

*Lab*   
Standard Methods



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## Technical Capability

Measurement	Instruments Used
Surface Area using Nitrogen	Autosorb, Nova, Quadrasorb, Monosorb
Surface Area using Argon	Autosorb, Nova, Quadrasorb, Monosorb
Surface Area using Krypton	Autosorb, Quadrasorb, Monosorb
Pore Size and Volume by Gas Adsorption	Autosorb, Nova, Quadrasorb
High Pressure Gas Sorption Measurement	iSorb
Heat of Adsorption	Aquadyne, Vstar, iSorb, Autosorb, ChemStar
Water Sorption	Aquadyne, Vstar
Chemisorption	Autosorb, ChemStar, ChemBET Pulsar
Pore Size and Volume by Mercury Porosimetry	PoreMaster
Pore Size and Volume by Capillary Flow Porometry	Porometer
True Density, Open- and Closed Cell Content by Gas Pycnometry	Ultrapycnometer, MicroUltrapyc
Foam Fracture and Compressibility by Gas Pycnometry	Ultrapycnometer, MicroUltrapyc
Tapped Packing Density/Bulk Density	Dual Autotap, PoreMaster
Particle Size Distribution by Laser Diffraction, Wet or Dry	Particle Size Analyzer
Sample Preparation	Riffler

## ASTM: Bulk and Tapped Density

Number	Title	Abstract	Reference Number
B527 - 15	Standard Test Method for Tap Density of Metal Powders and Compounds	This test method specifies a method for the determination of tap density (packed density) of metal powders and compounds.	10.1520/B0527-15
D4164-13	Standard Test Method for Mechanically Tapped Packing Density of Formed Catalyst and Catalyst Carriers	This test method covers the determination of the mechanically tapped density of formed catalyst and catalyst carriers. This test is best used for formed particles that will not break up during sampling, filling, or tapping of the measuring cylinder under test conditions.	10.1520/D4164
D4781-03(2013)	Standard Test Method for Mechanically Tapped Packing Density of Fine Catalyst Particles and Catalyst Carrier Particles	This test method covers the determination of the mechanically tapped packing density of fine catalyst and catalyst carrier particles smaller than 0.8 mm in diameter.	10.1520/D4781-03R13

## ASTM: Capillary Flow Porometry

Number	Title	Abstract	Reference Number
D6767-16	Standard Test Method for Pore Size Characteristics of Geo-textiles by Capillary Flow Test	This test method covers the determination of the pore size distribution of geo-textile filters with pore sizes ranging from 1 to 1000 $\mu\text{m}$ .	10.1520/D6767-14
E128-99(2011)	Standard Test Method for Maximum Pore Diameter and Permeability of Rigid Porous Filters for Laboratory Use	This test method covers the determination of maximum pore diameter and permeability of rigid porous filters used in the laboratory for filtration or diffusion. They are applicable to filters made of sintered glass, ceramic, metal, or plastic. This test method establishes a uniform designation for maximum pore diameter and also provides a means of detecting and measuring changes which occur through continued use.	10.1520/E0128-99R11
F316-03(2011)	Standard Test Methods for Pore Size Characteristics of Membrane Filters by Bubble Point and Mean Flow Pore Test	These test methods cover the determination of two of the pore size properties of membrane filters with maximum pore sizes from 0.1 to 15.0 $\mu\text{m}$ . Test Method A presents a test method for measuring the maximum limiting pore diameter of non-fibrous membranes. The limiting diameter is the diameter of a circle having the same area as the smallest section of a given pore. Test Method B measures the relative abundance of a specified pore size in a membrane, defined in terms of the limiting diameter.	0.1520/F0316-03R11

