling	**1. Number of test portions**: Determine the content of insoluble matter on two test portions. **2. Mass of test portion** : The mass of the test portion shall be approximately 5 g.
Procedure	**1. Iron powder** a) Weigh, to the nearest 0,000 1 g, a test portion of approximately 5 g of the test sample (mass m_2) and transfer it to a glass beaker. b) Place the glass beaker on a hotplate and heat the solution to boiling. Maintain boiling for about 1 min. Add 150 ml of water, reheat to boiling and maintain for about 1 min. Allow the solution to cool and settle for 5 min. c) Determine the mass of the crucible with the residue to the nearest 0,000 1 g (mass m3). **2. Copper, tin and bronze powders** a) Weigh, to the nearest 0.000 1 g, a test portion of approximately 5 g of the test sample (mass m_1) and transfer it to a glass beaker. b) Carefully add 50 ml of hydrochloric acid (5.5), cover with a watch glass, place on the edge of a hotplate and digest at low temperature for a minimum of 30 min.

IS 7512 : 2006 / Method for the determination of average particle size of metal powders by fisher sub-sieve sizer

Scope	This standard prescribes the method of determining the average particle size of metal powder by Fisher sub-sieve sizer. This test method uses air permeability to determine an envelope specific surface area and its associated average equivalent spherical diameters of metal powders and related compounds. The powders may be analyzed in their as supplied (shipped, received or processed) condition or after they have been de-agglomerated or milled by a laboratory procedure. The values obtained are not intended to be absolute but are generally useful on a relative basis for control purposes.
Terminology	For the purpose of this standard, the definition given in IS 5432 and the following shall apply. 1. **Fisher Sub-sieve Sizer** — A commercially available permeability instrument for measuring envelope-specific surface area. 2. **Envelope-Specific. Surface Area** — The specific surface area of a powder as determined by gas permearnetry. 3. **Air Permeability** — The measurement of air pressure drop across a packed bed of powder. 4. **De-agglomeration** — Process used to break up agglomerates of practices.
Procedure	1. **Temperature of Test:** Make Fisher number determinations with ±2°C of the temperature at which standardization of the Fisher sub-sieve was made. Re-standardize, if the temperature of the test varies more than ± 2°C. 2. **Size of Test Sample:** The mass of the sample used for tests should be equal in grams (within ±0.01 g) to the theoretical density of the powder (Tungsten, 19.3 g; molybdenum 10.22 g; tantalum 16.6 g, etc). 3. **Fisher Number Determination:** The Fisher number determination shall be made by the same operator who make the standardizations, and is started after standardization or the determination of another sample.

IS 8871 : 2018 / ISO 3953:1993 - Metallic powders - Determination of tap density

Scope	This International Standard specifies a method for the determination of tap density, i.e. the density of a powder that has been tapped into a container under specified conditions.
Apparatus	1. **Balance**, of appropriate capacity to satisfy the requirements shown in Table 2 and of an accuracy to weigh to the nearest 0.1 g. 2. **Graduated glass cylinder**, calibrated to contain 100 cm^3, the height of the graduated portion being approximately 175 mm. The graduations shall be at 1 cm^3 intervals, thus allowing a measuring accuracy of ±0.5 cm^3. Alternatively: Graduated glass cylinder, calibrated to contain 25 cm^3, the height of the graduated portion being approximately 135 mm. The graduations shall be at 0.2 cm^3 intervals. A 25 cm^3 cylinder shall be used for powders of apparent density higher than 4 g/cm^3, in particular for refractory metal powders, but may also be used for powders of lower apparent density.
Procedure	1. Clean the inside wall of the graduated cylinder with a suitable clean brush or, if necessary, by rinsing with a solvent, such as acetone. If a solvent is used, thoroughly dry the cylinder before re-use. 2. If the tapped surface is level, read the volume directly. If the tapped surface is not level, determine the tap volume by calculating the mean value between the highest and the lowest reading of the tapped surface. Read the final volume to the nearest 0.5 cm^3 when using a 100 cm^3 cylinder, and to the nearest 0.2 cm^3 when using a 25 cm^3 cylinder.

IS 8876 : 1978 - Method for determination of residue on chlorination of tungsten metal powder

Scope	This standard prescribes the method for determination of residue on chlorination of tungsten metal powder which is a measure of the purity of the sample.
Apparatus	1. **Gas Bubbler (1)** - For the inflow of chlorine gas from Kipp's apparatus and to check the flow rate.

	2. **Connecting Tubes (2)** - A row of three glass tubes, fitted with ground-glass joints and filled with activated charcoal. 3. **Gas Bubbler (3)** - For drying the chlorine gas by passing through concentrated sulphuric acid. 4. **Drying Tower (4)** -For drying the chlorine gas by passing through anhydrous calcium chloride.
Sampling	A representative sample shall -be drawn in accordance with IS 6492.
Procedure	The quartz boat shall be thoroughly cleaned and ignited at 700°C for one hour. It shall be cooled in a desiccator. a) The empty boat shall be weighed and 2 g of the sample shall be taken and weighed accurately in a precision balance. b) The apparatus shall be assembled; the quartz boat with the sample shall be inserted into the quartz ignition tube and all the connections shall be checked for leak-proof joints.

IS 10385 : 2019 / ISO 2739 : 2012 - Sintered metal bushings - Determination of radial crushing strength

Scope	This International Standard specifies a method of measuring the radial crushing strength of sintered metal parts in the form of hollow cylinders, commonly known as bushings. This method is applicable to sintered bushings composed of pure or alloyed metal powders.
Apparatus	1. **Pressing apparatus,** hat enables a radial load to be applied to a hollow cylinder. 2. **Load-measuring device,** accurate and readable to 0.1 % of the full scale. The lowest testing range that can provide a measurable result should be used. 3. **Loading plates,** two flat, ground, hardened steel plates of sufficient size to encompass the test specimen that can be fastened to the press platens and that will remain parallel.
Procedure	1. Clean any surface oil from the specimen and measure the outside diameter, the inside diameter and the length within 0.5 % tolerance. a) For test specimens with an outside diameter < 10 mm, the outside diameter may be measured to the nearest 0.05 mm. b) For test specimens with an inside diameter < 10 mm, the inside diameter may also be measured to the nearest 0.05 mm.

	c) For test specimens with a length ranging from ≥ 2 mm to < 10 mm, the length may be measured to the nearest 0.05 mm. d) For test specimens with a length< 2 mm, the length may be measured to the nearest 0.01mm **2.** Wipe the loading plates clean and lay the test specimen in the central region of the lower plate, the axis of the test specimen being parallel to the planes of the plates.

