2024 CATALOG

MATERIALS TESTING & RESEARCH CENTER

DESCRIPTION OF SERVICES OFFERED

The Materials Testing & Research Center (MTRC) is an independent research and referee testing laboratory, specializing in the evaluation of refractory, glass, whiteware, carbon, insulation, and advanced ceramic materials. It is operated by The Edward Orton Jr. Ceramic Foundation, a non-profit organization providing products and services to the ceramic materials community since 1896.

For an overview of the center operations and for details on submitting samples, see pages 2 and 3. For additional information contact Mr. Brian Rayner, Senior Manager Testing Services.

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THE ORTON MATERIALS TESTING & RESEARCH CENTER

Background

The Orton Materials Testing and Research Center (MTRC) is an independent, non-profit, laboratory that specializes in ceramic materials, high temperature measurements, and thermal analysis.

Initially, MTRC was known as The Refractories Fellowship Laboratory, which was established in 1917 at the Mellon Institute in Pittsburgh, Pennsylvania. It was relocated to The Ohio State University in Columbus, Ohio in 1965 and renamed the Refractory Research Center. Since 1990, the Center has been operated by the Edward Orton Jr. Ceramic Foundation, which is in Westerville, Ohio, a suburb of Columbus, Ohio.

Center Operation

Testing projects are reviewed for requirements and assigned to one of the MTRC staff. Results of tests are emailed to the customer.

Placing Orders

Please provide a purchase order and description of the materials to be tested along with identification of test work desired. Note that each test has an identifying T number (e.g., T9320), which can be used when placing an order. A request for testing services form is located on the last page of this catalog.

Completion time for a project varies, depending upon the type of test desired and the availability of equipment and personnel. Testing is conducted on a first come, first served basis with a typical turnaround time of 1 to 3 weeks for most tests. Every effort is made to be responsive to the client. If additional expenses are incurred to meet the special needs of the customer, then these will be quoted separately.

Samples And Correspondence

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Freight

Freight must be prepaid. A service charge will be assessed if sent collect.

Sample Identification

The identification of each sample is essential. Whenever possible, include the chemical or generic name(s) for the material(s). Please provide appropriate Safety Data Sheets (SDS).

Sample Sizing and Preparation

Some tests do not include specimen preparation. Specimen preparation is billed at an hourly rate.

Hazardous or Destructive Materials
To protect the health and safety of personnel, any toxic or hazardous materials present in the samples submitted for testing must be disclosed. Also, please advise if any possible toxic or hazardous reactions may occur because of preparing the samples for testing or during testing. When hazardous conditions or reactions that may be destructive to test instrument parts are known or anticipated please advise, so provisions can be made during testing to eliminate injury and minimize damage to testing equipment. If any damage occurs because of negligence by the customer to inform Orton of possible hazardous or destructive materials, all costs of repair or replacement of instrument parts will be included in the invoice.

Return of Materials
All test requests should include instructions for the return of samples if desired. Samples, which are not returned, will be held for six months, then discarded.

Quotations
All quotations and agreements are contingent upon strikes, accidents, fires, availability of materials, and all other causes beyond control of the Edward Orton Jr. Ceramic Foundation.

Billing
Invoices for test work completed are sent following delivery of the test results. Terms are net 30 days. A 3.5% fee is charged for orders paid with credit cards.

Arrangements for payment in U.S. funds need to be made for orders originating outside the United States before work begins.

Test Results
Results should be considered advisory and/or experimental in nature. Neither the Edward Orton Jr. Ceramic Foundation, nor its employees, assumes any obligation or liability for damages, including, but not limited to, consequential damages arising out of or in conjunction with the use, or inability to use, the resulting information.

ADVANCED CERAMIC TEST METHODS

ASTM C-1161 **FLEXURAL STRENGTH OF ADVANCED CERAMICS AT AMBIENT TEMPERATURE-T9763**

Flexural strength is determined in three-point or four-point bending on bars of rectangular cross-section. Testing of ten specimens per type/brand is recommended by ASTM.

ASTM C-1259 **DYNAMIC YOUNG'S MODULUS, SHEAR MODULUS, AND POISSON'S RATIO FOR ADVANCED CERAMICS BY IMPULSE EXCITATION OF VIBRATION-T9767**

A non-destructive sonic method is used to determine the modulus of elasticity and modulus of rigidity for calculation of Poisson's Ratio. Bars of rectangular cross-section are used for the measurements.

ASTM C-1341 **FLEXURAL PROPERTIES OF CONTINUOUS FIBER-REINFORCED ADVANCED CERAMIC COMPOSITES-T9764**

Flexural strength is determined in three-point or four-point bending on bars of rectangular cross-section. Testing of ten specimens per type/brand is recommended by ASTM.

ASTM C-1421 **FRACTURE TOUGHNESS OF ADVANCED CERAMICS AT AMBIENT TEMPERATURE-T9762**

Fracture toughness is determined in three-point or four-point bending on chevron-notched bars of rectangular cross-section. Testing of five specimens per type/brand is recommended by ASTM.

