HEVI-SAND®

Chromite Sand Testing

MINERALS TECHNOLOGIES

Metalcasting

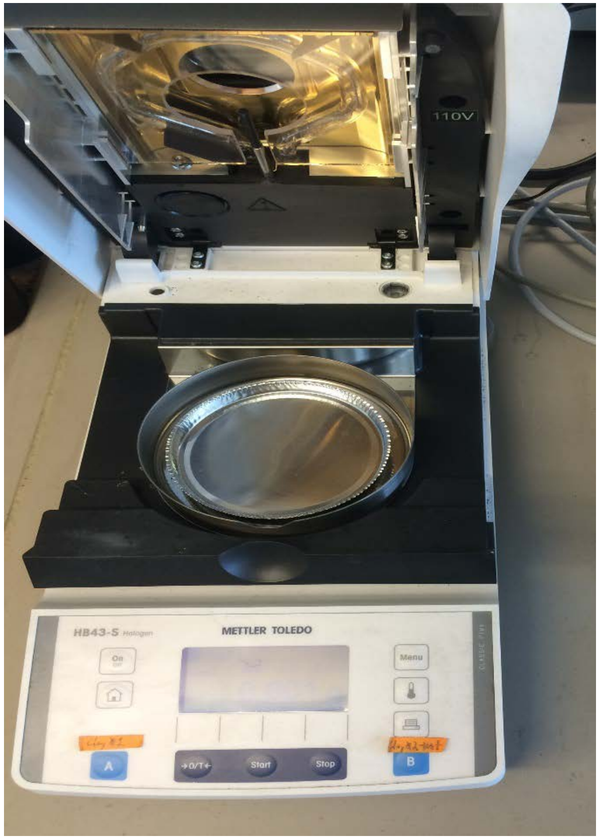
Typical Chromite Sand Testing

- South African Chromite Sand is the world standard for metalcasting and foundry applications, however there can be variations in the quality of chromite sand depending on grade, location, mining and beneficiation methods.
- There are many tests that are available to provide insight into the quality and suitability of chromite sand for a given application.

- Some of these tests can include:
  - **Moisture determination-** important for compatibility with chemical binders
  - **Chemical Analysis-** Foundry grade chromite should have high chromium oxide concentration and low silica content
  - **pH and Acid Demand Value-** important tests in predicting issues with curing and strength development in chemical binder systems
  - **LOI- Loss on Ignition-** can be used to look for accessory minerals and impurities associated with the chromite sand.
  - **Turbidity-** an indicator of the cleanliness of the chromite sand
  - **Particle Size Distribution-** AFS Grain Fineness Number- can influence packing density, permeability and surface finish of castings
  - **Bulk Density-** packing density can be important in some applications
  - **Tensile Strength Testing-** can be used to look for compatibility with chemical binder systems

Moisture

- This is an easy but important test. Moisture can severely impact typical chemical binder systems often used with mineral sands and result in incomplete curing and low tensile strengths.
- The moisture percentage can be checked in many ways, but typically is done with an infrared moisture balance.
- Can also be calculated by measuring the difference in weight between “as received” material and material that has been dried to a constant weight in an oven.



Infrared moisture balance

Chemical Analysis

- X-Ray Florescence (XRF) and Inductively Coupled Plasma Mass Spectroscopy (ICP-MS) are the most common approaches to determining the concentration of various elements in the chromite sand.
  - Results are typically reported as oxide values (Cr_2O_3, SiO_2 etc.)
  - Chromium Oxide, Silicon Dioxide, Iron Oxide, Magnesium Oxide, Aluminum Oxide and Calcium Oxide are all typically provided in this analysis

- There are different sample prep methods for XRF and ICP, but each should start with a representative sample that has been milled to analytical fineness to ensure good homogeneity.
- High quality standards and calibration curves in the expected ranges for each element are essential for any chemical analysis method.

Sample ID	Cr_2O_3	SiO_2	FeO	MgO	Al_2O_3	CaO	Total	Cr/Fe
Hevi-Sand®	46.66	0.44	25.96	10.41	14.97	0.06	98.50	1.58