IS 11506 : 2019 / ISO 13944 : 2012 - Lubricated metal-powder mixes - Determination of lubricant content - Modified Soxhlet extraction method

Scope	This International Standard specifies a method for the determination of the lubricant content of a powder mix. The method is also suitable for preparing samples for measuring the content of elements, e.g. graphite and oxygen, the determination of which is interfered with by the presence of a lubricant. A condition of the application of the method is that a suitable solvent for the lubricant concerned is known and available.
Apparatus and Materials	**1.** **Analytical balance:** capable of weighing the sintered glass filter crucible together with the test portion, to the nearest 1 mg. **2.** **Soxhlet apparatus:** as shown on figure 1, with ungreased joints, consisting of the following parts. a) **Allihn (bulb-type) condenser** b) **Soxhlet extractor,** with a volume of 150 ml to 200 ml. c) **Round- bottomed flask,** with a capacity of 500 ml, containing a bolling aid. **3.** **Organic solvent:** suitable for extraction of the lubricant concerned. Examples of such solvents are xylene, toluene and petroleum ether.
Procedure	**1.** Weigh the filter crucible together with a filter paper and a plug of glass wool in the mouth of the crucible to the nearest 1 mg (m_1). It is important to ensure that the filter paper is dry. If needed, the filter paper should be dried before the analysis to avoid errors caused by moisture. **2.** Place the test portion on the filter paper in the bottom of the crucible, and cover with the plug of glass wool. Weigh the crucible plus filter paper plus test portion plus glass wool together to the nearest 1 mg (m_2).

	3. Place the crucible plus contents in the Soxhlet extractor, using the length of glass tubing to bring the upper edge of the crucible level with the upper bend of the syphon.

IS 11518 : 1985 - Method for determination of The Magnetization coercivity in hardmetals

Scope	This standard specifies a method of determining (the magnetization) coercivity of hardmetals containing not less than 3 percent of a ferro-magnetic binder by mass.
Apparatus	1. Apparatus capable of the dc magnetization of the test piece up to the state of technical saturation in the dc magnetic field and providing its demagnetization. 2. The apparatus shall have an accuracy of 0.2 kA/m for coercivity values up to 20 kA/m and 1 percent for values over 20 kA/m. 3. In order to reach technical saturation, the value of the magnetic field strength shall be 200 to 400 kA/m depending on the type of apparatus used.
Procedure	1. Place the test piece in a dc magnetic field with its longest dimension in the direction of the field and magnetize it up to technical saturation. 2. Determine the coercivity HCM necessary for demagnetization of the test piece. NOTE- During the measurements disturbance of the magnetic field from metallic objects like trolley, chair, wrist watch, etc, close to the instruments should be considered and avoided.

IS 11627 : 1986 - Method for determination of apparent density of metallic powders by scott volumeter

Scope	This standard specifies the Scott volumeter method for the determination of the apparent density of metallic powders. It is applicable to powders that will not flow freely through a 5-mm orifice
Apparatus	**1. Scott volumeter** - It comprises the parts given below: a) **Funnel** -having a large and a small conical section separated by a cylindrical section and incorporating a brass sieve of aperture size 1.18 mm (16 mesh). b) **Baffle Box** -having a square section, and containing four glass baffles which may be located and retained by grooves in opposite sides of the box and may thus be removed for ease of cleaning. The

	baffles are arranged so that the powder falls on each of them in turn, thereby breaking the fall and reducing the velocity of the stream of powder. It is important that none of the powder can pass between the upper edge of the glass baffles and the sides of the baffle box. It is also important that the lower edges of the glass baffles are either in line or slightly overlap in a vertical plane. **2. Cylindrical Cup** - having a capacity of 25 ± 0.05 cms and an internal diameter of 30 ± 1 mm. **3. Balance** - of sufficient capacity, permitting weighing to an accuracy of ± 0.05 g.
Procedure	**1.** Pour or feed the powder carefully by means of a spatula into the funnel until the cup is completely filled and powder flows over. **2.** If the powder is not free flowing, its passage through the sieve may be aided by light brushing with a soft brush. **3.** Level the powder with a straight-edge, taking care not to compress or pull out powder and not to disturb or vibrate the cup.

IS 11959 : 1987 / Method for metallographic determination of microstructure in hardmetals

Scope	This standard specifies the methods of metallo-graphic determination of the microstructure of hardmetals.
Apparatus	**1. Metallographic Microscope :** capable of magnifications up to 1500 X. **2. Equipment :** for the metallographic preparation of test specimen.
Procedure	**1.** Examine the microstructure by gradual development of the phases by etching. Examples of suitable etching techniques are given in Table 1. Care shall be taken to ensure that the true microstructure is revealed. **2.** Determine the presence of ŋ-type phases by lightly etching the section with Technique 1 (see Table 1). Phases of ŋ-type are coloured orange to brown. γ-phase may etch lightly, while the other phases remain unetched. Etching by Technique 1 does not prevent subsequent etching by Techniques 2 or 3. Examine the entire section at low magnification and, if necessary, at magnification up to 1 500 x. Note and record the existence of ŋ-type phases and their distribution.

IS 11960 : 1987 / Method for metallographic determination of apparent porosity and uncombined carbon in hard metals

Scope	This standard specifies the procedure for the metallographic determination of the presence, type and distribution of porosity and uncombined carbon in hardmetals.
Apparatus	1. **Metallographic Microscope** - or other suitable equipment permitting observations and measurements up to a magnification of 200 X. 2. **Equipment** - for the metallographic preparation of test specimens.
Procedure	1. Pore size is defined as the maximum dimension of the pore in the section. Special reference shall be made to the presence of cracks or slits. 2. Pore up to 10 pm shall be assessed by scanning the surface of the test piece section at a magnification of either 100 or 200 X. An area fully representative of the test piece section shall be examined and compared with the range of photo-micrographs shown in Fig. 1 or 2, according to the chosen magnification. The porosity level shall be reported by reference to the appropriate photo-micrograph and designated as A02, A04, A06 or A08. 3. Pores within the range 10 to 25 pm shall be assessed by scanning the surface of the test piece section at a magnification of 100 X. An area fully representative of the test piece section shall be examined and shall be compared with the range of photomicrographs shown in Fig. 3. The porosity level shall be reported by reference to the appropriate photomicrograph and designated as B02, B04, B06 or B08.

