ANALYTICAL LABORATORIES

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ASSAYING AND LABORATORY SERVICES

FEE SCHEDULE

Effective February 1, 2019

Page

Serving the Mineral and Chemical Industries Since 1961

ORDERING INFORMATION

GENERAL

Please complete either our Analytical Services Request Form, (download from our website) or supply the following information. (Include copy with samples):

1. Purchase Order Number (see the Terms and Payment section on page 4)
2. Reporting and billing addresses.
3. Reporting phone, and email address.
4. Street address for sample return.
5. Sample Identifications.
6. Analyses requested.
7. Information about the chemical composition and physical properties of all samples.
8. The expected levels and required detection limits of requested analytes.
9. Any hazards associated with the samples (include SDS).
10. Sample disposal information (see below).

Samples arriving after 2:00 p.m. will be logged into our system on the next business day. Hazen Laboratories reserves the right to refuse to receive or analyze samples that are deemed to be unsafe to handle in our facilities or for any other reason.

SAMPLE QUANTITY REQUIRED

See Table on page 6.

ANALYSIS REPORTS

Analysis reports are normally sent by email. Upon request, reports will additionally be provided by first class mail for $2.00. Must include valid mailing address. Most reports can be supplied in Excel format. Inquire about other custom electronic reporting formats and data deliverable requirements.

All results are held in strict confidence. Results will be released to a third party only if authorized by original client.

QUOTATIONS

Written quotations are available to secure pricing for projects and special analyses. These quotations are valid for 90 days unless otherwise noted. A copy of the quotation must accompany an order to insure proper billing for the analyses performed.

SAMPLE STORAGE, RETURN, AND DISPOSAL

All samples remain the property of the client.

Any unused portion of a sample will be returned at client cost or a fee of $2.00 per sample will be billed to dispose of non-hazardous samples.

A minimum $50.00 surcharge will be added to orders requiring special packaging and labeling as hazardous materials.

Samples are normally held for 90 days after reporting prior to sample disposal or return.

PRICING POLICY

It is the policy of the Hazen laboratories to set prices at a fair and equitable level for quality analytical services. While we attempt to maintain the listed rates, the prices are subject to change without notice. Specific test methods and pricing may not be applicable to all sample types. In these cases the customer will be notified and, if appropriate, a special price quotation will be provided.

All prices are in U.S.D., and unless otherwise specified, are per sample. (See the Minimum Charges section below).

MINIMUM CHARGES

Our QA program requires, at minimum, that a blank, duplicate, and calibration check standard be analyzed with each group of 10 samples, or each significant matrix. Our minimum charges (minimum samples charged per test) help offset the cost of QA/QC and other handling costs for small quantity orders. The minimum charges are $50.00 for standard service time and $100.00 for priority service.

DISCOUNT PRICING POLICY

On large projects, we are frequently able to provide significant price discounts. These are offered by quotation only, and are based upon cost savings afforded to our laboratory. This is determined not simply by number of samples or gross dollar amount but by the specific analyses, sample quantity, sample matrix, analyte concentration ranges, required turnaround time, and other analytical process factors. We strongly encourage you to inquire about potentially substantial cost and time savings for your larger batch sample submittals or ongoing analytical projects. Advance scheduling of sample submittals may result in faster turnaround times and lower charge for priority service.

TERMS AND PAYMENT

Orders are accepted based on receipt of an acceptable Purchase Order or valid credit card information. Terms and conditions attached to purchase orders cannot be accepted for payment of analytical work. Terms and conditions must be deferred or waived if a purchase order is to be used as a form of payment. Terms are net 14 days from the date of invoice. A 1.5% per month surcharge will be assessed on all past due accounts. In the event of default on payment, the client is responsible for all reasonable collection and legal fees. By sending samples for analysis, client agrees that services shall be governed by Hazen's analytical terms and conditions; Hazen's terms and conditions supersede other terms and conditions.