## ASTM: Chemisorption

Number	Title	Abstract	Reference Number
D3908-03(2015)	Standard Test Method for Hydrogen Chemisorption on Supported Platinum Catalysts by Volumetric Vacuum Method	This test method covers the determination of the chemisorption of hydrogen at 298K (25°C) on supported platinum catalysts that have been reduced in flowing hydrogen at 723K (450°C). It incorporates a static volumetric vacuum technique at constant volume.	10.1520/D3908-03R15
D4824-13	Standard Test Method for Determination of Catalyst Acidity by Ammonia Chemisorption	This test method covers the determination of acidity of catalysts and catalyst carriers by ammonia chemisorption. A volumetric measuring system is used to obtain the amount of chemisorbed ammonia.	10.1520/D4824
D5160-95(2014)	Standard Guide for Gas-Phase Adsorption Testing of Activated Carbon	This guide covers the evaluation of activated carbons for gas-phase adsorption. It presents a procedure for determining the dynamic adsorption capacity, and critical bed depth, for an activated carbon used to remove a specific adsorbate from a gas stream under conditions chosen by the user.	10.1520/D5160-95R14
D5228-16	Standard Test Method for Determination of Butane Working Capacity of Activated Carbon	This test method covers the determination of the butane working capacity (BWC) of new granular activated carbon. The BWC is defined as the difference between the butane adsorbed at saturation and the butane retained per unit volume of carbon after a specified purge. The test also produces a butane activity value defined as the total amount of butane adsorbed on the carbon sample and is expressed as a mass of butane per unit weight or volume of carbon.	10.1520/D5228-92R15
D5742-16	Standard Test Method for Determination of Butane Activity of Activated Carbon	This test method covers determination of the activation level of activated carbon. Butane activity (BA) is defined herein as the ratio (in percent) of the mass of butane adsorbed by an activated carbon sample to the mass of the sample, when the carbon is saturated with butane under the conditions listed in this test method.	10.1520/D5742-95R15

## ASTM: Helium Pycnometry: True Density, Open and Closed Cell Content

Number	Title	Abstract	Reference Number
B923-16	Standard Test Method for Metal Powder Skeletal Density by Helium or Nitrogen Pycnometry	The performance of many sintered or cast metal structures may be predicted from the skeletal density of the starting metal. This test method covers determination of skeletal density of metal powders.	10.1520/B0923-10
C110-16	Standard Test Methods for Physical Testing of Quicklime, Hydrated Lime, and Limestone	These test methods cover physical testing of quicklime and hydrated lime, and of limestone. It includes methods for density measurement.	10.1520/C0110-15
C604-02(2012)	Standard Test Method for True Specific Gravity of Refractory Materials by Gas-Comparison Pycnometer	This test method covers the determination of the true specific gravity of solid materials, and is particularly useful for materials that easily hydrate and react with water.	10.1520/C0604-02R12
D2638-10(2015)e1	Standard Test Method for Real Density of Calcined Petroleum Coke by Helium Pycnometer	This test method covers the determination of the real density of calcined petroleum coke. Real density, by definition is obtained when the particle size of the specimen is smaller than 75 $\mu\text{m}$ (U.S. No. 200 Sieve).	10.1520/D2638-10R15E01

## ASTM: Helium Pycnometry: True Density, Open and Closed Cell Content

Number	Title	Abstract	Reference Number
D4892-14	Standard Test Method for Density of Solid Pitch (Helium Pycnometer Method)	This test method covers the determination of pitch density by helium pycnometer. It is applicable at a range of room temperatures of 15 to 35°C.	10.1520/D4892
D5550-14	Standard Test Method for Specific Gravity of Soil Solids by Gas Pycnometer	This test method covers the determination of the specific gravity of soil solids by means of a gas pycnometer.	10.1520/D5550-14
D5965-02(2013)	Standard Test Methods for Specific Gravity of Coating Powders	This method provides three procedures for determining the specific gravity of coating powders, including the use of helium pycnometry for testing with the greatest precision.	10.1520/D5965
D6093-97(2016)	Standard Test Method for Percent Volume Nonvolatile Matter in Clear or Pigmented Coatings Using a Helium Gas Pycnometer	This test method covers the determination of the percent volume nonvolatile matter of a variety of clear and pigmented coatings. The technique should provide faster and more accurate results than the use of the liquid displacement technique in Test Method D2697, particularly for coatings that are difficult to wet or that contain voids, cracks or other defects.	10.1520/D6093-97R11
D6226-15	Standard Test Method for Open Cell Content of Rigid Cellular Plastics	This method covers the open/closed cell content of cellular plastics. It is a porosity determination, measuring the accessible cellular volume of a material.	10.1520/D6226-15