ASTM C-1424 **MONOTONIC COMPRESSIVE STRENGTH OF ADVANCED CERAMICS AT AMBIENT TEMPERATURE-T9907**

The compressive strength is determined on a right cylinder. Testing of at least five specimens per type/brand is recommended by ASTM.

ASTM C-1499 **EQUIBIAXIAL STRENGTH AT AMBIENT TEMPERATURE-T9771**

Equibiaxial strength is determined by concentric ring configurations under monotonic uniaxial loading. Testing of ten specimens per type/brand is recommended by ASTM.

ASTM E-112 **AVERAGE GRAIN SIZE-T9769**

Average grain size is determined by the linear intercept method on a polished section by optical microscopy.

ASTM E-494 **ULTRASONIC VELOCITY IN MATERIALS-T9908**

A non-destructive sonic method is used to determine the longitudinal and transverse velocities for the calculation of the modulus of elasticity, modulus of rigidity, and Poisson's Ratio. Specimens with parallel sides are used for the measurements.

CARBON TEST METHODS

ASTM C-454 DISINTEGRATION OF CARBON REFRACTORIES BY ALKALI-T9540

Ten 2" cube specimens are required by ASTM. A 1" hole is drilled into the face of each specimen and filled with 8 grams of potassium carbonate. The effects of being fired at 1750°F for 5 hours are determined visually.

ASTM C-559 BULK DENSITY BY PHYSICAL MEASUREMENTS OF MANUFACTURED CARBON AND GRAPHITE ARTICLES-T9556

The bulk density is determined using the specimen weight and dimensions.

ASTM C-561 ASH IN A GRAPHITE SAMPLE-T9558

Ash content of graphite materials is determined by oxidation at 950°C. The ash content for two representative specimens per type/brand is determined.

ASTM C-611 ELECTRICAL RESISTIVITY OF MANUFACTURED CARBON AND GRAPHITE ARTICLES AT ROOM TEMPERATURE-T9585

Electrical resistivity of carbon and graphite materials is determined by a DC method. Specimens may be in the form of plates, rods, bars, or tubes. Sixteen measurements per specimen are recommended by ASTM.

ASTM C-651 FLEXURAL STRENGTH OF MANUFACTURED CARBON AND GRAPHITE ARTICLES USING FOUR-POINT LOADING AT ROOM TEMPERATURE-T9587

Flexural strength is determined in four-point bending on specimens of rectangular cross-section.

ASTM C-695 COMPRESSIVE STRENGTH OF CARBON AND GRAPHITE-T9588

The compressive strength is determined on a right cylinder. The diameter of the specimen must be ten times the maximum particle size and the ratio of height to diameter must be between 1.9 and 2.1.

ASTM C-747 MODULI OF ELASTICITY AND FUNDAMENTAL FREQUENCIES OF CARBON AND GRAPHITE MATERIALS BY SONIC RESONANCE-T9600

A non-destructive sonic method is used to determine the modulus of elasticity and modulus of rigidity for calculation of Poisson's Ratio. Bars of rectangular cross-section are used for the measurements.

ASTM C-767 THERMAL CONDUCTIVITY OF CARBON REFRACTORIES-T9610
Same as ASTM C-182

ASTM C-769 SONIC VELOCITY IN MANUFACTURED CARBON AND GRAPHITE MATERIALS FOR USE IN OBTAINING AN APPROXIMATE YOUNG'S MODULUS-T9620

Approximation of Young's Modulus is calculated through sonic velocity measurements in 3 directions. The velocity of sound waves is measured using a James V-meter.

ASTM C-838 **BULK DENSITY OF AS-MANUFACTURED CARBON AND GRAPHITE SHAPES-T9660**

Bulk density is calculated from weight and volume measurements.

ASTM C-1025 **MODULUS OF RUPTURE IN BENDING OF ELECTRODE GRAPHITE-T9747**

Flexural strength is determined in four-point bending on 6" x 1 1/2" x 1 1/2" specimens.

ASTM C-1039 **APPARENT POROSITY, APPARENT SPECIFIC GRAVITY, AND BULK DENSITY OF GRAPHITE ELECTRODES-T9748**

A vacuum is used to determine the apparent porosity, bulk density, liquid absorption, and apparent specific gravity. Testing of five specimens (2" diameter x 7 1/2" high) per type/brand is suggested by ASTM.

FIBROUS INSULATION TEST METHODS

ASTM C-165 COMPRESSIVE PROPERTIES OF THERMAL INSULATIONS-T9404

The compressive resistance is determined on either rigid board or blanket insulation. Specimens can be square or circular with a preferred width or diameter of 6”. Testing of four specimens per type/brand is recommended by ASTM.

ASTM C-167 THICKNESS AND DENSITY OF BLANKET OR BATT THERMAL INSULATIONS-T9405

One representative roll of insulation is required. Density is calculated from weight and dimensional measurements.

ASTM C-203 BREAKING LOAD AND FLEXURAL PROPERTIES OF BLOCK-TYPE THERMAL INSULATIONS-T9403

Flexural strength is determined on 1" x 4" x 12" specimens. Testing of four specimens per type/brand is recommended by ASTM.