IS 12279 : 2005 / ISO 3325:1996 - Sintered metal materials excluding hardmetals - Determination of transverse rupture strength

Scope	This International Standard specifies a method for the determination of the transverse rupture strength of sintered metal materials, excluding hardmetals. The method is particularly suitable for comparing the sintered strength of a batch of metal powder with that of a reference powder or with a reference strength. The method is applicable to sintered metal materials, excluding hardmetals, whether they have been subjected to heat treatment after sintering or not, and also to materials that have been sized or coined after sintering. It is especially suitable for materials having a uniform hardness throughout their section and negligible ductility, i.e. a ductility corresponding to a permanent deformation of less than about 0.5 mm measured between the two supports during the transverse rupture strength

	determination. If the test is applied to materials under conditions other than those specified above, the conditions shall be reported. NOTE 1: The permanent deformation can be measured with sufficient precision from the two fragments of the broken or cracked bar by indexing the lower surface. Alternatively, the deflection of a straight line drawn horizontally on the' side of the test piece can be measured using an optical instrument such as a measuring microscope or optical comparator.
Apparatus	**1.** Test equipment, of any type providing static loading conditions and an accuracy of ± 1 %. **2.** The equipment shall have two support cylinders (rollers) with a fixed distance between them and a load-application cylinder (roller). All three cylinders shall be 3.2 mm & 0.1 mm in diameter and shall be made either of hardened steel with a hardness of at least 700 HV or of hardmetal. **3.** The support cylinders shall be mounted parallel to each other, and the distance between their centrelines shall be either 25.0 mm ± 0.2 mm or 25.4 mm ± 0.2 mm, measured with an accuracy of A 0.1 mm for the calculation. The load-application cylinder shall be mounted midway between the support cylinders. **4.** For better accuracy, the mounting of the cylinders should preferably be such as to compensate for any deviation from parallelism between the top and bottom faces of the test piece. This can be accomplished by mounting the support cylinders so that each can be adjusted vertically.
Procedure	**1.** Measure the width and thickness of the test piece at its midpoint to the nearest 0,01 mm. **2.** Place the test piece on one of its 30 mm x 12 mm faces symmetrically on the support cylinders so that its longitudinal axis is at 90° * 30' to the longitudinal axes of the cylinders. Precise positioning of the test piece can be easily ensured by pushing the side of the test piece up against a suitably located, removable stop. Apply a load at a position midway between the two cylinders. Increase the load slowly and steadily, so that the time to fracture is not less than 10s. Record the value at which the load suddenly drops due to formation of the first crack. **3.** Repeat the determination with a suitable number of test pieces

IS 12286 : 1988 / ISO 28080:2011-Method for determination of abrasive wear resistance of hardmetals

Scope	This standard covers the method for determination of abrasive wear resistance of hardmetals.
Apparatus	**1. Wheel-** Made of annealed mild steel (Designation 20C8) and shall rotate in the centre of the vessel at 100 ± 5 rpm. The direction of rotation shall be from the slurry to the specimen. Four curved vanes shall be affixed to either side of the wheel to agitate and mix the slurry and to propel it towards the specimen, The maximum wheel diameter shall be 170 mm and the width shall be 12.7 ± 0.1 mm, The wheel shall be discarded when its diameter has decreased to 165 mm, *Min*. after repetitive use, In use, a slight burr will

	form at the periphery. This burr will compensate for wheel wear by widening the wear path in the specimen, it shall not be removed. 2. **Specimen Holder** - To be pressed against the periphery of the wheel. This specimen holder shall be mounted so that not more than 0.05mm of side play occurs at the line of contact between the specimen and the wheel. The specimen is tangential to the wheel at the centre line of the wheel ant the specimen. A 10 kg weight shall be attached to the other end of the specimen holder lever arm With a lever advantage of two-to-one, a force of 20 kg is thus applied to the specimen at the line of contact.
Procedure	1. Weigh the specimen on an analytical balance to the nearest 0.001 g. 2. Determine the density. 3. Place the specimen in a specimen holder and fasten rigidly with set screws and pressure plates. 4. Insert the specimen holder into the abrasion wear test machine.

IS 12473 (Part 1) : 1988 / Chemical analysis of hardmetals by flame atomic absorption spectrometry-Part 1 general requirements

Scope	This standard (Part 1) specifies the general requirements for the chemical analysis of hard-metals by flame atomic absorption.
Apparatus	1. Ordinary laboratory apparatus and atomic absorption spectrometry apparatus shall be used. NOTE1 -All measurement parameters should be chosen to give optimum sensitivity. NOTE2 - Single element hollow cathode lamps are recommended. The recommended instrument requirement are shown in the relevant parts of this standard.
Sampling	If necessary, the sample may be crushed in a mortar made of a material which does not alter the sample composition. If the sample contains lubricant, this shall be extracted before analysis. NOTE - In case of sintered hardmetals, the method of sampling may be mutually agreed to between the supplier and the purchaser.
Procedure	The procedure is given in the relevant parts of this Indian standard.

IS 12473 (Part 2) : 1988 / Chemical Analysis of Hardmetals by Flame Atomic Absorption Spectrometry - Part 2 Determination of Calcium Potassium Magnesium and Sodium in Contents from 0

Scope	**1.** This standard (Part 2) specifies the method to be used for the determination of calcium, potassium, magnesium and sodium contents in hardmetals within the range 0.001 to 0.02 percent (*m/m*) by flame atomic absorption spectrometry. **2.** General requirements concerning the field of application, principle, interfering elements, apparatus, sampling and test report are given in Part 1 of this standard
Reagents	During the analysis, only reagents of analytical grade, and distilled water or water of equivalent purity shall be used. *a) Hydrofluoric Acid (ρ = 1.12 g/ml)* *b) Concentrated Nitric Acid (ρ = 1.42 g/ml)* *c) Ammonium Fluoride (0.1 g/m] solution)* d) *Caesium Chloride (00.01 g/ml solution*)
Procedure	**1.** Test Portion - Weigh, to the nearest 0'001 g, approximately 1 g of the test sample. Transfer it to a 100 ml polytetrafluoroethylene beaker. Cover the beaker. **2.** Dissolution of the Test Portion - Add 10 ml of water, 5 ml of hydrofluoric acid and then 5 ml of concentrated nitric acid, drop by drop, to the beaker containing the test portion and heat gently until the test portion is completely dissolved. Add 10 ml of caesium chloride solution and 10 ml of ammonium fluoride solution. Then transfer the solution totally to a 100 ml polyethylene volumetric flask and dilute to the mark and mix.