Example of typical results from XRF measurement

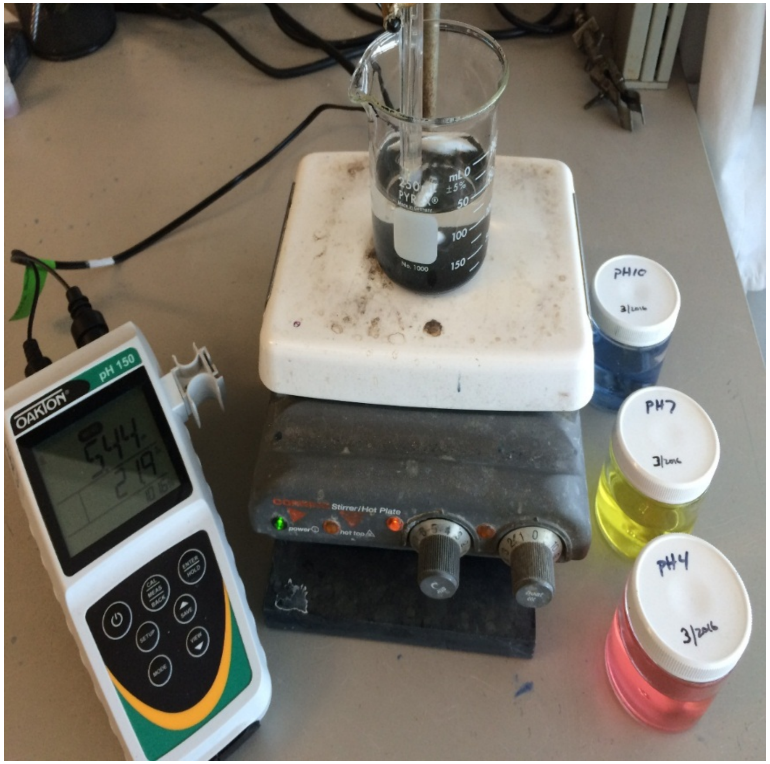
pH and Acid Demand Value

pH

- The pH test is a measure of the amount of hydronium ions present in a solution. The pH test is used to determine the acidity or alkalinity of a sand when mixed with water.
- Chromite sand is typically slightly basic with a pH value between 7-9.
- pH is reported on a logarithmic scale from 0 to 14 with low values being acidic (<7.0) and higher values being basic (>7.0)

Acid Demand Value

- The Acid Demand Value (ADV) is a measure of any acid soluble material present in the sand.
- Certain minerals are not soluble in water and therefore are inert in the pH test, but are soluble in slightly acidic conditions and can then participate in acid/base reactions.
- Consistent and low acid demand values are preferred to ensure predictable and consistent curing of the sand in typical organic foundry binder systems.
- High acid demand values can interfere with both acidic and basic catalyzed systems and lead to slow or overly rapid curing times and low strengths.



pH meter, pH buffers and magnetic stir plate

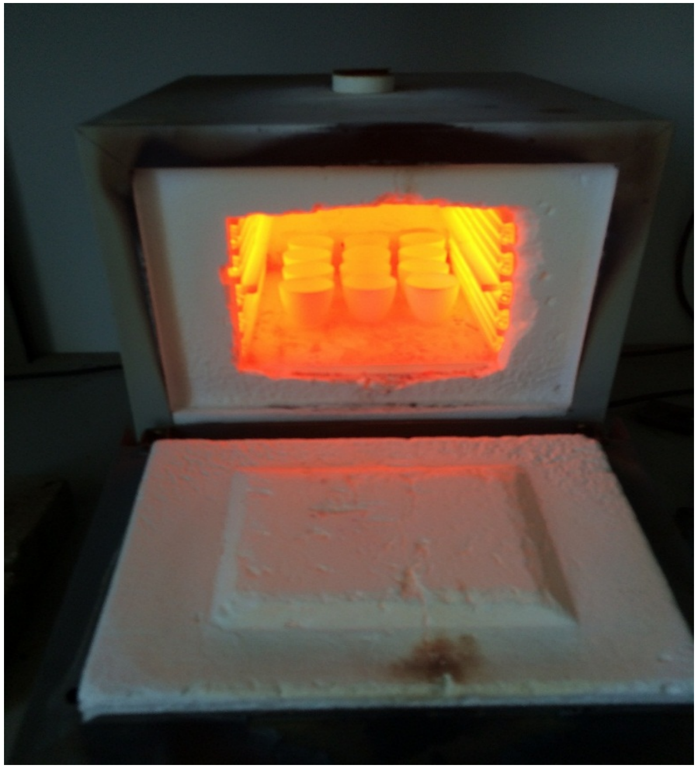
Loss on Ignition

- The loss on ignition test is a test to measure the change in weight of a sample (gain or loss) when a sample is heated to 982°C

- Material can lose weight due to removal of volatile organics, removal of chemically bound water, disassociation of inorganic compounds and accessory minerals often associated with chromite sand deposits.