## ASTM: Mercury Porosimetry

Number	Title	Abstract	Reference Number
D4284-12	Standard Test Method for Determining Pore Volume Distribution of Catalysts and Catalyst Carriers by Mercury Intrusion Porosimetry	This test method covers the determination of the pore volume distributions of catalysts and catalyst carriers by mercury intrusion porosimetry in the range of 100 to 0.003 $\mu\text{m}$ .	10.1520/D4284-12
D4404-10	Standard Test Method for Determination of Pore Volume and Pore Volume Distribution of Soil and Rock by Mercury Intrusion Porosimetry	This test method covers the determination of the pore volume and the pore volume distributions of soil and rock by mercury intrusion porosimetry.	10.1520/D4404-10
D6761-07(2012)	Standard Test Method for Determination of the Total Pore Volume of Catalysts and Catalyst Carriers	This test method covers the determination of the total pore volume of catalysts and catalyst carriers, that is, the volume of pores having pore diameter between approximately 14 $\mu\text{m}$ and 0.4 nm.	10.1520/D6761-07R12
F2450-10	Standard Guide for Assessing Microstructure of Polymeric Scaffolds for Use in Tissue-Engineered Medical Products	This guide covers an overview of test methods that may be used to obtain information relating to the dimensions of pores, the pore size distribution, the degree of porosity, interconnectivity, and measures of permeability for porous materials used as polymeric scaffolds in the development and manufacture of tissue-engineered medical products (TEMPs).	10.1520/F2450-10

## ASTM: Particle Size

Number	Title	Abstract	Reference Number
B822-10	Standard Test Method for Particle Size Distribution of Metal Powders and Related Compounds by Light Scattering	This test method covers the determination of the particle size distribution of catalyst, catalyst carrier, and catalytic raw material particles and is one of several found valuable for the measurement of particle size. The range of average particle sizes investigated is from 1 to 300 $\mu\text{m}$ equivalent spherical diameter.	10.1520/B0822-10
D4464-15	Standard Test Method for Particle Size Distribution of Catalytic Materials by Laser Light Scattering	This test method covers the determination of the particle size distribution by light scattering, reported as volume percent, of particulate materials in the range of 0.4 to 2000 $\mu\text{m}$ . This method applies to analyses with both aqueous and non-aqueous dispersions. In addition, analysis can be performed with a gaseous dispersion for materials that are hygroscopic or react with a liquid carrier.	10.1520/D4464-15

## ASTM: Pore Size and Volume by Gas Adsorption

Number	Title	Abstract	Reference Number
D4222-03(2015)e1	Standard Test Method for Determination of Nitrogen Adsorption and Desorption Isotherms of Catalysts and Catalyst Carriers by Static Volumetric Measurements	This test method covers the determination of nitrogen adsorption and desorption isotherms of catalysts and catalyst carriers at liquid nitrogen temperature. A static volumetric measuring system is used to obtain sufficient equilibrium adsorption points on each branch of the isotherm to adequately define the adsorption and desorption branches.	10.1520/D4222-03R15E01
D4365-13	Standard Test Method for Determining Micropore Volume and Zeolite Area of a Catalyst	This test method covers the determination of total surface area and mesopore area for zeolites. The micropore volume is related to the percent zeolite in the catalyst. The zeolite area, a number related to the surface area within the zeolite pores, may also be calculated.	10.1520/D4365
D4641-12	Standard Practice for Calculation of Pore Size Distributions of Catalysts and Catalyst Carriers from Nitrogen Desorption Isotherms	This practice covers the calculation of pore size distributions for catalysts and catalyst carriers from nitrogen desorption isotherms. The computational procedure is particularly useful for determining how the pore volume is distributed in catalyst samples containing pores whose radius ranges from approximately 1.5 to 100 nm.	10.1520/D4641-12