IS 12473 (Part 3) : 1988 / Chemical analysis of hardmetals by flame atomic absorption spectrometry Part 3 determination of cobalt iron manganese and nickel in contents from 0 01 to 0 5 percent M m

Scope	**1.** This standard (Part 3) specifies the method to be used for the determination of cobalt, iron, manganese and nickel contents in hardmetals within the range 0.01 to 0.5 percent (m/m) by flame atomic absorption spectrometry.

	2. General requirements concerning the field of application, principle, interfering elements, apparatus, sampling and test report are given in Part 1 of this standard.
Reagents	During the analysis, USC: only reagents of analytical grade, and distilled water or water of equivalent purity. *a) Hydrofluoric Acid- ρ - 1.12 g/ml.* *b) Concentrated Nitric Acid (ρ = 1.42 g/ml* *c) Ammonium Fluoride (0.1 g/ml solution)* d) *Caesium Chloride (0.01 g/ml solution)*
Procedure	**1.** Test Portion -Weigh, to the nearest 0.001 g, approximately 1 g of the test sample. Transfer it to a 100 ml polytetrafluoroethylene beaker. Cover the beaker. **2.** Dissolution of the Test Portion - Add 10 ml of water, 5 ml of hydrofluoric acid and then 5 ml of concentrated nitric acid, drop by drop, to the beaker containing the test portion, and heat gently until the test portion is completely dissolved, Add 10 ml each of caesium chloride and ammonium fluoride solution. Then transfer the solution to a 100 ml polyethylene volumetric flask and dilute to the mark.

IS 12473 (Part 4) : 1988 / Chemical analysis of hardmetals by flame atomic absorption spectrometry Part 4 determination of molybdenum titanium and vanadium in contents from 0 01 to 0 5 % (*m/m*)

Scope	**1.** This standard (Part 4) specifies the method to be used for determination of molybdenum, titanium and vanadium contents in hardmetals within the range 0.01 to 0.5percent (m/m) by flame atomic absorption spectrometry. **2.** General requirements concerning the field of application, principle, interfering elements, apparatus, sampling and test report are given in Part 1 of this standard.
Reagents	During analysis, only reagents of analytical grade and distilled water or water of equivalent purity shall be used. a) *Hydrofluoric Acid* (ρ=1*12 g/ml) b) *Concentrated Nitric Acid* (ρ=1'42 g/ml) c) *Ammonium Fluoride* - 0.1 g/ml solution d) *Caesium Chloride* - 0.01 g/ml solution.
Procedure	**1.** Test Portion - Weigh to the nearest 0.001 g, approximately 1 g of the test sample. Transfer it to a 100 ml tetrafluoroethylene beaker. Cover the beaker.

	2. Dissolution of the Test Portion - Add 10 ml of water, 5 ml of hydrofluoric acid, and then 5 ml of concentrated nitric acid, drop by drop, to the beaker containing the test portion and heat gently until the test portion is completely dissolved. Add 10 ml of caesium chloride solution and 10 ml of ammonium fluoride solution. Then, transfer the solution to a 100 ml polyethylene volumetric flask and dilute to the mark and mix. **3.** Dilution Volume **4.** Preparation of Calibration and Blank Solutions **5.** Adjustment of the Atomic Absorption Spectrometer. **6.** Atomic Absorbance Measurements

IS 12473 (Part 5) : 1988 / Chemical analysis of hardmetals by flame atomic absorption spectrometry Part 5 determination of cobalt iron manganese molybdenum nickel titanium and vanadium in contents from 0 5 to 2 percent M m

Scope	**1.** This standard (Part 5) specifies the method to be used for the determination of cobalt, iron, manganese molybdenum, nickel, titanium and vanadium contents in hardmetals within the range 0.5 to 2 percent (m/m) by flame atomic absorption spectrometry. **2.** General requirements concerning the field of application, principle, interfering elements, apparatus, sampling and test report are given in Part 1 of this standard. **NOTE -** Determination of element contents in high concentration by the atomic absorption spectrometry method yields a wider scattering of results than are obtainable by other methods.
Reagents	During analysis, only reagents of analytical grade and distilled water or water of equivalent purity shall be used. a) Hydrofluoric Acid (p 2 1.12 g/ml) b) Concentrated Nitric Acid (p – 1.42 g/ml > c) Ammonium Fluoride (0.1 g/ml solution) d) Caesium Chloride (0.1 g/ml solution) e) Standard Cobalt Solution (1 ml = 1 mg of Co) - Weigh 1.000 0 g of pure cobalt metal and dissolve in minimum quantity of dilute nitric acid (1:1). Add 40 ml of dilute sulphuric acid (1:1). Heat to white fumes, cool and transfer to 1 Litre volumetric flask and make up the volume and mix. - f) Alternatively, dissolve 4.769 8 g of cobalt sulphate ($CoSO_1 .7H_2O$) in water and transfer to 1 litre volumetric flask and make up the volume and mix.

Procedure	**1. Test Portion -** Weigh, to the nearest 0.001 g, approximately 1 g of the test sample. Transfer it to a 100 ml polytetra-fluoroethylene beaker. Cover the beaker. **2. Dissolution of the Test Portion -** Add 10 ml of water, 5 ml of hydrofluoric acid, and then 5 ml of concentrated nitric acid, drop by drop, to the beaker containing the test portion and heat gently until the test portion is completely dissolved. Add 10 ml each of caesium chloride and ammonium fluoride solution. Then transfer the solution to a 100 ml polyethylene volumetric flask and dilute to the mark and mix

IS 12473 (Part 6) : 1988 / Chemical analysis of hardmetals by flame atomic absorption spectrometry Part 6 determination of chromium in contents from 0 01 to 2 percent M m