We accept cash, check, Visa, MasterCard, American Express, and Discover for payment of services.

LIMITS OF LIABILITY AND WARRANTY

It is the intent of Hazen's laboratories to provide the most reliable data possible for contracted analyses. These services are provided without warranty or liability, implied or otherwise, of any kind. The sole remedy shall be limited to repeating the analyses or refunding the amount paid to Hazen Research, Inc. for services provided.

PRIORITY SERVICE

Routine analyses are normally reported within 10–15 working days for non-radiochemistry analysis. Radiochemistry routine analysis varies. Please contact for quotation. Samples arriving after 2:00 p.m. Mountain Time are logged into our system on the following business day.

When our analysis load permits, priority services are available for an additional charge. These services do not guarantee results within the number of days specified as some procedures or combinations of procedures require additional time. Priority service does insure that your samples will be prioritized over standard service samples. **Priority services require prior arrangement to insure availability.** Projects requiring exceptional levels of effort (e.g. same-day turnaround), if available, may be subject to additional surcharges.

Priority ..... 100% surcharge
Results are delivered by phone or email, typically within 5–7 working days after sample receipt.

QUALITY ASSURANCE/QUALITY CONTROL

We maintain a QA/QC program to assure reliable results. We maintain a supply of certified standard reference materials for a wide variety of matrices and analytes, which allows us to provide better matching between reference material and samples. In many cases, we have alternate methods that can be used to confirm values obtained by our standard methods. Our results are very reliable, but we encourage customers to contact us if data does not meet expectations. Since quality is very important to us, we will, within reason, verify results at no additional charge.

Quality control (QC) data is available as a part of your report at an additional charge. These data normally include associated raw data, including adjacent blank, control values, and replicates associated with your sample(s). Contact Hazen Laboratories for information on customized data deliverables and QA/QC packages.

QA/QC Data Reporting ..... 25% surcharge
($50.00 minimum)

REPLICATE ANALYSES

Replicate analyses are usually charged at the multiple of the normal rate of a single analysis. Some services have special rates for duplicate or higher level replicate analyses and are listed in the fee schedule. Please contact us.

SAMPLE RETURN

See page 3 for sample storage, return and disposal policies, and charges.

We are licensed by USDA Annual and Plant Health Inspection Service to ship, recycle, and dispose of unsterilized soil from foreign sources or domestically quarantined areas. **Please contact us for a copy of our permit before shipment.**

Treatment and disposal of samples and containers handled under this permit $50.00
(minimum per sample batch)

†Quantity discounts are available. Refer to the Minimum Charges and Discount Pricing sections on page 3 for more information.

SAMPLE QUANTITY REQUIREMENTS

Analysis Requested	Required	Ask For
AA		
Solids	0.2–0.5 g	10 g
Liquids	1 mL	10 mL
Fire Assay, Fire Assay with AA Finish, or Fire Assay with ICP–OES Finish		
Solid	30 g	100 g
ICP		
Solids	0.2–0.5 g	10 g
Liquids	1 mL	10 mL
LECO Carbon or Sulfur		
Solids	2 g	10 g
Particle Size Analysis		
Solid*	1 g	10 g
Liquid (slurry)	50 mL	100 mL
*For "coarse material" (>150 µm) we need substantially more (1–2 kg).		
Rad Chem		
Gross alpha/beta		
Water	200 mL	1,000 mL
Solid	1 g	5 g
Gross Gamma		
Solid	30 g	30 g
Radium 226/228		
Water	1 L	2 L
Solid	1 g	5 g
Radon (water) (special glass containers)	30 mL	60 mL
Tritium		
Water (glass container)	100 mL	500 mL
All Others		
Solids	0.5 g	5 g
Water	1 L	1 L
Uranium		
Water	25 mL	100 mL
Solid	0.5 g	5 g
Wet Chemistry		
Solids	1 g	10 g
Liquids	10 mL	100 mL
XRF		
Solid	25 g	50 g
Biomass	**Call for required sample quantities**	