## ASTM: Surface Area

Number	Title	Abstract	Reference Number
B922-10	Standard Test Method for Metal Powder Specific Surface Area by Physical Adsorption	This test method covers determination of surface area of metal powders from the multi-point and single point BET methods.	10.1520/B0922-10
C1069-09(2014)	Standard Test Method for Specific Surface Area of Alumina or Quartz by Nitrogen Adsorption	This test method covers the determination of the specific surface area of aluminas and silicas used in the manufacture of ceramics.	10.1520/C1069-09R14
C1274-12	Standard Test Method for Advanced Ceramic Specific Surface Area by Physical Adsorption	This test method determines the specific surface area of solid ceramic materials based on multilayer physisorption of gas using the Brunaur, Emmett, Teller (BET) method and IUPAC recommendations (1984, 1994). The method includes specific outgassing procedures for common ceramics such as amorphous and crystalline silicas, TiO <sub>2</sub> and kaolin.	10.1520/C1274-12
D1993-03(2013)e1	Standard Test Method for Precipitated Silica-Surface Area by Multipoint BET Nitrogen Adsorption	This test method focuses on the surface area measurement of precipitated hydrated silicas using the BET method for multi-point determinations.	10.1520/D1993-03R13E01
D3663-03(2015)	Standard Test Method for Surface Area of Catalysts and Catalyst Carriers	This test method covers the determination of surface areas of catalyst and catalyst carriers that have Type II or IV nitrogen adsorption isotherms, and at least 1 m <sup>2</sup> /g of area. A volumetric measuring system is used to obtain at least four data points which fit on the linear BET2 equation line.	10.1520/D3663-03R15

## ASTM: Surface Area

Number	Title	Abstract	Reference Number
D4567-03(2013)	Standard Test Method for Single-Point Determination of Specific Surface Area of Catalysts and Catalyst Carriers Using Nitrogen Adsorption by Continuous Flow Method	This test method covers the single-point determination of the surface area of catalysts and catalyst carriers that exhibit Type II or Type IV nitrogen adsorption isotherms using a nitrogen-helium flowing gas mixture. This test method is applicable for the determination of total surface areas from 0.1 to 300 m <sup>2</sup> , where rapid surface area determinations are desired.	10.1520/D4567
D4780-12	Standard Test Method for Determination of Low Surface Area of Catalysts and Catalyst Carriers by Multipoint Krypton Adsorption	This test method covers the determination of the specific surface area of catalysts and catalyst carriers in the range from 0.05 to 10 m <sup>2</sup> /g. A volumetric measuring system is used to obtain at least three data points which fall within the linear BET region.	10.1520/D4780-12
D5604-96(2012)	Standard Test Methods for Precipitated Silica—Surface Area by Single Point B.E.T. Nitrogen Adsorption	This test method covers a procedure to measure the surface area of precipitated hydrated silicas by a single point approximation of the BET theory of multilayer gas adsorption. Quality control applications and comparative tests on near-identical samples of close chemical and micro-structural composition are likely to be the applications of greatest value.	10.1520/D5604-96R12
D6556-16	Standard Test Method for Carbon Black—Total and External Surface Area by Nitrogen Adsorption	This test method is used to measure the total and external surface area of carbon blacks based on multi-point nitrogen adsorption. Measurements are based on the BET theory and include the total surface area and micropores less than 2 nm. The external surface area, based on the statistical thickness method (STSA), is defined as the specific surface area that is accessible to rubber.	10.1520/D6556-16

## DIN Standards

Number	Title
66133	Determination of Pore Volume Distribution and Specific Surface Area of Solids by Mercury Intrusion
66134	Determination of the pore size distribution and the specific surface area of mesoporous solids by means of nitrogen sorption - Method of Barrett, Joyner and Halenda (BJH)
66135-1	Particle Characterization - Micropore Analysis by Gas Adsorption - Part 1: Fundamentals and Testing Procedure
66135-2	Particle Characterization - Micropore Analysis by Gas Adsorption – Part 2: Evaluation by Isotherms Comparison
66135-3	Particle characterization - Micropore analysis by gas adsorption - Part 3: Determination of the micropore volume according to Dubinin and Radushkevich
66135-4	Particle size analysis - Micropore analysis by gas adsorption - Part 4: Determination of pore distribution according to Horvath-Kawazoe and Saito-Foley