- Materials can also gain weight due to oxidation reactions. This is especially true of chromite sands when tested in an oxidizing atmosphere such as a typical laboratory furnace. Typical foundry grade chromite sands will show a weight gain of 0.5 to 1.0 in a standard LOI test.

- To avoid oxidation reactions, chromite sands can be heated under an inert atmosphere such as nitrogen. Under these conditions a high quality foundry chromite sand will experience a minimal weight loss of 0 to 0.2%



Laboratory muffle furnace capable of 982°C

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Turbidity- Traditional

- The turbidity test measures the amount of light scattering caused by the fine particulates that are left suspended in water after agitating chromite sand for a fixed amount of time.
- In traditional processing methods these fine particulates are often low melting silicates that are entrained in the chromite sand during processing and can contribute to certain types of casting defects.
- This test has traditionally been conducted with a Jackson turbidity tube which is a glass cylinder with a candle placed under it. A sample of chromite was shaken in a beaker with water and the turbid liquid is decanted and poured slowly into the cylinder with the operator looking down into the cylinder, the end point was reached when the operator saw that the candle was obscured.
    - The test is calibrated using series of solutions prepared from diatomaceous earth as standards. This is why results were often reported in parts per million of silica or Jackson Turbidity Units (JTU).
    - This test was prone to a variety of errors and was highly dependent on operator judgment

Jackson Tube apparatus

Turbidity- Modern

- In a effort to make the turbidity test more consistent, repeatable, and meaningful, many changes have been made to the traditional turbidity test.
  - Consistent repeatable agitation of the sand and water mixture is achieved by using a wrist action shaker. Mechanical agitation is more consistent and repeatable than a human operator shaking a beaker.
  - Introduction of a modern turbidity meter (Nephelometer) which uses a light source with a consistent wavelength fixed at 90° from the sample being tested and measured with an electronic detector.
  - Incorporation of traceable, universally available calibration standards that can be used across all labs. Best practice for turbidity measurements in other applications use Formazin standards with units reported as NTU (Nephelometric Turbidity Units).
- Please note NTU and JTU are not equivalent. There are many other turbidity units that are used for different applications and may indicate a different type of light source or observation angle being used (FNU and FAU for example)

Modern Instrument for turbidity measurement

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Particle Size Distribution- AFS GFN

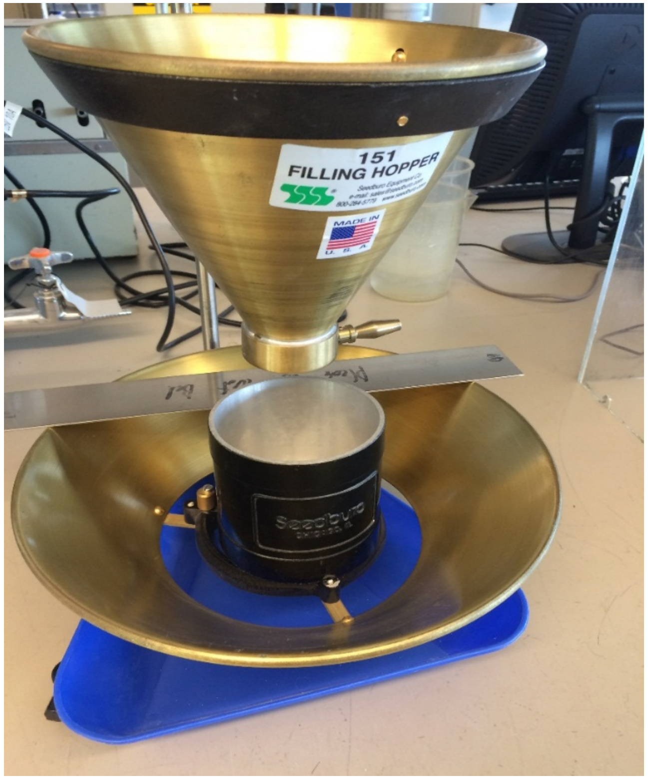
- The American Foundry Society (AFS) Grain Fineness Number (GFN) is a calculation that is derived from the amount of material retained on a series of nested ASTM E-11 wire mesh sieves.
- The sizes to be used are specified by the AFS procedure and a multiplication factor is given for each sieve size. Other sieve designations such as British Series (BS) can be used but alternative factors must be used to account for the different sized apertures in those sieves.
- The amount retained on each sieve is recorded and then multiplied by its corresponding factor. The results are calculated to arrive at a single Grain Fineness Number with the higher the number, the finer the sand distribution.