Scope	**1.** This standard (Part 6) specifies the method to be used for the determination of chromium content in hardmetals within the range 0.01 to 2 percent (*m/m*) by flame atomic absorption spectrometry. **2.** General requirements concerning the field of application, principle, interfering elements, apparatus, sampling and test report are given in Part 1 of this standard.
Reagents	During analysis, only reagents of analytical grade and distilled water or water of equivalent purity shall be used. a) *Potassium Pyrosulphate* b) *Perchloric Acid* (ρ = 1.54 or 1.67 g/ml). c) *Ammonium Citrate Solution* - Dissolve 100 g of citric acid in 1 500 ml of water and add 400 ml of ammonia solution (ρ = 0.91 g/ml). d) *Hydrogen Peroxide* - 30 percent (*m/m*), e) *Standard Chromium Solution* (1 ml = 1 mg of Cr) - Weigh 2.8289 g of potassium dichromate previously dried at 110°C and cooled in a desiccator and dissolve in water and transfer to 1 litre volumetric flask, dilute with water up to the mark and mix.
Procedure	**1. Test Portion** - Weigh, to the nearest 0.001 g, the relevant amount of the test sample indicated in Table 1. Transfer it to a 100 ml conical flask (preferably of quartz). NOTE - In this special case, the sample shall pass through a 180 pm sieve. **2. Dissolution of the Test Portion** - Add 5 g of potassium pyrosulphate and a few drops of perchloric acid to the beaker containing the test portion and heat gently until the test portion is completely dissolved. Add 40 ml of ammonium citrate solution and about 0.5 ml of hydrogen peroxide. Then

	transfer the solution to a 100 ml polyethylene volumetric flask and dilute to the mark and mix. **3. Dilution Volume** - Prepare the relevant dilution volume for the analysis according to Table 1 as follows. a. *Dilution Volume (100 ml = 1 g of Test Sample)* - Use the solution in **2**. b. *Dilution Volume (500 ml = 1 g of Test Sample)* - Transfer 20 ml of the solution in **2** to a 100 ml polyethylene volumetric flask and dilute to the mark.

IS 12483 : 1988 / Determination of titanium in hardmetals by spectrophotometric method

Scope	This standard covers a spectrophotometric method for the determination of the titanium content in carbides and hardmetals. 1. This method is applicable to the following having titanium content exceeding 0.2 percent (*m/m*): a. Carbides and binder metal powder mixtures, free of lubricant; and b. All grades of presintered or sintered hardmetals.
Reagents	During the analysis, use only reagents of analytical grade, and distilled water or water of equivalent purity. a) *Ammonium Hydrogen Fluoride* b) *Ammonium Sulphate* c) *Sodium Disulphite* d) *High Purity Titanium Metal or Titanium Dioxide* e) *Citric Acid Solution* - 30 percent (*m/m*). f) *Perchloric Acid* - ρ = 1.54 or 1.67 g/ml. g) *Concentrated Sulphuric Acid* - ρ = 1.84 g/ml. h) *Dilute Sulphuric Acid* - ρ = 1.54 g/ml (concentrated sulphuric acid, ρ = 1.84 g/ml, diluted 1 + 1). i) *Hydrogen Peroxide* - 30 percent (*m/m*). j) *Hydrofluoric Acid* - ρ = 1.12 g/ml. k) *Concentrated Nitric Acid* - ρ = 1.42 g/ml
Apparatus	1. Ordinary Laboratory Apparatus 2. Spectrophotometer or Filter Photometer
Procedure	1. ***Test Portion*** - Weigh, to the nearest 0.0001 g, 0.1 or 0.2 g of the test sample. 2. ***Dissolution*** - Transfer the test portion into a 100 to 200 ml conical flask or a 250 ml beaker. Add 5 g ammonium sulphate and 10 ml concentrated sulphuric acid. Cover the beaker or flask with a watch glass. Heat to boiling until complete dissolution is achieved.

	Alternative dissolution method - Transfer the test portion into a platinum dish. Add 10 ml of water and 5 ml of hydrofluoric acid. Cover the dish with a polypropylene or platinum cover. Heat to approximately 800°C. Add the concentrated nitric acid drop by drop until dissolution is complete. Cool, add 10 ml of concentrated sulphuric acid and 5 g of ammonium sulphate. Heat until fumes of SO_3 are observed, and cool again.

IS 12513 : 1988 / Determination of cobalt in hardmetals by potentiometric method

Scope	This standard covers a potentiometric method for the determination of cobalt content in hardmetals. **1.** This method is applicable to the following, having cobalt content exceeding 1 percent: a. Carbides and binder metal powder mixtures free of lubricant, and b. All grades of presintered or sintered hardmetals.
Apparatus	a) ***Ordinary Laboratory Apparatus*** b) ***Potentiometric Titration Apparatus*** - With stirrer or some other arrangement for agitation. c) ***Platinum Electrode*** d) ***Tungsten Wire or Any Other Reference Electrode*** e) ***Burrettes*** - Of capacity 10 ml.
Procedure	**1.** Weigh, to the nearest 0.0001 g, 0.1 to 0.5 g of the test sample, depending on the cobalt content. **2.** Transfer the test portion into a 400 ml beaker, add 10 to 15 ml concentrated sulphuric acid, 3 ml concentrated hydrochloric acid and 5 g ammonium sulphate. end heat until complete dissolution is achieved. Cover the beaker with a watch-glass and heat until complete dissolution is achieved. Cool. Add, in small portions, 40 to 60 ml ammonium citrate solution. Rinse the watch-glass and the beaker walls with 20 to 60 ml of water, Heat the solution gently until all salts are dissolved. Cool. **3.** Add 1 drop of methyl red indicator solution or use indicator paper. Carefully neutralize the solution with ammonia solution and maintain *p*H 3 to 5 and cool. **4.** Add 80 ml of ammonia solution and preferably cool to 10°C. Immediately add potassium ferricyanide solution from the burette to an excess of a few millilitres. Volume used : V_1 ml. back titrate with a standard cobalt sulphate solution. Volume used : V_2 ml.

IS 12539 : 2022 / ISO 3907:2009 - Hardmetals Determination of total carbon Gravimetric method

Scope	This International Standard specifies a gravimetric method for the determination of the mass fraction of total carbon in carbides and hardmetals. This method is applicable to – carbides of chromium, hafnium, molybdenum, niobium, tantalum, titanium, vanadium, tungsten and zirconium, – mixtures of these carbides and binder metals, free of lubricant, – all grade of pre sintered or sintered hardmetals, produced from these carbides, and having a mass fraction of total carbon exceeding 4 %
Reagents	During the analysis, use only reagents of recognized analytical grade, and only distilled water or water of equivalent purity. a) **Oxygen**, with a limitation of carbon-containing impurities of u 0.6 ml of carbon per cubic metre of oxygen. b) **Magnesium perchlorate**, anhydrous c) **Flux**, for example tin metal, copper metal or oxide, iron metal. d) **Ascarite**[1]
Apparatus	Ordinary laboratory apparatus and the following. a) **Apparatus**, consisting of an electric furnace with a combustion tube, a purification train and a system to absorb carbon dioxide. If it is necessary to obtain oxygen of adequate purity, an oxygen purification train may also be used. The apparatus is shown schematically in Figure 1. b) **Source of oxygen** (3.1), with a pressure-regulating valve. c) Flow meter. d) **Electric furnace,** capable of operation at up to 1350 °C, with a suitable device for temperature control.
Procedure	**1. General** Check the temperature in the combustion zone (1200 °C to 1 350 °C, and not less than 1300 °C if chromium carbide is present), the gastightness of the apparatus and the efficiency of the oxygen purification. Pass oxygen through the apparatus for 10 min to 15 min at a rate of 300 cm^3/min to 500 cm^3/min depending on the diameter of the tube used. Then disconnect the absorption bulbs (see Figure 1, item reference 8), weigh them at ambient temperature and place them in position again. **2. Test portion** The mass of the test portion (m_0) shall be such that it contains approximately 0.03 g of carbon, and shall be determined to the nearest 0.0001 g. If necessary, add 0.2g to 1 g of the flux (3.3) to the test portion. **3. Blank test** Carry out the blank test by combustion (proceed as described in 6.4 and 6.5) in the presence of the quantity of flux used in the analysis, and carefully determine the increase in mass (m_1) of the absorption bulbs.