## ISO: Bulk and Tapped Density

Number	Title	Abstract	Reference Number
ISO 787-11:1981	General methods of test for pigments and extenders -- Part 11: Determination of tamped volume and apparent density after tamping	This method provides a means to determining tamped (tapped) volume and density via sieving a dried sample into graduated cylinder and tapping for a set number of revolutions until there is a less than 2mL change in tamped volume.	87.060.10
ISO 3953:2011	Metallic powders -- Determination of tap density	This 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.	77.160
ISO 8460:1987	Instant coffee -- Determination of free-flow and compacted bulk densities	The principle of the determination of the free-flow bulk density consists in pouring a sample through a specified funnel into a specified receptacle of known volume and weighing the contents of the receptacle. In order to determine the compacted bulk density a volume of a given mass of the product shall be measured after a fixed number of taps (usually 300) in a tapping volumeter.	67.140.20
ISO 8967:2005	Dried milk and dried milk products -- Determination of bulk density	This method is used for the determination of the bulk density of dried whole milk, dried partly skimmed milk and dried skimmed milk, whether non-instant or instant.	67.100.10

## ISO: Capillary Flow Porometry

Number	Title	Abstract	Reference Number
ISO 4003-1977	Permeable sintered metal materials – Determination of bubble test pore size	This specifies a method for the determination of the pore size of filters, porous bearings, porous electrodes and other parts with interconnected porosity. The bubble test shall be considered as a quality control test and not as a test for defining filter grades or determining exact pore size and pore size distribution.	77.160

## ISO: Helium Pycnometry: True Density, Open and Closed Cell Content

Number	Title	Abstract	Reference Number
ISO 787-10:1993	General methods of test for pigments and extenders -- Part 10: Determination of density -- Pycnometer method	Describes common sampling method, expression of results and test report for two methods of density determination using a pycnometer (method A and B) as well as their apparatus and procedure in detail.	87.060.10
ISO 4590:2002	Rigid cellular plastics -- Determination of the volume percentage of open cells and of closed cells	This method specifies a general procedure for the determination of volume percentage of open and closed cells of rigid cellular plastics by measurement of the geometrical and air-impenetrable volumes of test specimens. The procedure includes the correction of the apparent open-cell volume by taking into account the surface cells opened by cutting during specimen preparation.	83.100
ISO 8130-2:1992	Coating powders -- Part 2: Determination of density by gas comparison pycnometer (referee method)	This method can be used for all types of coating powder. It is based on the determination of the volume of a weighed test portion by measuring the volume of the gas displaced. This is achieved by equalizing the pressure difference which arises due to the displacement of the gas.	87.040
ISO 12154:2014	Determination of density by volumetric displacement -- Skeleton density by Gas Pycnometry	This method specifies an efficient determination of the skeleton density of solid material samples of regular or irregular shape, whether powdered or in one piece, by means of a gas displacement pycnometer.	19.120

## ISO: Mercury Porosimetry

Number	Title	Abstract	Reference Number
ISO 15901-1:2016	Evaluation of pore size distribution and porosity of solid materials by mercury porosimetry and gas adsorption -- Part 1: Mercury porosimetry	This method describes the evaluation of the pore size distribution and the specific surface area of pores in solids by mercury porosimetry. It is a comparative test, usually destructive due to mercury contamination, in which the volume of mercury penetrating a pore or void is determined as a function of an applied hydrostatic pressure, which can be related to a pore diameter.	19.120

## ISO: Particle Size

Number	Title	Abstract	Reference Number
ISO 13320:2009	Particle size analysis -- Laser diffraction methods	This method provides guidance on instrument qualification and size distribution measurement of particles in many two-phase systems (e.g. powders, sprays, aerosols, suspensions, emulsions and gas bubbles in liquids) through the analysis of their light-scattering properties. It is applicable to particle sizes ranging from approximately 0.1 µm to 3 mm.	19.120