ASTM C-303 DENSITY OF PREFORMED BLOCK-TYPE THERMAL INSULATION-T9406

Minimum specimen size is 4” x 8” in cross-section. Density is calculated from weight and dimensional measurements.

ASTM C-356 LINEAR SHRINKAGE OF PREFORMED HIGH-TEMPERATURE THERMAL INSULATION SUBJECTED TO SOAKING HEAT-T9505

Linear shrinkage is determined after a thermal insulating material is exposed to soaking heat for 24 hours. Four 6” x 2 1/2" x 1" or 2" specimens are required by ASTM.

ASTM C-686 PARTING STRENGTH OF FIBROUS INSULATING MATERIAL-T9407

Tensile strength is measured on O-ring specimens. A 5 sq. ft. representative section of insulation should be submitted.

ASTM C-892 UNFIBERIZED SHOT CONTENT OF INORGANIC FIBROUS BLANKETS-T9715

A 10-gram specimen is fired to 2300°F and forced consecutively through No. 30, 50, and 70 screens. Shot content is determined by percent retained on each screen.

ASTM C-892 THERMAL CONDUCTIVITY OF FIBROUS INSULATING MATERIAL-T9716
Same as ASTM C-182

GLASS TEST METHODS

ASTM C-158 **STRENGTH OF GLASS BY FLEXURE-T9501**

Flexural strength is determined in three-point or four-point bending on bars of rectangular or circular cross-section. Between ten to thirty specimens per type/brand is recommended by ASTM.

ASTM C-336 **ANNEALING POINT AND STRAIN POINT OF GLASS BY FIBER ELONGATION-T9502**

The annealing point of a glass is defined as the temperature at which a round fiber, nominally 0.65 mm in diameter, elongates under a load of 1.0 kg at a rate of 0.14 mm/min when it is cooled at a rate of 4°C/min. The strain point is determined by extrapolation of the annealing point data as the temperature at which the elongation rate is 0.0316 times that at the annealing temperature. A representative sample of 50 gram or more of flame workable glass in pieces a minimum of 5 mm in diameter is required. Fritted or ground samples must be remelted to obtain a piece large enough from which fibers can be drawn.

ASTM C-338 **SOFTENING POINT OF GLASS BY FIBER ELONGATION-T9503**

The softening point of a glass is defined as the temperature at which a round fiber, nominally 0.65 mm in diameter and 235 mm long, elongates under its own weight at a rate of 1 mm/min when the upper 100 mm of its length is heated at a rate of 5°C/min. A representative sample of 50 gram or more of flame workable glass in pieces a minimum of 5 mm in diameter is required. Fritted or ground samples must be remelted to obtain a piece large enough from which fibers can be drawn.

ASTM C-598 **ANNEALING POINT AND STRAIN POINT OF GLASS BY BEAM BENDING-T9575**

The annealing point of a glass is defined as the temperature at which a 3-point loaded beam, nominally 3 to 4 mm in cross section on a 50 mm span, elongates under a load of between 0.2 kg and 1.0 kg at a rate determined by the span, load, and moment of inertia when it is cooled at a rate of 4°C/min. The strain point is determined by extrapolation of the annealing point data as the temperature at which the elongation rate is 0.0316 times that at the annealing temperature. Representative specimens, nominally 3 to 4 mm in cross section and 75 mm in length, are required.

ASTM C-657 **DC VOLUME RESISTIVITY OF GLASS-T9577**
Same as D-257.

ASTM C-829 **LIQUIDUS TEMPERATURE OF GLASS BY THE GRADIENT FURNACE METHOD-T9576**

The liquidus temperature is the maximum temperature where equilibrium exists between the amorphous glass and its primary crystalline phase. A sample of about 30 gram is crushed to -20 mesh and placed in a platinum boat with dimensions of 0.5” x 0.5” x 6.0”. The glass specimen is held at a specified temperature gradient over its entire length for a period necessary to obtain thermal equilibrium between the crystalline and glassy phases. The specimen is quenched and viewed with a microscope to determine the glass/crystalline interface location and corresponding temperature.

ASTM C-965 **VISCOSITY OF GLASS ABOVE THE SOFTENING POINT-T9578**

The viscosity of glass above the softening point is determined using a platinum alloy spindle immersed in a platinum crucible of molten glass. The crucible is placed in a vertical tube furnace capable of 1600°C. The viscometer is mounted above the tube furnace and is capable of measuring from 1.5 to 5.0 Poise ($\log_{10}$). About 400 gram of glass is necessary for the test. After the data is collected, it is fit to a Fulcher equation to describe the viscosity/temperature relationship.

<u>ASTM C-1350</u> **VISCOSITY OF GLASS BETWEEN SOFTENING POINT AND ANNEALING RANGE BY BEAM BENDING-T9579**

The viscosity of glass from 10 to 15 Poise ($\log_{10}$) is determined by measuring the rate of viscous bending of a loaded glass beam. Representative specimens, nominally 3 to 4 mm in cross section and 75 mm in length, are required.