IS 12548 : 2022 / ISO 3908:2009 - Hardmetals Determination of insoluble free carbon Gravimetric method

Scope	This International Standard specifies a gravimetric method for the determination of the mass fraction of insoluble (free) carbon in carbides and hardmetals. This method is applicable to – carbides of hafnium, molybdenum, niobium, tantalum, titanium, vanadium, tungsten and zirconium, – mixtures of these carbides and binder metals, free of lubricant, and – all grades of pre sintered or sintered hardmetals, produced from these carbides, having a mass fraction of insoluble carbon between 0.02 % and 0.5 %
Apparatus	Ordinary laboratory apparatus and the following. a) **Apparatus**, as specified in ISO 3907. b) **Platinum dish**, of capacity 200 ml. c) **Filter device:** ceramic filter device or bed of suitable refractory fibrous or powder material in a Gooch crucible.
Procedure	**1. Test portion** Weigh, to the nearest 0.01 g, approximately 2.5 g of the test sample. **2. Attack** Transfer the test portion (7.1) into the platinum dish (5.2). Add 75 ml of the nitric acid (4.1) and place the dish on a steam bath for 5 min. Add, drop by drop, 10 ml of the hydrofluoric acid (4.2), and leave the dish on the steam bath for about 1 h until complete dissolution is obtained. Cool the solution to ambient temperature. **3. Preparation of the Gooch crucible** Insert the ceramic filter device (5.3) into the crucible. If a refractory material is used, fill the crucible to a depth of approximately 8 mm to 10 mm and press it down so that the residue will be retained on the refractory material and the time of filtering will not be too slow.

IS 12570 : 2022 / ISO 4492:2017 - Metallic powders excluding powders for hardmetals Determination of dimensional changes associated with compacting and sintering

Scope	This document specifies a method by which the dimensional changes associated with compacting and sintering of metallic powders are compared with those of a reference powder when processed under similar conditions (see Clause 4). The method applies to the determination of three types of dimensional changes involved with the processing of metallic powders, excluding powders for hardmetals.

Principle	Compaction of a metallic powder or powder mix with admixed lubricant was used to produce a test piece that was sintered under controlled conditions. Depending upon the particular dimensional change required, measurement of the dimension of the uploaded die cavity, the green compact, and/or the sintered test piece is calculated. The algebraic difference between these various measurements is calculated as a percentage of the dimension of the die cavity or the green compact. (See Clause 9.)
Apparatus	a) **Tools set**, that will produce cylindrical (see Figure 1), rectangular (see Figure 2) or tensile test pieces (in accordance with ISO 2740), or test pieces similar to the actual components for which the powder is required. b) **Press**, capable of applying the pressures necessary to achieve the required density or required compacting pressure. See Figure 3. c) **Scale**, capable of weighing at least 100 g and readable to 0.001 g.
Procedure	**1.** The test powder and the reference powder shall be mixed under the same conditions with the same mass of additives, including lubricant, each taken from the same batch, to produce the composition of the sintered components for which the powder is required. A test powder supplied ready for pressing shall be tested in the as-received condition. To avoid the possibility of distortion during sintering, it is recommended that the test pieces should not be less than 5 mm thick. **2.** Measure, to the nearest 0.005 mm, the test dimension (diameter or length) of the die in the unloaded condition and record the value d_1) obtained.

IS 12571 : 1988 / Method for determination of green strength by transverse rupture of rectangular compacts of metallic powder

Scope	This standard specifies a method for determination of green strength by measuring the transverse rupture strength of compacts of rectangular cross-section.
Principle	The test consists of subjecting a compact pressed from metallic powder to a uniformly increasing transverse force under controlled conditions until fracture occurs. The transverse rupture strength, or green strength as used herein, is the stress, calculated from the flexure formula, required 10 break the compact as a simple beam supported near the ends and applying the force midway between the fixed centres of the supports.
Apparatus	a) **Die** — Preferably of cemented carbide or alternatively of tool steel, and two punches for producing rectangular test pieces with dimensions according to 4.

	b) **Press** – Capable of applying forces UP to about 300 kN with a minimum accuracy of A2 percent and adjustable to permit an even increase of force at a rate not higher than 50 kN/s. c) **Balance** — Capable of weighing the compacts to an accuracy of ± 0.01 g.
Procedure	**1. Cleaning of the Die and Punches** - Wipe the die cavity and the punches with soft and clean paper towelling soaked with an appropriate solvent, such as acetone. Allow the solvent to evaporate. **2. Powder Testing Conditions** Powder which do not contain a lubricant can be compacted in the following ways: **a.** In a dry die, **b.** In a die with lubricated walls (*see* 5.3.1), or **c.** After admixing a lubricant (*see* 5.3.2) and in a dry die

IS 12783 : 1989 - Hardmetals - Vickers hardness test

Scope	This standard specifies the method of conducting vickers hardness test for hardmetals.
Principle	A diamond indenter in the form of a right pyramid with a square base and a specified angle α between opposite faces at the vertex, is forced into the surface of the hardmetal test piece under the test force F (see Fig. 1). The diagonal d of the indentation left in the surface, after removal of the test force F, is measured (see Fig. 2).
Testing Equipment	**a) Testing Machine** Capable of applying a predetermined force (s) within the range of 9.807 N to 490.3 N (HV 1 to HV 50) in accordance with IS 1754 (Part 1) : 1986. **b) Indenter** Consists of a diamond in the form of a right pyramid with square base. The angle at the vertex between opposite faces of the indenter is 136 ± 0.5° (see Fig. 1).
Procedure	**1.** The test is carried out at ambient temperature unless otherwise stated. **2.** Throughout the test the testing equipment should be protected from shock or vibration. **3.** The test force shall be within the range of 9.0807 N (HV 1 > to 490.3 N (HV 50), the preferred force being 294.2 N (HV 30). **4.** The test piece shall be placed firmly on a rigid support. The contact surfaces shall be clean and free from foreign matter (scale, oil, dirt, etc). It shall be ensured that the test piece lies

	firmly on the support so that displacement cannot occur during the test.