ANALYSIS OF GEOLOGIC AND METALLURGICAL MATERIALS

Determination	Fee	Determination	Fee
Acid, insoluble	$30	Molybdenum	$20
Aluminum	$25	Neodymium	$25
Ammonium	$40	Nickel	$20
Antimony	$20	Niobium	$25
Arsenic	$25	Nitrogen, total	$27
Barium	$20	Palladium (Fire Assay ICP–OES Finish)	$50
Beryllium	$20	Phosphorus	$30
Bismuth	$20	Platinum (Fire Assay ICP–OES Finish)	$50
Boron	$20	Pt/Pd (Fire Assay ICP–OES Finish)	$70
Cadmium	$20	Pt/Pd/Rh (Fire Assay ICP–OES Finish)	$90
Calcium	$20	Potassium	$20
Carbon, total	$28	Praseodymium	$25
Carbon dioxide	$26	Rhenium	$25
Carbon, organic	$51	Rhodium (Fire Assay ICP–OES Finish)	$50
Cerium	$25	Samarium	$25
Chloride, soluble	$25	Scandium	$20
Chloride, total	$35	Selenium	$30
Chromium	$20	Silicon	$20
Cobalt	$20	Silver (Fire Assay)	$26
Copper	$20	Silver (AA)	$20
Copper, oxide	$20	Sodium	$20
Dysprosium	$25	Strontium	$20
Erbium	$25	Sulfur, total	$22
Fluorine	$35	Sulfur, sulfate	$35
Gadolinium	$25	Sulfur, sulfide	$55
Gallium	$20	Sulfur, sulfite	$50
Germanium	$20	Sulfur, elemental	$35
Gold (Fire Assay)	$22	Tantalum	$20
Gold and silver (Fire Assay)	$30	Tellurium	$20
Gold (Fire Assay AA Finish)	$36	Terbium	$25
Hafnium	$25	Thallium	$20
Holmium	$25	Thorium	$70
Indium	$20	Thulium	$25
Iron	$20	Tin	$20
Lanthanum	$25	Titanium	$20
Lutetium	$25	Tungsten	$40
Lead	$20	Uranium	$45
Lime, available	$50	Vanadium	$20
Lithium	$20	Yttrium	$25
Loss on ignition	$20	Ytterbium	$25
Magnesium	$20	Zinc	$20
Manganese	$20	Zirconium	$20
Mercury	$35		

Fees do not include sample preparation. See sample preparation fee list on page 12 for solid samples that are not received at minus 150 mesh or finer.

INDUCTIVELY COUPLED PLASMA-OPTICAL EMISSION SPECTROMETRY (ICP-OES)

Quantitative Multi-Element Analysis

METALS SCAN $150

Elements Included: Al, As, Ba, Be, Bi, Ca, Cd, Ce, Co, Cr, Cu, Fe, K, La, Mg, Mn, Mo, Na, Ni, P, Pb, Re, S, Sb, Sr, Te, Th, Ti, V, Y, Zn, Zr

Description: A four acid digestion method is used to bring sample into solution, and the solution analyzed by ICP-OES. This suite is appropriate for non-refractory materials. Aluminum, arsenic, barium, sulfur, titanium, and zirconium are not truly quantitative using this dissolution method and analysis.

RARE EARTHS SCAN $175

Elements Included: Al, Be, Ca, Ce, Cr, Dy, Er, Eu, Fe Gd, Hf, Ho, K, La, Lu, Mg, Mn, Na, Nb, Nd, P, Pr, Sc, Si, Sm, Ta, Tb, Th, Ti, Tm, Y, Yb, Zr

Description: lithium metaborate/lithium tetraborate fusion of the sample followed by acid dissolution and solution analysis on ICP-OES. This method is appropriate for highly refractory materials and other difficult-to-digest samples.

For custom ICP-OES analysis suites, please contact us.