REFRACTORY TEST METHODS

ASTM C-16 LOAD TESTING REFRACTORY BRICK AT HIGH TEMPERATURES-T9300

A 25-psi load is applied to 9" x 4 1/2" x 2 1/2" or 3" bricks during a specified heating schedule. A minimum of two specimens per type/brand is suggested by ASTM. The percent deformation is measured on each brick after testing simultaneously in a gas-fired kiln up to 3150°F.

ASTM C-20 APPARENT POROSITY, WATER ABSORPTION, APPARENT SPECIFIC GRAVITY, AND BULK DENSITY OF BURNED REFRACTORY BRICK AND SHAPES BY BOILING WATER-T9310

The apparent porosity, bulk density, apparent specific gravity, and water absorption are determined by the boiling method. Testing of five specimens (1/4 brick or a 25 to 30 in^3 piece) per type/brand is suggested by ASTM.

ASTM C-24 PYROMETRIC CONE EQUIVALENT OF FIRECLAY AND HIGH ALUMINA REFRACTORY MATERIALS-T9320

Compares the deformation of prepared cone specimens with Orton PCE test cones. Indicate approximate cone value anticipated or describe material. A representative sample of 150 gram or more of granular material to pass a No. 70 ASTM Sieve (No. 65 Tyler) should be submitted.

ASTM C-92 SIEVE ANALYSIS AND WATER CONTENT OF REFRACTORY MATERIALS-T9350

Water Content: A 2 to 5 lb. representative sample of material should be submitted.

Sieve Analysis: Tyler Standard series sieves are used. A 2 to 5 lb. representative sample of material should be submitted.

ASTM C-113 REHEAT CHANGE OF REFRACTORY BRICK-T9370

Three 9" x 4 1/2" x 2 1/2" or 3" bricks are heated on a specified heating schedule and the percent linear change is reported. At least three 9" bricks per brand/type are suggested by ASTM.

ASTM C-133 COLD CRUSHING STRENGTH AND MODULUS OF RUPTURE OF REFRACTORIES-T9380

Crushing Strength: The crushing load is applied to the 2" x 2" face of a 2" cube or the 2" diameter face of a 2" diameter x 2" high cylinder. Testing of five specimens per type/brand is recommended by ASTM.

MOR: Flexural strength is determined in three-point bending on 9" x 4 1/2" x 2 1/2" or 3" bricks. Other sizes can be used depending on the material. Testing of five specimens per type/brand is recommended by ASTM.

ASTM C-134 SIZE AND BULK DENSITY OF REFRACTORY BRICK AND INSULATING FIREBRICK-T9390

The weight per volume is determined using the specimen weight and dimensions. Warpage is measured with the use of warpage wedges. Testing of ten specimens of each type/brand is suggested by ASTM.

ASTM C-179 **DRYING AND LINEAR CHANGE OF REFRACTORY PLASTIC AND RAMMING MIX SPECIMENS-T9410**

Three 9" bricks are molded in a press at 1000 psi and the linear drying and firing shrinkage is determined. A 50 lb. representative sample should be submitted, including a specification of the type/class of the material.

ASTM C-181 **WORKABILITY INDEX OF FIRECLAY AND HIGH-ALUMINA PLASTIC REFRACTORIES-T9420**

The workability/consistency of as-received material is determined. Cylindrical specimens are impacted under a 14-lb. load and the percent deformation is reported. The testing of five specimens is recommended by ASTM. A 10 lb. representative sample should be submitted, including the production date for the material.

ASTM C-182 **THERMAL CONDUCTIVITY OF INSULATING FIREBRICK-T9430**

The heat flow through a refractory is determined with a water-cooled copper calorimeter. The temperature limit of refractory must be specified, as well as the hot face or mean test temperatures desired. The maximum hot face temperature for testing is 2700°F. The specimens required are six 9" bricks or an 18" x 13.5" x 2.5" slab.

ASTM C-198 **COLD BONDING STRENGTH OF REFRACTORY MORTAR-T9440**

Fireclay brick halves are bonded with a 1/16" thick joint. After air and oven drying, the MOR is determined for the brick/joint assembly. Testing of 5 specimens is suggested by ASTM. At least 10 lbs. of mortar should be submitted for analysis.

ASTM C-199 **PIER TEST OF REFRACTORY MORTARS-T9450**

A multiple brick pier is made with 1/8" thick vertical and horizontal joints. The assembly is air and oven dried, and then fired for 5 hours at the specified temperature. If the mortar flows from the joints during firing, it fails the test. At least 10 lbs. of mortar should be submitted of analysis.

ASTM C-201 **THERMAL CONDUCTIVITY OF REFRACTORIES-T9460**
Same as ASTM C-182

ASTM C-202 **THERMAL CONDUCTIVITY OF REFRACTORY BRICK-T9470**
Same as ASTM C-182

ASTM C-210 **REHEAT CHANGE OF INSULATING FIREBRICK-T9480**

Three 9" x 4 1/2" x 2 1/2" or 3" bricks are fired for 24 hours after which the percent linear and volume changes are measured.

ASTM D-257 **D-C RESISTANCE OR CONDUCTANCE OF INSULATING MATERIALS-T9485**

Surface and volume electrical resistivity of insulating materials are determined by DC, as well as by AC methods. Specimen dimensions and electrode configuration are determined on an individual basis.