IS 13780 : 2020 / ISO 4506 : 2018 - Hardmetals Compression Test

Scope	This document specifies a method of determining the ultimate strength and proof stress of cemented carbide under uniaxial compressive loads.
Principle	Axial loading of a test piece, placed between two cemented carbide or pcd (polycrystalline diamond) coated cemented carbide bearing blocks at room temperature, until the intended deformation occurs or until the test piece fractures.
Apparatus	a) The test machine shall be designed and constructed so that loads can be applied at a uniform rate and so that, within the measuring range in question, the maximum loading error will be ±1 %. b) The test piece shall be affixed between two well-centred and rigidly secured cemented carbide anvils with a hardness not less than 1800 HV. These contact surfaces shall be perpendicular to the loading axis and parallel to each other within 0,5 µm/mm. An example of a suitable anvil is given in Figure 1.
Procedure	1. **Rate of stress increase:** The rate at which the load is applied shall be as uniform as possible, and any changes in this rate shall be made gradually and without shock. The rate shall not exceed 8000 N/s, corresponding approximately to 100 N/(mm^2 × s). 2. **Determination of proof stress:** The proof stress, for example the 0.2 % proof stress, is determined according to Figure 3. This method is based on the fact, valid for almost all metals, that if a load is removed after the elastic limit, D, has been exceeded, the load-compression curve will follow a linear path that is roughly parallel to the loading curve below the elastic limit.

IS 13781 : 1993 / ISO 4003:1977 - Permeable sintered metal materials - Determination of bubble test pore size

Scope	This International Standard specifies a method, known as the bubble test method, for the determination of the pore size of permeable sintered powder metallurgical materials, i.e. filters, porous bearings, porous electrodes and other parts with interconnected porosity.
Definition	**Bubble test pore size :** The maximum equivalent capillary diameter in the test piece which is calculated from the measured minimum pressure

	required to force the first bubble of gas through the test piece (under standardized conditions) impregnated with a liquid. The first bubble of gas will form at the pore having the greatest throat, the throat being the narrowest section of this pore.
Apparatus	a) **Dry and filtered gas (generally air) supply**, at an adequate pressure. b) **Pressure regulator** affording constant and precise control of the gas pressure, i.e. a gradual increase of the pressure at a predetermined rate, or a stepwise increase of pressure and the facility to maintain a constant pressure at each step. c) **Flow-meter,** if required
Procedure	**1.** The test piece shall be clean, dry and free from extraneous material and any trace of grease or similar substances likely to hinder the perfect and uniform wetting action of the test liquid. **2.** Impregnate the test piece completely with the test liquid insert it in the bubble test apparatus and maintain it fixed, immersed under the smallest depth of test liquid consistent with the convenient observation of the appearance of the bubbles. Measure this depth h (see the figure) and the temperature of the liquid.

IS 13782 : 1993 / ISO 4022:1987 - Permeable sintered metal materials - Determination of fluid permeability

Scope	This International Standard specifies a method for the determination of the fluid permeability of permeable sintered metal materials in which the porosity is deliberately continuous or interconnecting, testing being carried out under such conditions that the fluid permeability can be expressed in terms of viscous and inertia permeability coefficients (see annex A).
Apparatus	**Equipment** The choice of apparatus is mainly dictated by the size, shape and physical characteristics of the test piece. This International Standard refers to two different types of apparatus suitable for determining the fluid permeability of porous test pieces.
Procedure	**1. Measurement of thickness and area of the test piece** a) **Flat test pieces:** The size of micrometer anvils shall not be larger than the size of the surface irregularities, nor smaller than the pore size. b) The test area is defined as that area normal to the direction of fluid flow, and, provided that the pressure gradient is uniform, this definition is meaningful and the test area is readily **2. Measurement of pressure drop**

	The pressure drop may be determined either by measuring the upstream and downstream pressures separately and taking the difference or by using a differential pressure gauge. The apparatus correction is obtained by using the equipment with no test piece in place and observing the pressure drop over the required range of flow rates. The apparatus correction should preferably not exceed 10 % of the pressure drop (see the table).

IS 13803 : 1993 / ISO 3312:1987 - Sintered metal materials and hardmetals - Determination of young modulus

Scope	This International Standard specifies a method for the determination of the dynamic (adiabatic) Young modulus by longitudinal oscillations of sintered metal materials and hardmetals.
Apparatus	a) **Fixture**, for mounting test piece. b) **Ultrasonic oscillator**, having a continuous control of frequencies in the range from 20 to 100 kHz. c) **Device**, for determining resonance frequency.
Procedure	**1.** Determine the density of the test piece to the nearest 0.0l g/cm^3 according to IS0 2738. **2.** Measure the length of the test piece to the nearest 0.1 mm. **3.** Mount the test piece in the apparatus Smoothly increase the frequency of the oscillator until the lowest frequency of the natural longitudinal oscillations of the test piece is obtained. Determine the resonance frequency to the nearest 50 Hz.

IS 15554 : 2018 / ISO 2740 : 1999 - Sintered metal materials excluding hardmetals - Tensile test pieces First Revision

Scope	This International Standard is applicable to all sintered metals and alloys, excluding hardmetals. This International Standard specifies: – the die cavity dimensions used for making tensile test pieces by pressing and sintering, and by Metal Injection Moulding (MIM) and sintering; – the dimensions of tensile test pieces machined from sintered and powder forged materials.
Method of testing	**1.** Test pieces shall be tested in accordance with ISO 6892, and the tensile test machine shall be calibrated to Class 1, in accordance with ISO 7500-1. **2.** Data are to be reported for three or more test pieces.