X-RAY FLUORESCENCE (XRF)

Bruker S8 Wavelength Dispersive XRF

XRF can analyze elements sodium through uranium at concentrations ranging from 50 ppm to 100%. Loose powders, pressed powder pellets, and borate fusion prep methods are used. Multiple packages are offered and project-specific methods can be developed for high throughput/volume applications by request.

Quantitative Multi-Element Analysis

BORATE FUSION WHOLE ROCK PACKAGE $120

Borate fusion elements by XRF: Al_2O_3, CaO, Fe_2O_3, K_2O, MgO, MnO, Na_2O, P_2O_5, SiO_2, SO_3, TiO_2, Ba, Ce, La, Nb, Sr, Ta, Th, U, Y, Zn, Zr, LoI

Description: following sample fusion into a glass disc, major mineralogical elements are determined and reported as oxides. Loss on ignition is also determined. This method is suitable for non-sulfide ores, silicates, feldspar, gypsum, bauxite, and limestone. It is not appropriate for sulfide content greater than 1 percent, precious metals, or PGM analysis.

ANALYSIS OF GEOLOGIC AND METALLURGICAL MATERIALS (CONTINUED)

Semi-Quantitative/Qualitative Multi-Element Analysis

QUANTEXPRESS PRESSED POWDER ANALYSIS $60

Elements reported: Ag, Al, As, Au, Ba, Bi, Br, Ca, Cd, Ce, Cl, Co, Cr, Cs, Cu,Dy, Er, Eu, Fe, Ga, Gd, Ge, Hf, Hg, Ho, I, In, Ir, K, La, Mg, Mn, Mo, Na, Nb, Nd, Ni, P, Pb, Pd, Pr, Pt, Rb, Re, Rh, Ru, S, Sb, Sc, Se, Si, Sm, Sn, Sr, Ta, Tb, Te, Th, Ti, Tl, U, V, W, Y, Yb, Z, Zr

Description: a finely ground sample is mixed with binder, pressed into a pellet, and a full XRF scan is conducted. Specific wavelength intensities are measured, and fundamental parameters concentrations are assigned to the specified intensities. This is a qualitative method only, and is appropriate for general materials characterizations.

COAL AND BIOMASS

Determination	Fee
Moisture, ash, sulfur, Btu (short proximate)	$96
Proximate (moisture, volatile matter, fixed carbon, ash)	$63
Proximate plus sulfur and Btu	$117
Ultimate (moisture, ash, sulfur, carbon, hydrogen, nitrogen, oxygen by difference)	$132
Chlorine (additional)	$36
Ultimate and proximate plus Btu (same sample)	$185
Fusion temperatures of ash:	
Oxidizing or reducing atmosphere (each)	$55
Oxidizing and reducing atmosphere (same sample)	$110
Elemental analysis of ash (Al, Ca, Fe, K, Mg, Na, P, S, Si, and Ti)	$240
Chlorine and carbon dioxide (additional)	$62
Minor/trace elements: instrumental methods (ICP, colorimetry, AA, XRF)	By quote
Forms of sulfur	$75
Water soluble alkalis:	
Sodium or potassium	$25
Sodium and potassium (same sample)	$44
Specific gravity (true)	$60

Fees do not include sample preparation. See sample preparation fee list on page 12 for solid samples that are not received minus 60 mesh or finer.

RADIOCHEMISTRY FEE SCHEDULE

Determination	Fee
Gross gamma (radium equivalent), solids only	$65
Lead -210	$200
Radium -226	
Liquids	$70
Solids	$80
Radium -228	
Liquids	$110
Solids	$120
Radon in Water	$50
Radiocesium (Cs-137+ Cs-134)	$100
Radiostrontium (Sr-90 + Sr-89)	$110
Strontium -90	$125
Strontium -89/90	$135
Thorium, Natural (soil)	$70
Thorium -230	$90
Thorium -228/230/232	$105
Tritium in water	$75
Uranium, Natural (soil)	$45
Uranium (water)	$35
Gross alpha/beta (solids)	$65
Gross alpha/beta in drinking water	
(<500 mg/L total dissolved solids)	$52
(>500 mg/L total dissolved solids)	$78
Gross alpha in drinking water	
(<500 mg/L total dissolved solids)	$46
(>500 mg/L total dissolved solids)	$69
Solid waste prep	$20
Solid waste % moisture	$20
Standard Fees	
Environmental waste management fee	$2 per sample
Bottle shipping fee	Cost of shipment plus 15% overhead
Minimum charge	$50 per order

WASTE AND HAZWASTE
(FUEL PROPERTIES)

Determination	Fee
Proximate analysis (moisture, volatile matter, fixed carbon, ash)	$110
Ultimate analysis (moisture, ash, sulfur, carbon, hydrogen, nitrogen)	$240
Chlorine (additional)	$70
Ultimate and proximate plus Btu (same sample)	$340
Heating value (Btu)	$60
Fusion temperatures of ash:	
Oxidizing or reducing atmosphere (each)	$55
Oxidizing and reducing atmosphere (same sample)	$110
Elemental analysis of ash (10 elements)	$240
Chlorine and carbon dioxide (additional)	$96
Water content (Karl Fischer titration)	$45

PETROLEUM PRODUCTS

Determination	Fee
Ash content	$45
Calorific value, Btu/lb	$40
Carbon and hydrogen (both/each)	$52/$35
Water content, Karl Fischer titration	$45
Sulfur	$27
Metals	By quote
Ultimate analysis	$201

Fees do not include sample preparation. See sample preparation fee list on page 12 for solid samples that are not received at minus 60 mesh or finer.

SAMPLE PREPARATION

ROUTINE PREPARATION

Samples 10 pounds or less:

Rock and ore ..... $20 for first the 2 pounds plus $3 per pound for each additional pound

Coal ..... $20 for the first 5 pounds plus $3 per pound for each additional pound

Wood and biomass ..... $20 for 1-gallon container or smaller
The charge for larger quantities is based on time required to prepare the sample..... $75/h

Industrial waste ..... Time basis, $75/h

Municipal waste ..... $20 prep; $20 moisture analysis

Small samples requiring hand mortar and pestle ..... $35 per sample

Metals and alloys requiring drilling (excludes tool steels and extremely hard alloys) ... $35 per sample

Samples over 10 pounds: ..... Time basis, $75/h

Cryogenic prep with liquid N_2 (up to 10 lbs) ..... $40 per sample

CUSTOM PREPARATION..... By quote

- Crushing ton quantities of rock and ore
- Drill core sawing and splitting
- Bulk density
- Reduction of 200- to 300-pound sample in porcelain ball mill
- Blending, compositing, packaging

ASSAY STANDARD PREPARATION

Customized assay standards preparation including round robin testing. Call for more information.

SIEVE ANALYSIS

Size distribution analysis for samples typically ranging in size from 2 inch to minus 400 mesh using 8-inch diameter U.S. and Tyler sieve series.

Basic analysis (dry screen up to 1 kg of sample) (Ro Tap)..... $85
Wet analysis (required to effectively screen fines in some samples)..... $140 (or time)

PARTICLE SIZE ANALYSIS

Horiba LA-950V2 laser diffraction size analyzer..... $175 per sample
Malvern laser diffraction size analyzer..... $175 per sample

PRECIOUS METALS RECOVERY

GRAVITY SEPARATION .....By quote

Mineral Technologies spirals; diagnostic heavy liquid separation (HLS); jigs; Wilfley, Deister, and Gemeni shaking tables; Gold Strake Knelson KC-MD3 centrifugal concentrator; Falcon L-40 concentrator; and cyclone size separators are available for gold/silver/platinum recovery.

CHEMICAL PROCESS DEVELOPMENT.....By quote

Heap, cyanidation, bottle roll, and agitation leaching, zinc precipitation, carbon-in-pulp process, pressure oxidation, chlorination, roasting, and effluent treatment.

PLACER GOLD RECOVERY .....By quote

Pound to ton quantities of deposit material evaluated by gravity and fire assay techniques. Please contact Hazen for more information.

MINERALOGICAL CHARACTERIZATION OF GOLD ORE $5,000

Samples will be subjected to a sizing and upgrading procedure that provides preliminary information on the response to gravity concentration and on liberation–locking and other characteristics pertinent to processing. This procedure also enhances the detection of a statistically valid number of gold particles.

METALLIC ASSAY PROCEDURE $350

MINERALOGY

POLARIZING MICROSCOPY.....$800 per sample

Leitz Panphot, Ortholux, Orthoplan, and Wild research microscopes with complete accessories, including digital photomicrographic equipment; used for polarized, transmitted, and reflected light microscopic analysis of rock, ore, and metallurgical product samples, to include mineral identification, paragenesis determination, textures, liberation characteristics, and grain sizes and distributions.

BULK SEMI-QUANTITATIVE X-RAY DIFFRACTOMETRY (XRD).....$295

Utilizes a Bruker D8 Advance with Davinci design and a Lynxeye detector and state-of-the-art software packages to analyze rock samples or mineral mixtures to identify the crystalline phases and determine the relative amounts. Sample preparation includes pulverizing minus 212 micron received material to very fine powder and scanning the bulk powder on the XRD instrument. The technique requires very little material for analysis (minimum of 0.5 g).

CLAY MINERAL X-RAY DIFFRACTOMETRY (XRD) $800

Utilizes a Bruker D8 Advance with Davinci design and a Lynxeye detector and state-of-the-art software packages to identify minerals present in the minus 2 micron-size fraction material and includes the estimation of percent swelling clay, mixed-layer clay ordering, and relative clay mineral percentages. Sample preparation includes separation of the minus 2 micron material and analysis of oriented dried, glycolated, and heated scans. The technique requires 3 to 5 g of material for analysis.

BULK QUANTITATIVE X-RAY DIFFRACTOMETRY (XRD) $370

Utilizes a Bruker D8 Advance with Davinci design and a Lynxeye detector and state-of-the-art software packages to analyze rock samples or mineral mixtures. Results are reported as weight percent of relative amounts of minerals and can be performed using Rietveld Refinement procedures on all crystalline. Sample preparation includes pulverizing (micronizing) and scanning the bulk powder. The technique requires 3 to 5 g of material for analysis.

ELECTRON MICROSCOPY AND X-RAY MICROANALYSIS $3,000

JEOL JXA-733 Electron Microprobe equipped with an Energy Dispersive Spectrometer (EDS), four Wavelength Dispersive Spectrometers (WDS), and a backscattered electron detector with TV scanning rate enabling rapid scanning of samples. The instrument utilizes dPict32 and Image-Pro Plus digital imaging.

This instrument enables qualitative and quantitative analysis at the micron level to characterize materials such as minerals, metals, reaction products, and contaminants. It is also capable of identifying and analyzing elements as low as oxygen in atomic number. The detection limit is about 0.1% for EDS and about 0.05% for WDS dependent on the sample composition. The rapid scanning rate backscattered electron detector is useful for locating phases and particles with variable average atomic number.

QEMSCAN ..... By quote

QEMSCAN is an automated, electron-beam based system that provides rapid quantitative analysis of minerals or other inorganic material. The technique determines a wide range of mineral characteristics, including mineral abundance, grain size, textural relations, and liberation.

POLISHED SECTION PREPARATION ..... $75 per specimen

- Vacuum epoxy impregnated 30 mm mounts
- Using automated Struers Equipment

LIMESTONE SO_2 REACTIVITY STUDY $850

Limestone SO_2 reactivity study by TGA provides a graphic representation of a sorbent's ability to absorb SO_2 from a gas stream. Useful for comparing characteristics of individual sorbents to a database for qualitative rankings.

THERMAL DECREPITATION TEST (STATIC TEST)..... $250

Certain limestones lose their structural bond when heated, thereby reducing the particle size distribution of the overall sample by decrepitating to smaller particles. Size retention is important for bubbling fluidized-bed applications. Decrepitation may be beneficial in some circulating fluidized-bed applications. Using this test, potential limestone sources are compared and ranked for their relative abilities to resist decrepitation.

DYNAMIC ATTRITION TEST .....By quote

The static test is not adequate for making comparisons in certain applications. A dynamic test is more appropriate. This procedure evaluates the change in mean particle size of a limestone having a close size range during a two-hour period of high temperature fluidization. The test is conducted in a two-inch fluidized-bed furnace.

COMBUSTION TESTING

The most accurate method for determining the sorbent requirement for reducing sulfur dioxide emissions to an acceptable level is to conduct an actual test. Hazen uses pilot plant fluidized-bed test equipment to conduct these determinations.

Each test requires eight hours. This includes the time required to heat the test stand to thermal equilibrium and to establish steady-state operating conditions.

A cost quotation will be provided upon request. Because of the extensive test work required, this procedure is reserved for making final comparisons. Candidates for testing are usually the two or three highest ranking limestones.

QUICKLIME PROPERTIES

Properties of the quicklime produced from the limestone material are important if the quality of the sample warrants lime production. Standard ASTM procedures can be used to measure characteristics of quicklime produced from calcining the limestone. Slaking rate and hydrate acid neutralization potential are included. Contact our pyrometallurgy department for a quotation.

COMMINUTION AND GRINDABILITY

Breakage Characterization–JK Tech Procedures	**Fee**
Full drop-weight test procedure, (requires 80–100 kg of minus 4-inch material)	$5,500
SAG mill comminution (SMC) test, (requires 12 kg of $^1/_4$ core or 20 kg of minus 2-inch rock)	$2,200
Bond rod mill grindability (requires 25 kg of minus $^1/_2$-inch material)	$950
Bond ball mill grindability (requires 12 kg of minus 6-mesh material)	$950
Bond abrasion test (requires 1.6 kg material, $^3/_4$ inch by $^1/_2$ inch)	$400
SAG feed belt cut particle size distribution, up to 500 kg	$3,000

The cost per test includes required sample preparation (up to 4 times the required amount), engineer oversight, and reporting (no add-ins). Sample disposal or shipping is not included in the cost.

VISCOMETRY

Listed prices are for determinations performed on common matrices and at standard or noted conditions. High temperatures and/or unusual matrix requests are quoted individually.

Anton Parr (0–60°C)	$200
Brookfield	$150
Falling Sphere	$125

Fees do not include sample preparation. See the Sample Preparation Fee List on page 12 for solid samples that are not received at 150 mesh or finer.

LIMESTONE SO_2 REACTIVITY STUDY BY TGA (see description on page 17)..... $850

Customized run conditions, simultaneous techniques, and analytical interpretation assistance available on request, by quote.

THERMOGRAVIMETRIC ANALYSIS (TGA)

Samples up to 1,100°C..... $450
Samples up to 1,400°C..... $650

Determines weight losses or gains of a sample as a function of temperature. Useful for studying oxidation reactions and weight loss reactions of a wide variety of materials under programmed heating rate conditions.

Macro TGA (Samples up to 1,100°C) $600

Determines the weight loss or gains of a sample as a function of temperature using a sample cup up to 5 mL to generate a larger sample for additional analysis.

SIMULTANEOUS ANALYSIS

Samples are typically run in an inert atmosphere unless requested; there are some limitations to atmosphere composition at high temperatures.

Thermogravimetric analysis and differential scanning calorimetry (TGA/DSC)
- Samples up to 1,100°C..... $750
- Samples up to 1,400°C..... $950

Simultaneously measures the weight losses or gains of a sample and the heats associated with the chemical or physical changes occurring in the material as a function of temperature.