ASTM C-288 **DISINTEGRATION OF REFRACTORIES IN AN ATMOSPHERE OF CARBON MONOXIDE-T9500**

Shows the comparative behavior of refractory products with accelerated exposure to nearly pure CO at 940°F. The sample performance is rated based on the ASTM visual criteria. Specimens shall be 9" x 2 1/2" or 3" square in cross section. Maximum capacity of the test furnace is 25 specimens.

ASTM C-357 **BULK DENSITY OF GRANULAR REFRACTORY MATERIALS-T9510**

A 3 mesh by 8 mesh specimen of about 70 gram is weighed, boiled in water, and its volume measured using a buret. A sample of at least 5.5 lbs. should be submitted as recommended by ASTM.

ASTM C-403 **TIME OF SETTING OF CONCRETE MIXTURES BY PENETRATION RESISTANCE-T9511**

The resistance of the concrete mixture to penetration by standard needles is measured. The initial and final setting times are determined from a plot of penetration resistance versus time. A sample of at least 25 lbs. should be submitted.

ASTM C-417 **THERMAL CONDUCTIVITY OF UNFIRED MONOLITHIC REFRACTORIES-T9520**
Same as ASTM C-182

ASTM C-496 **SPLITTING TENSILE STRENGTH OF CYLINDRICAL CONCRETE SPECIMENS-T9551**

A diametral compressive load is applied along the length of a cylindrical specimen (2” diameter x 4” high) until tensile failure occurs.

ASTM C-577 **PERMEABILITY OF REFRACTORIES-T9560**

Air or nitrogen is used to determine permeability. The direction of flow should be indicated by arrows on the specimens. Testing of four 2" cube specimens of each type/brand is recommended by ASTM.

ASTM C-580 **FLEXURAL STRENGTH AND MODULUS OF ELASTICITY OF CHEMICAL RESISTANT MORTARS, GROUTS, MONOLITHIC SURFACINGS, AND POLYMER CONCRETES-T9910**

Flexural strength is determined in three-point bending on bars of rectangular cross-section. Testing of six specimens per type/brand is recommended by ASTM.

ASTM C-583 **MODULUS OF RUPTURE OF REFRACTORY MATERIALS AT ELEVATED TEMPERATURES-T9570**

Flexural strength is determined for 1" x 1" x 6" bars at temperature in three-point bending. Price includes a 12 hour hold at the test temperature. Testing of five specimens per type/brand is recommended by ASTM.

ASTM C-604 **TRUE SPECIFIC GRAVITY BY GAS COMPARISON PYCNOMETER-T9571**

A volume displacement technique is used to determine the true specific gravity of a ground specimen. A completely representative sample is required for the analysis.

ASTM C-621 **ISOTHERMAL CORROSION RESISTANCE OF REFRACTORIES TO MOLTEN GLASS-T9581**

The corrosion resistance of a specimen (0.39” x 0.39” x 2.0”) in contact with molten glass under static, isothermal conditions is determined.

ASTM C-704 **ABRASION RESISTANCE OF REFRACTORY MATERIALS AT ROOM TEMPERATURE-T9590**

The volume of materials abraded by a specified exposure to silicon carbide grit blast is measured. Specimens are typically 4 1/2" square and 3" thick.

ASTM C-830 **APPARENT POROSITY, LIQUID ABSORPTION, APPARENT SPECIFIC GRAVITY, AND BULK DENSITY OF REFRACTORY SHAPES BY VACUUM PRESSURE-T9630**

A vacuum is used to determine the apparent porosity, bulk density, liquid absorption, and apparent specific gravity. Testing of five specimens (1/4 brick or 25 to 30 in^3 piece) per type/brand is suggested by ASTM.

ASTM C-831 **RESIDUAL CARBON, APPARENT RESIDUAL CARBON, AND APPARENT CARBON YIELD IN COKED CARBON CONTAINING BRICKS AND SHAPES-T9640**

Used for characterization and comparison of carbon containing brick and shapes. A 1" x 3" x 6" specimen is suggested by ASTM.

ASTM C-832 **MEASURING THE THERMAL EXPANSION AND CREEP OF REFRACTORIES UNDER LOAD-T9650**

This method determines thermal expansion and creep under a 25 psi compressive stress for 50 hours. Other compressive stresses, up to 100 psi can be specified. The percent linear change is recorded continuously during the heat up and creep period under load. Specimen size is 1 1/2" square by 4 1/2" long. Two specimens are suggested by ASTM.

DETERMINING AND MEASURING CONSISTENCY OF REFRACTORY CONCRETE-T9670

These methods determine the optimum water content and consistency of castable products. Consistency is judged with the Ball-in-Hand method (ASTM C-860) or measured with the Flow Table method (ASTM C-1445).

ASTM C-862 **PREPARING REFRACTORY CONCRETE SPECIMENS BY CASTING-T9680**

Five brick specimens are prepared using the water content determined in ASTM C-860. This procedure assures the preparation of uniform samples for testing purposes. At least 50 lbs. of each material for testing should be submitted. Mixing is performed in a Hobart mixer and casting is performed either by spading or by vibration.