IS 15567 : 2020 / Sintered Metal Materials Excluding Hardmetals Fatigue Test Pieces First Revision

Scope	This document specifies — the die cavity dimensions used for making fatigue test pieces by pressing and sintering, together with certain dimensions of the test piece obtained from such a die, and — the dimensions of the test pieces machined from sintered and powder forged materials. This document is applicable to all sintered metals and alloys, excluding hardmetals.
Test specifications	**Pressed and sintered test pieces for fatigue test by reverse bend and axial testing** **1. General:** The pressed and sintered piece may also be subjected to further treatment, such as sizing, polishing or heat treatment. If such treatments are applied, they shall be stated in the test report. In a metallographically examined cross section of a test piece, in the gauge region, the piece shall show no micro-lamination greater than 0.25 mm in length. The press tool shall be maintained in a good condition to avoid excessive burr. The edges of the sintered parts shall be broken in the gauge area to remove any burr from compaction. **2. Test piece specification:** unnotched Figure 2 a) shows a drawing of the unnotched test piece. The flatness and parallelism of 0.1 mm are mandatory. The other dimensions are advisory. **3. Test piece specification:** notched Figure 3 a) shows a drawing of the notched test piece. The flatness and parallelism of 0.1 mm are mandatory. The other dimensions are advisory. As the 5.5 mm tooling radius of the die is subject to wear, the corresponding radius dimension of the test piece shall be reported.

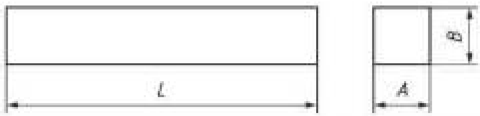
IS 15574 : 2022 / ISO 5754 : 2017 - Sintered metal materials excluding hardmetals Unnotched impact test piece

Scope	This document specifies the dimensions of an unnotched impact test piece of sintered metal materials. The test piece may be obtained directly by pressing and sintering or by machining a sintered part. This document applies to all sintered metals and alloys, with the exception of hardmetals. However, for certain materials (for example, materials with low porosity or materials with high ductility), it may be more appropriate to use a

	notched test piece which, in this case, will give results with less scatter. (In this case, refer to ISO 148-1.) NOTE For porous sintered materials, the results obtained from impact tests are not necessarily very accurate compared with results obtained from tests on solid metals.

The dimensions of the piece shall be those shown in Figure 1.

Dimensions in millimetres



L	*A*	*B*
55 ± 1	10 ± 0,2	10 ± 0,2

Figure 1 — Dimensions of the test piece

IS 15703 : 2018 / ISO 4498 : 2005 -Sintered metal materials excluding hardmetals - Determination of apparent hardness and microhardness

Scope	This International Standard specifies methods of hardness testing of sintered metal materials, excluding hardmetals.
Apparatus	a) **Procedure 1:** Vickers, Brinell and Rockwell hardness testing machines and test methods meeting the requirements of ISO 6506-1, ISO 6507-1 and ISO 6508-1, respectively. b) **Procedure 2:** Vickers and Knoop microhardness testing machines and test methods meeting the requirements of ISO 4516.
Sampling	**1.** Since the apparent hardness of a sintered material is affected by density, which can vary throughout a part, the position of the hardness indentations, for the purpose of quality control, shall be agreed between the parties. **2.** The sintered metal surface shall be clean, smooth and flat to obtain well-defined hardness indentations. Test samples will have anvil-support surfaces filed or ground flat wherever practicable, so as to prevent burrs from affecting results. This is particularly important when determining Vickers and Brinell hardness. Emery paper of 180 to 240 grit is acceptable for grinding. It is generally found sufficient to clean the surface with a suitable solvent. If not, the surface may be lightly polished, provided that laboratory measurements have shown that the influence of such polishing is insignificant.

Test procedures	**1. Procedure 1 — Determination of apparent hardness** a) The tests shall be carried out in accordance with the requirements of ISO 6506-1, ISO 6507-1 or ISO 6508-1, but also with the additional requirements given in 5.1.2 to 5.1.5. b) The hardness class to which a test piece belongs shall be determined by Vickers hardness testing using a test force of 49,03 N (HV 5). The test conditions shall then be selected from Table A.1 according to the class determined. Details of the conditions for the Rockwell test are given in Table A.2. **2. Procedure 2 — Determination of microhardness** a) When determining the microhardness of surface-treated material (as described in 1.3), reference shall be made to ISO 4516 for test conditions (precautions, load, velocity and direction of application of the force). Figure 1 shows an indication of the force to be used as a function of the thickness of material which has undergone surface modification by one of the methods listed in 1.3. b) When determining the microhardness of the metal phase, the use of the test forces in Table A.3 is recommended for Vickers microhardness. In the case of Knoop microhardness, 0,981 N is the most commonly used test force.

IS 17074 : 2019 / ISO 13517 : 2013 - Metallic powders - Determination of flow rate by means of a calibrated funnel Gustavsson Flowmeter

Scope	This International Standard specifies a method for determining the flow rate of metallic powders, including powders for hardmetals and mixes of metallic powders and organic additives such as lubricants, by means of a calibrated funnel (Gustavsson flowmeter). The method is applicable only to powders which flow freely through the specified test orifice.
Apparatus	a) **Calibrated funnel**, with the dimensions shown in Figure 1 (see Clause 4). The dimensions shown for the flowmeter funnel, including the orifice, are not to be considered controlling factors. Calibration with emery, as specified in Clause 4, determines the working flow rate of the funnel. The funnel shall be made of a non-magnetic, corrosion-resistant metallic material with sufficient wall thickness and hardness to withstand distortion and excessive wear.1) b) **Stand and horizontal vibration-free base**, to support the funnel rigidly, e.g. as indicated in Figure 21). c) **Balance,** of sufficient capacity, capable of weighing the test portion to an accuracy of ± 0.05 g. d) **Stopwatch**, capable of measuring the elapsed time to an accuracy of ± 0.1 s.
Sampling	**1.** The mass of the test sample shall be at least 200 g. **2.** In general, the powder shall be tested in the as-received condition. In certain cases, and after agreement between the supplier and user, the

		powder may be dried. However, if the powder is susceptible to oxidation, the drying shall take place in a vacuum or in inert gas. If the powder contains volatile substances, it shall not be dried.
	3.	Immediately before the test, weigh out a 50 ± 0.1 g test portion.
	4.	Alternatively, a test portion of 90 to 110 g can be sampled and weighed to a precision of ± 0.1 g or better.
Procedure	**1.**	Transfer the test portion to the funnel, keeping the discharge orifice closed by a dry finger. Take care that the stem of the funnel is filled with powder. Start the stopwatch (3.4) when the orifice is opened and stop it at the instant when the last of the powder leaves the orifice. Record the elapsed time measured to the nearest 0.1 s.
	2.	Alternatively, the orifice can be kept open, when the test portion is transferred to the funnel with the rest of the procedure being the same.

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