	Series Designation			Hevi-Sand®
	Standard	Alternate		
Percent Retained on USA Std. Sieves with ASTM Specification E-11-86 and I.S.O.	3.35 mm	No.	6	0.00
	1.70 mm	No.	12	0.00
	850 µm	No.	20	0.05
	600 µm	No.	30	2.24
	425 µm	No.	40	13.38
	300 µm	No.	50	31.19
	212 µm	No.	70	33.26
	150 µm	No.	100	16.47
	106 µm	No.	140	3.13
	75 µm	No.	200	0.27
	53 µm	No.	270	0.02
	Pan		Pan	0.00
Total				100.0
AFS Grain Fineness Number.				48.6

Example of particle size distribution and AFS value

Bulk Density

- Density is a measure of mass divided by volume
- Bulk density is often measured on aggregates to look for packing efficiency of the particles. It differs from specific gravity and apparent density because the voids between the particles are included in the volume.
- Bulk density can be influenced by the shape of the particles in the aggregate as well as the particle size distribution
    - Typically a 3-4 screen distribution will provide optimum packing density , smaller particles can fill the voids left by grain to grain contact of larger particles
- Bulk density can be measured loose or “tapped” where an effort is made to settle or compact the aggregate by agitation or “tapping”
- Results are reported as pounds per cubic foot (lbs/ft^3) or kilograms per cubic meter (kg/m^3) often converted to grams per cubic centimeter (g/cm^3)



Apparatus for measuring free flowing bulk density

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AFS Tensile Strength Testing

AFS Tensile Testing –often called “Dogbone” Testing

- Tensile strength of various sands (chromite, silica, olivine etc.) can be measured by mixing with a foundry resin system and preparing 1 inch thick (2.54 cm) tensile specimens or “Dogbones”.
- The tensile specimens are prepared and allowed to cure for various amounts of time before measuring the tensile strength (30 minutes 4 hours, 24 hours etc.). Curing can be done in ambient conditions or under controlled humidity conditions.
- Work Time and Strip Time (WT/ST) measurements are also recorded on the chemically bonded sand during curing
- MTI laboratories can measure tensile strength in a variety of commonly used foundry binder systems such as phenolic urethane no bake (PUNB), furan no bake (FUNB), ester cured phenolic or alkaline phenolic, and phenolic urethane cold box (PUCB).
- Transverse tensile strength and compressive strength can also be measured and is more commonly seem in Europe and Asia.

Gauge on tensile testing equipment and standard AFS tensile specimens

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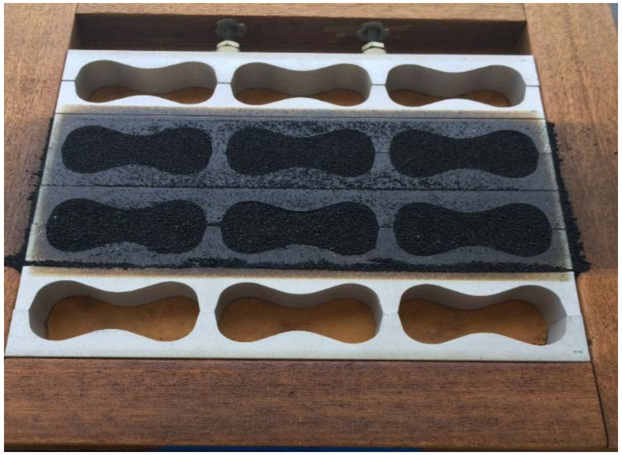
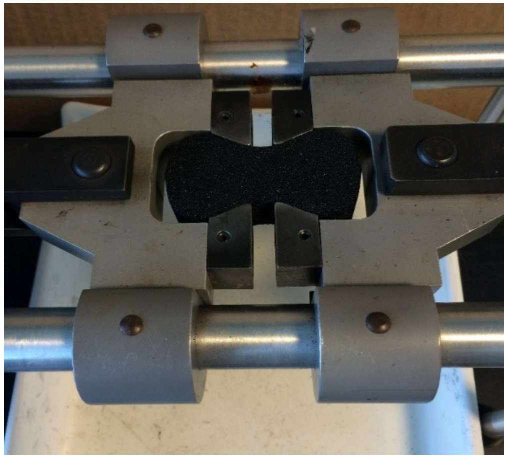
How Can MTI help?

- Many of the tests described here are part of typical Hevi-Sand quality control testing. Other tests are used for more customer application specific testing.
- Many of these testing methods can be applied to other mineral sands or engineered specialty aggregates
- MTI Laboratories can assist with any chromite sand testing needs whether it is testing, training or advice - Just ask!





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