ASTM C-863 **EVALUATING OXIDATION RESISTANCE OF SILICON CARBIDE REFRACTORIES AT ELEVATED TEMPERATURES-T9690**

Steam is used to accelerate the oxidation of silicon carbide refractories at elevated temperatures. ASTM specifies a 500 hour test duration at a temperature between 800°C and 1200°C. The average volume and bulk density changes are measured on three specimens per material.

<u>ASTM C-865</u> **FIRING REFRACTORY CONCRETE SPECIMEN-T9700**

Firing schedules are for five refractory concrete specimens made in accordance with ASTM C-862 and classified by ASTM C-401. Price includes linear change measurement.

<u>ASTM C-874</u> **ROTARY SLAG TESTING OF REFRACTORY MATERIALS-T9721**

This method compares the behavior of refractories to the action of molten slag in a rotating furnace. Five specimens and a control constitute a lining. Specimens are machined from 9” straight bricks.

<u>ASTM C-914</u> **BULK DENSITY AND VOLUME OF SOLID REFRACTORIES BY WAX IMMERSION-T9720**

This method is used to determine volume and bulk density of a refractory of any shape providing it has sufficient structural integrity to permit handling. At least five representative specimens, as suggested by ASTM, should be supplied.

<u>ASTM C-973</u> **PREPARING TEST SPECIMENS FROM BASIC REFRACTORY GUNNING PRODUCTS BY PRESSING-T9730**

Five brick specimens are prepared using the water content specified by the manufacturer. This procedure assures the preparation of uniform specimens for testing purposes. At least 50 lbs. of each material for testing should be submitted. Mixing is performed in a Hobart mixer and specimens are formed at 1800 psi.

<u>ASTM C-974</u> **PREPARING TEST SPECIMENS FROM BASIC REFRACTORY CASTABLE PRODUCTS BY CASTING-T9740**

Five brick specimens are prepared using the water content specified by the manufacturer. This procedure assures the preparation of uniform specimens for testing purposes. At least 50 lbs. of each material for testing should be submitted. Mixing is performed in a Hobart mixer and casting is either performed by spading or by vibration.

<u>ASTM C-975</u> **PREPARING TEST SPECIMENS FROM BASIC REFRACTORY RAMMING PRODUCTS BY PRESSING-T9745**

Five brick specimens are prepared using the water content specified by the manufacturer. This procedure assures the preparation of uniform specimens for testing purposes. At least 50 lbs. of each material for testing should be submitted. Mixing is performed in a Hobart mixer and specimens are pressed at 10,000 psi.

<u>ASTM C-987</u> **VAPOR ATTACK ON REFRACTORIES FOR FURNACE SUPERSTRUCTURES-T9746**

The corrosion resistance of a specimen (2.2” x 2.2” x 0.8”) in contact with vapors under static, isothermal conditions is determined. Three specimens are suggested by ASTM.

<u>ASTM C-1054</u> **PRESSING AND DRYING REFRACTORY PLASTIC AND RAMMING MIX SPECIMENS-T9750**

Five brick specimens are prepared at 1000 psi. This procedure assures the preparation of uniform specimens for testing purposes. At least 50 lbs. of each material for testing should be submitted.

ASTM C-1099 **MODULUS OF RUPTURE OF CARBON-CONTAINING REFRACTORY MATERIALS AT ELEVATED TEMPERATURES-T9758**

Flexural strength is determined for 1" x 1" x 6" bars at 2550°F in three-point bending. Testing of five specimens per type/brand is recommended by ASTM.

ASTM C-1113 **THERMAL CONDUCTIVITY OF REFRACTORIES BY HOT WIRE-T9855**

The hot wire technique is a transient, intermittent isothermal method for measuring thermal conductivity. A platinum wire is placed between two appropriately prepared 9" bricks of same material. Heat generated by current applied to the wire is conducted away from the wire at a rate dependent on the thermal conductivity of the material. Minimum of two bricks required.

ASTM C-1171 **QUANTITATIVELY MEASURING THE EFFECT OF THERMAL CYCLING ON REFRACTORIES-T9765**

Determination of the relative thermal shock resistance of refractories by using 5 alternating 10-minute heating at 2190°F and cooling in air cycles. Ten specimens 1" x 1" x 6" per type/brand are required by ASTM and both the actual and percent change in strength and ultrasonic properties are reported.

ASTM C-1223 **GLASS EXUDATION FROM AZS FUSION-CAST REFRACTORIES-T9766**

Specimens (1" x 1" x 4.0") are subjected to temperatures that produce glass exudation. The quantity of exuded glass is calculated from the volume change.

ASTM C-1419 **SONIC VELOCITY IN REFRACTORY MATERIALS AT ROOM TEMPERATURE AND ITS USE IN OBTAINING AN APPROXIMATE YOUNG'S MODULUS-T9768**

Approximation of Young's Modulus is calculated through sonic velocity measurements in 3 directions. The velocity of sound waves is measured using a James V-meter.