## ISO: Pore Size and Volume by Gas Adsorption

Number	Title	Abstract	Reference Number
ISO 15901-2:2006	Pore size distribution and porosity of solid materials by mercury porosimetry and gas adsorption -- Part 2: Analysis of mesopores and macropores by gas adsorption	This method describes the evaluation of porosity and pore size distribution by gas adsorption. The method is limited to the determination of the quantity of a gas adsorbed per unit mass of sample at a controlled, constant temperature.	19.120
ISO 15901-3:2007	Pore size distribution and porosity of solid materials by mercury porosimetry and gas adsorption -- Part 3: Analysis of micropores by gas adsorption	This method describes the evaluation of the volume of micropores (pores of internal width less than 2 nm) and the specific surface area of microporous material by low-temperature adsorption of gases. The methods use physisorbing gases that can penetrate into the pores under investigation.	19.120

## ISO: Surface Area

Number	Title	Abstract	Reference Number
ISO 4652:2012	Rubber compounding ingredients -- Carbon black -- Determination of specific surface area by nitrogen adsorption methods -- Single-point procedures	This standard specifies a method for the determination of the single point specific surface area of types and grades of carbon black for use in the rubber industry.	83.040.20
ISO 8008:2005	Aluminum oxide primarily used for the production of aluminum -- Determination of specific surface area by nitrogen adsorption	This standard provides a method for the determination of specific surface area of smelter-grade alumina by nitrogen adsorption by a single- or multi-point method.	71.100.10
ISO 9277:2010	Determination of the specific surface area of solids by gas adsorption – BET method	This method specifies the determination of the overall specific external and internal surface area of disperse or porous solids by measuring the amount of physically adsorbed gas according to the BET method. It takes account of the International Union for Pure and Applied Chemistry (IUPAC) recommendations of 1984 and 1994.	19.120
ISO 18757:2003	Fine ceramics (advanced ceramics, advanced technical ceramics) -- Determination of specific surface area of ceramic powders by gas adsorption using the BET method	This method provides guidelines for the determination of the total specific external and internal surface area of disperse or porous fine ceramic materials by measuring the amount of physically adsorbed gas according to the BET method. This standard only focuses on specific details relevant to fine ceramic materials.	81.060.30
ISO 18852:2015	Rubber compounding ingredients -- Determination of multi-point nitrogen surface area (NSA) and statistical thickness surface area (STSA)	This method specifies the determination of the nitrogen surface area (NSA) of carbon blacks and other rubber compounding ingredients, like silicas and zinc oxides, based on the Brunauer, Emmett and Teller (BET) theory of gas adsorption using a multi-point determination as well as the determination of the statistical thickness surface area (STSA), otherwise known as the external surface area.	83.040.20

## IUPAC

Number	Title	Abstract	Reference Number
Pure and Applied Chemistry., 84, 107-136 (2012)	Liquid intrusion and alternative methods for the characterization of macroporous materials (IUPAC Technical Report)	This document deals with the characterization of porous materials having pore widths in the macropore range of 50 nm to 500 $\mu\text{m}$ . In recent years, the development of advanced adsorbents and catalysts (e.g., monoliths having hierarchical pore networks) has brought about a renewed interest in macropore structures. Mercury intrusion-extrusion porosimetry is a well-established method, which is at present the most widely used for determining the macropore size distribution.	10.1351/PAC-EP-10-11-19
Pure Appl. Chem., 87, 1051-1069 (2015)	Physisorption of gases, with special reference to the evaluation of surface area and pore size distribution (IUPAC Technical Report)	Gas adsorption is an important tool for the characterization of porous solids and fine powders. Major advances in recent years have made it necessary to update the 1985 IUPAC manual on Reporting Physisorption Data for Gas/Solid Systems. The aims of the present document are to clarify and standardize the presentation, nomenclature and methodology associated with the application of physisorption for surface area assessment and pore size analysis and to draw attention to remaining problems in the interpretation of physisorption data.	10.1515/pac-2014-1117



## MPIF Standards

Number	Title
01	Sampling Metal Powders
46	Determination of Tap Density of Metal Powders
63	Density Determination of MIM Components (Gas Pycnometer)

## USP Standards

Number	Title
267	Porosimetry by Mercury Intrusion
268	Porosity By Nitrogen Adsorption-Desorption
429	Light Diffraction Measurement of Particle Size
616	Bulk Density (Method I) and Tapped Density (Method II) of Powders
699	Density of Solids - Gas Pycnometry
846	Specific Surface Area