Thermogravimetric analysis and differential thermal analysis (TGA/DTA)
- Samples up to 1,100°C..... $750
- Samples up to 1,400°C..... $950

Simultaneously measures the weight losses or gains of a sample and detects the temperature difference between a sample and an empty reference cup. The DTA records the temperature difference as endothermic or exothermic reactions occurring in the sample. Can be used to measure temperatures of phase transitions, melting points, volatilizations, and dehydrations.

HEAT CAPACITY

Samples up to 1,100°C..... $1,500
Samples up to 1,400°C..... $2,000

Measures the heat capacity of a material by comparing the DSC signal to a known reference material in an inert atmosphere at a slow heating rate. This can be useful in determining the heat requirement of a material within a system. For multiple analyses, each additional sample cost is $750.

Customized run conditions (heat rate, soak temperature/time, atmospheres), simultaneous techniques, and analytical interpretation assistance is available on request, by quote.

CONVERSION FACTORS AND DEFINITIONS

WEIGHTS AND CONCENTRATIONS

1 ppm = 0.0001% = 1 mg/kg
oz/ton = troy oz/short ton
oz/ton x 34.3 = ppm
ppm x 0.0292 = oz/ton
1 lb avoirdupois = 16 oz avoirdupois = 14.58 troy oz
1 short ton = 2000 lb avoirdupois = 29,167 troy oz = 0.9072 metric ton

UNITS OF RADIOACTIVE DECAY

1 curie (Ci) = 3.7×10^{10} dps (disintegrations per second)
1 becquerel (Bq) = 1 dps
1 becquerel = 2.70×10^{-11} Ci = 27 pCi
1 pCi = 2.22 dpm (disintegrations per minute)

1 pCi	$= 10^{-12}$ Ci	1 KBq	$= 10^{03}$ Bq
1 nCi	$= 10^{-09}$ Ci	1 MBq	$= 10^{06}$ Bq
1 uCi	$= 10^{-06}$ Ci	1 GBq	$= 10^{09}$ Bq
1 mCi	$= 10^{-03}$ Ci	1 TBq	$= 10^{12}$ Bq

RADIATION DOSE

1 rad = 0.01 joule/kg = 100 ergs/g of absorbed dose
1 rem = basic unit of absorbed dose equivalent = 1 rad of X-rays
1 sievert (Sv) = 100 rem
1 mrem = 0.001 rem = 0.01 mSv
1 Gray (Gy) = 100 rad

CALORIFIC VALUES

1 Btu = 1055.1 Joules (J)
1 Btu/lb = 2.326 J/g
1.8 Btu/lb = 1.0 cal/g
1 Calorie = 4.1868 J

RADIATION EXPOSURE RATE

1 uSv/hr = 0.1 mrem/hr
1 mSv/hr = 100 mrem/hr

MASS TO ACTIVITY

% U(nat) x 6770 = pCi/g
ppm U(nat) x 0.677 = pCi/g
% Th(nat) x 2180 = pCi/g
ppmTh(nat) x 0.218 = pCi/g
% K x 8.2 = pCi/g K-40

GRAVIMETRIC CONVERSION FACTORS

Element	Oxide	Factor	Element	Oxide	Factor	Element	Oxide	Factor
Al	Al_2O_3	1.889	Mg	MgO	1.658	Sr	SrO	1.183
Ba	BaO	1.117	Mn	MnO	1.291	Ti	TiO_2	1.668
Ca	CaO	1.399	Na	Na_2O	1.348	U	U_3O_8	1.179
Fe	FeO	1.286	P	P_2O_5	2.291	V	V_2O_5	1.785
Fe	Fe_2O_3	1.430	S	SO_3	2.497	W	WO_3	1.261
K	K_2O	1.205	Si	SiO_2	2.139	Zr	ZrO_2	1.351