ASTM C-1548 **DYNAMIC YOUNG'S MODULUS, SHEAR MODULUS, AND POISSON'S RATIO FOR REFRACTORY MATERIALS BY IMPULSE EXCITATION OF VIBRATION-T9767**

A non-destructive sonic method is used to determine the modulus of elasticity and modulus of rigidity for calculation of Poisson's Ratio. Bars of rectangular cross-section are used for the measurements.

DIN 51053 **DETERMINATION OF CREEP OR REFRACTORINESS UNDER LOAD-T9900**
ISO 3187

One cylindrical specimen (50 mm diameter x 50 mm high) is tested per firing. The percent linear change is recorded continuously during the heat-up and creep period under load. The minimum size required is a half brick. Standard conditions are 0.2 N/mm^2 (29 psi) load and 50 hour hold.

ALCOA MODIFIED ALUMINUM CUP PENETRATION-T9810

The comparative resistance of refractory brick, mortars, or monolithic can be determined using this cup test, with 7075 aluminum alloy at 1500°F for 72 hours. Two 9" bricks are required. Before and after metal analysis is available at an additional cost of $195 per analysis.

ALCOA MODIFIED DISINTEGRATION OF REFRACTORIES BY ALKALI-T9540

Nine 2" cube specimens are required. A 1" hole is drilled into the face of each specimen and filled with either 8 gram of potassium carbonate, 8 gram of sodium carbonate, or a mixture of 4 gram of potassium carbonate and 4 gram of sodium carbonate. The effects of firing three cubes each at 900°C, 1000°C, or 1100°C for 5 hours are determined visually.

ALKALI RESISTANCE-T9800

Test specimens are fired to 1700°F in two cycles in the presence of potassium carbonate. MOR, MOE, and visual observations are taken before and after exposure to alkali. Ten 1" x 1" x 6" bars are required.

BONDING STRENGTH AFTER FIRING-T9820

Fireclay brick halves are bonded with a 1/16" thick joint. After air and oven drying and a 5 hour hold at the specified firing temperature, the MOR is determined for the brick/joint assembly. Five 9" bricks are required. At least 10 lbs. of mortar should be submitted for analysis.

CHEMICAL ANALYSIS-T9830

Full service analytical capabilities are offered. All analyses are performed by a subcontractor. MTRC prefers to prepare the needed representative powder from the bulk sample(s) submitted. Typical materials analyzed by MTRC are listed below.

Standard Analysis (Al_2O_3, SiO_2, CaO, MgO, K_2O, Na_2O, Fe_2O_3, TiO_2, P_2O_5, Cr_2O_3, MnO, NiO, ZrO_2)

DYNAMIC CORROSION RESISTANCE OF REFRACTORIES TO MOLTEN GLASS-T9582

The corrosion resistance of a specimen (0.75” x 0.75” x 8.0”) in contact with molten glass under dynamic, isothermal conditions is determined. Known as the finger test, up to four specimens are attached to a rotating shaft that is lowered into molten glass (up to 1650ºC). Test duration is typically 24 or 48 hours. Visual or quantitative analysis can be conducted on the corroded specimens.

MICROSCOPIC ANALYSIS-T9775

Optical Microscope: Reflected light techniques are used to characterize the microstructure of materials submitted. Photomicrographs can be provided, if requested.

Scanning Electron Microscope: Electron beam techniques are used to characterize the microstructure of materials submitted. Photomicrographs can be provided, if requested.

PERIODIC KILN FIRINGS-T9200

Periodic kiln firing can be performed within all commercial ranges of temperatures and atmospheres, using almost any schedule used by commercial equipment. The prices apply to one firing with at least 1 cubic foot setting space up to a 24-hour cycle.

X-RAY DIFFRACTION ANALYSIS-T9790

The major and minor crystalline phases present in a sample are determined on a qualitative basis. All analyses are performed by subcontractor. MTRC prefers to prepare the needed representative powder from the bulk sample(s) submitted.

ELEVATED TEMPERATURE ABRASION RESISTANCE OF REFRACTORY MATERIALS-T9590

A specimen is heated to elevated temperature and the volume of materials abraded by a specified exposure to silicon carbide grit blast is measured. Specimens are typically 4 1/2" square and 3" thick.

THERMAL ANALYSIS METHODS

DIFFERENTIAL THERMAL ANALYSIS (DTA)-T9140

Differential Thermal Analysis is a determination of the temperature difference between the sample and a known reference as a function of the reference temperature. It is a sensitive qualitative test for determining the temperature at which chemical and physical changes occur in the sample. DTA is especially useful in control and analysis and for indicating temperature regions for closer study or evaluation by other thermal analytical techniques.

THERMAL GRAVIMETRIC ANALYSIS (TGA)-T9170

Thermogravimetric Analysis provides the change in weight of a sample as function of temperature. It is a precise quantitative method of determining combustibles, loss of volatiles, curing times, decomposition of hydrates and carbonates, and weight loss changes. Rates of weight loss or gain are easily determined from the curve. The use of controlled atmospheres allows for the study of solid-gas reactions.

SIMULTANEOUS DIFFERENTIAL THERMAL ANALYSIS / THERMAL GRAVIMETRIC ANALYSIS (DTA / TGA)-T9150

Simultaneous DTA / TGA Analysis combines the two thermal analysis techniques, Differential Thermal Analysis and Thermogravimetric Analysis, in one measurement. The instrument is configured with the differential thermocouple assembly mounted on the balance, which allows monitoring the weight change and temperature differential simultaneously as a function of temperature.

ASTM E-228 THERMAL LINEAR ANALYSIS (THERMAL EXPANSION/CONTRACTION)-T9110

Thermal Linear Analysis determines the expansion and/or contraction characteristic of a specimen as a function of temperature. Numerical and graphical results show the percent of linear thermal change (expansion or shrinkage) versus temperature using an Orton dilatometer. Tests on larger refractory specimens can also be made using a vertical thermal expansion furnace (see ASTM C-832).

Sample Sizing-T9100

Sample Required: For specimens run to 1000°C, the maximum diameter is 1/2" and the standard lengths are 1/2", or 1", or 2". For specimens greater than 1000°C, the maximum diameter is 5/8" and the standard length is 1". Length can vary by 0.1". Specimen ends need to be flat and parallel and within ± 0.001". Tests can be made on specimens of non-standard length and unusual shapes (foils, wafers, or stacking small pieces).

Heating and Cooling Rates: 3°C/minute (standard)

ASTM Standard Conditions: Thermal linear analysis can be performed according to other standard conditions, such as outlined in C-372, C-824, and E-831.

ASTM E-1269 HEAT CAPACITY BY DIFFERENTIAL SCANNING CALORIMETRY (DSC)-T9151

Specific heat capacity is measured by differential scanning calorimetry. For the Setaram DSC unit, the sample size for oxides is a 0.232” (plus 0.000”/minus 0.005”) diameter x 0.527” high cylinder and for non-oxides is a 0.192” (plus 0.000”/minus 0.005”) diameter x 0.456” high cylinder. For the Netzsch DSC unit, the sample size is a 0.236” (plus 0.000”/minus 0.005”) diameter x 0.040” thick disk. Since sample configuration may be dependent on sample composition, inquire before machining samples for submittal.

HEAT CAPACITY CALCULATED FROM THERMODYNAMIC DATA-T9909

Specific heat capacity is calculated from thermodynamic data. Chemistry must be supplied for this calculation.

ASTM E-1461 THERMAL DIFFUSIVITY AND CONDUCTIVITY BY FLASH METHOD-T9111

Thermal diffusivity and heat capacity is measured by light flash. The specimen sizes are a 12.7 mm diameter disk, 10.0 mm diameter disk, or 10.0 mm square. Specimen thickness may be 1-4 mm. Thermal conductivity is calculated from the thermal diffusivity, heat capacity, and density.

WHITEWARE TEST METHODS

ASTM C-67 **BRICK AND STRUCTURAL CLAY TILE TESTING-T9340**

A minimum of five full size brick or tile units per type/brand is suggested by ASTM for determination of modulus of rupture, compressive strength, absorption, and saturation coefficient.

TEST DESCRIPTION
Modulus of Rupture
Compressive Strength (includes capping)
Absorption: 5 or 24 hour submersion test
Absorption: 1, 2, or 5 hour boil test
Saturation Coefficient
Efflorescence

ASTM C-373 **WATER ABSORPTION, BULK DENSITY, APPARENT POROSITY, AND APPARENT SPECIFIC GRAVITY OF FIRED WHITEWARE PRODUCTS-T9515**

The water absorption, bulk density, apparent porosity, and apparent specific gravity are determined by the boiling method. Testing of five unglazed specimens (of at least 50 gram/piece) is suggested by ASTM.

ASTM C-554 **CRAZING RESISTANCE OF FIRED GLAZED CERAMIC WHITEWARES BY A THERMAL SHOCK METHOD-T9516**

The resistance to crazing of fired glazed whitewares is determined when subjected to thermal stresses. Specimens are initially heated at 250°F and water quenched. This cycle is repeated three times. If crazing does not take place, then the three cycles are repeated in 25°F increments up to 450°F. Failure is defined as the temperature at which crazing is observed. Testing of five specimens is suggested by ASTM.

ASTM C-674 **FLEXURAL PROPERTIES OF CERAMIC WHITEWARE MATERIALS-T9517**

Flexural strength is determined in three-point bending on bars of circular or rectangular cross-section. Testing of ten specimens per type/brand is recommended by ASTM.

ASTM C-773 **COMPRESSIVE (CRUSHING) STRENGTH OF FIRED WHITEWARE MATERIALS-T9518**

The compressive strength is determined on a right cylinder. Testing of at least ten specimens per type/brand is recommended by ASTM. **Two contact cylinders per specimen are required.**

LABOR CHARGES

LABOR CHARGES

Technician Time and Sample Preparation-T8200
Engineer Time-T8100

MACHINING SERVICES-T9881

Machining services for advanced ceramic test coupons include diamond cutting, coring, and surface grinding.

SPECIAL PROJECTS-T9880

For special projects, a proposal is submitted covering work to be done along with time and costs. Most projects are done on a cost-incurred basis. Orton makes every effort to provide high quality technical services on a responsive basis.

SUBJECT INDEX

Sample Preparation

Thermal Properties

Notes: