Ceramic media increases precision, reduces defects and improves safety in green sand casting

Comprehensive research study confirms a safe, superior alternative to silica sand

Executive summary

For years, naturally occurring silica sand has been the most widely used molding media in the metal casting industry, due to its low cost and abundant availability.

However, the demand for increasingly complex castings requires media with greater thermal stability, increased dimensional accuracy and enhanced casting capabilities. In addition, increased environmental, health and safety (EHS) risks associated with silica sand have resulted in increasingly rigorous workplace regulations. Foundries face the requirement to add expensive systems and equipment, or to find an alternative to silica sand altogether.

This paper compares the use of ACCUCAST® and KRYPTOCAST™ high-performance ceramic casting media versus silica sand in the green sand casting process. It is based on the findings of a comprehensive study conducted by the Metal Casting Center of the Department of Industrial Technology at the University of Northern Iowa, supplemented by other university studies and industry testing.

Ceramic casting media is a manufactured product that contains no quartz silica and produces no dust. In addition, ceramic casting media has been proven to produce higher quality castings with increased dimensional accuracy, fewer defects and reduced cleaning costs.

Ceramic media: A proven superior alternative to silica sand

The initial introduction of ceramic media to the metal casting industry occurred in 1994 via a Department of Energy (DOE) Energy Conservation study titled "Alternative Granular Media for the Metal Casting Industry" (DE95017626). The work, performed by the University of Western Michigan, reviewed 16 materials as potential alternatives for silica sand. Of the materials evaluated, the synthetic ceramic products had the best overall performance (Guichelaar, Ramrattan, Tieder 1994).

ACCUCAST media products from CARBO have provided superior performance to the metal casting industry for decades. KRYPTOCAST represents the latest generation of

ceramic media technology, delivering even greater levels of particle strength, durability, smoothness and consistency.

State-of-the-art study proves real-world benefits

The University of Northern Iowa has one of the most advanced facilities for evaluating products and processes for metal casting. All the tests conducted for characterizing the five green sand mixtures followed AFS standards using Simpson precision testing devices. With 55 GFN silica sand as a baseline sample, the following CARBO products were evaluated:

- ACCUCAST ID 50 (Intermediate Density)
- ACCUCAST LD 45 (Low Density)
- KRYPTOCAST LD30 (Low Density)
- KRYPTOCAST HD20 (High Density)

The samples were initially given a mull down test to evaluate the relative speed of bond development. Sodium bentonite clay and other required materials were added in corrected proportions, mulled for 10 minutes, and moisture corrections were made to obtain a compactability in the range of 42 ± 2. Twelve additional cycles were run at 5-minute intervals. At the end of the final cycle, the five green sand mixtures were evaluated for a full array of green properties.

Baseline strengths demonstrate the power of technology

All of the ceramic samples showed significantly higher green compression strength than silica sand. The newer KRYPTOCAST technology demonstrated superior strength in almost every test parameter.

	Green Compression Strength (psi)	Dry Compression Strength (psi)	Green Shear Strength (psi)	Dry Shear Strength (psi)	Wet Tensile Strength (psi)
ACCUCAST ID50	28.31	43.77	6.65	12.56	0.31
ACCUCAST LD45	27.45	45.70	6.25	12.60	0.34
KRYPTOCAST LD30	31.43	54.66	7.52	13.13	0.45
KRYPTOCAST HD20	30.06	55.97	7.33	12.85	0.44
55 GFN Silica	22.57	46.62	7.25	13.50	0.47

Preventing surface defects due to waste gases

The lower measured loss on ignition indicates that the ceramic media will give off less gas in the heat of the casting process. The significantly higher permeability means that any gas produced can flow away from the casting. (The permeability of KRYPTOCAST HD20 actually exceeded the measuring capability of the test equipment.)

Loss on ignition and AFS permeability results

	Loss on Ignition (%)	AFS Permeability
ACCUCAST ID50	0.87	411.33
ACCUCAST LD45	0.91	451.00
KRYPTOCAST LD30	0.90	918.67
KRYPTOCAST HD20	0.85	*
55 GFN Silica	0.93	185.67

*Greater than the upper measurable limit of the equipment

Lower loss on ignition coupled with higher permeability means that ceramic media reduces gas defects, lowering cleanup time and minimizing the solid waste footprint, thus improving environmental factors.

Smoother casting surfaces

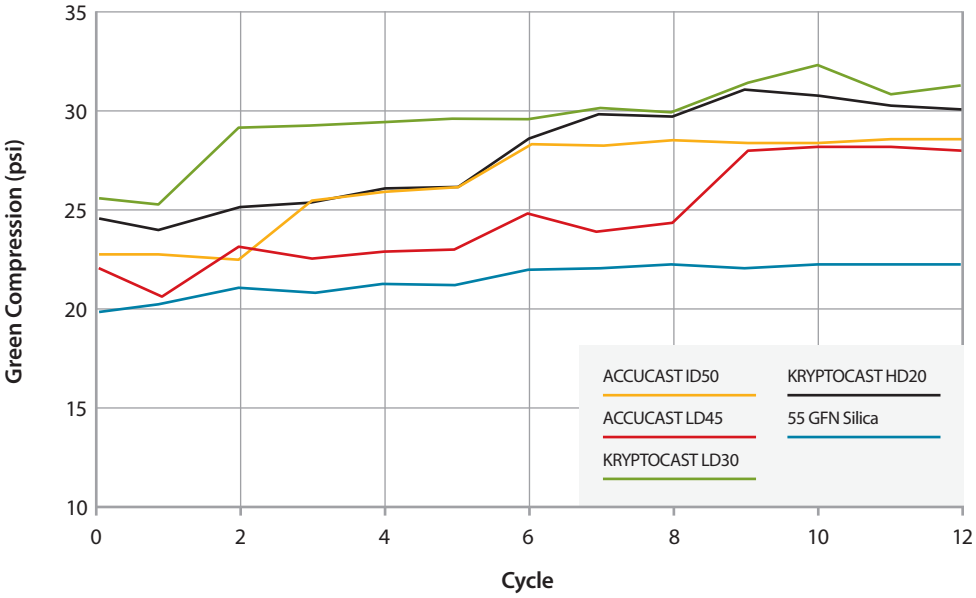
KRYPTOCAST technology yields a harder mold to produce smoother surfaces on the castings, while all of the CARBO ceramic media require less clay content than silica sand.

	Mold Hardness (B scale)	Methylene Blue Clay (%)
ACCUCAST ID50	76.67	7.46
ACCUCAST LD45	92.00	7.37
KRYPTOCAST LD30	95.67	7.47
KRYPTOCAST HD20	92.67	7.37
55 GFN Silica	91.00	7.51

Greater strength and getting stronger with use

With successive mulling cycles, ACCUCAST and KRYPTOCAST media showed higher green compressive strength versus silica sand with repeated use. Silica sand was consistent through the repeated cycles but never as strong as the ceramic media.

Green compression (psi)—mull down test results



Ceramic media greatly enhances reclamation and recycling. The engineered strength, thermal stability, consistent shape and smooth surfaces of ceramic pellets allow them to be reclaimed and reused multiple times. Irregularly shaped silica sand grains, on the other hand, will break down during handling following exposure to high temperature and pressure. This decreases permeability—and worse—releases fine particles of hazardous quartz silica dust.

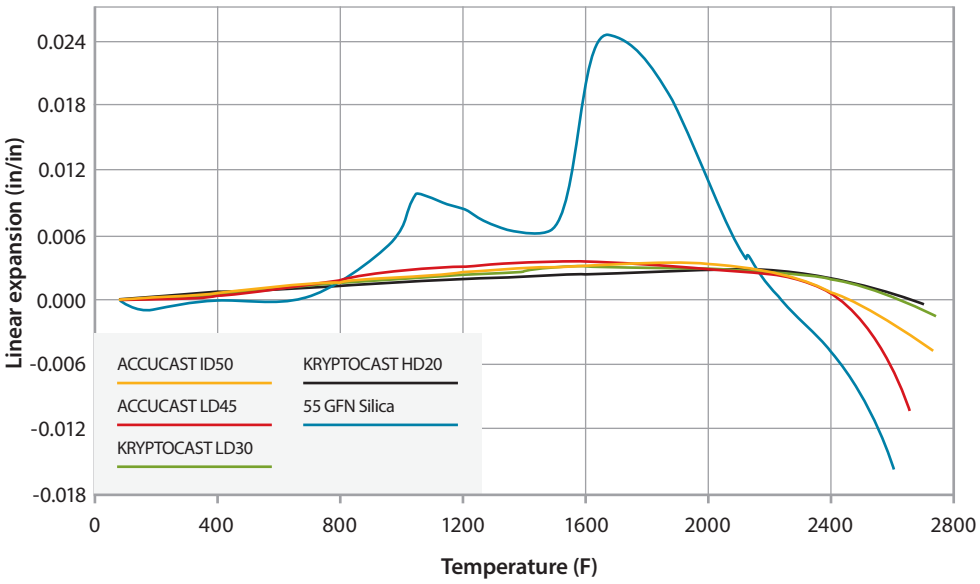
Low thermal expansion for improved casting quality

ACCUCAST and KRYPTOCAST media are manufactured with a high temperature sintering process that produces primary crystalline structures of mullite and corundum enabling them to exhibit minimal thermal expansion and high durability during the casting process. This thermal stability provides increased dimensional accuracy and enhanced casting capabilities that allow the production of more complex parts with repeatable accuracy. Its low, linear thermal expansion prevents the occurrence of expansion-related defects such as:

- Veining
- Penetration
- Burn-on
- Hot tears
- Associated costs to clean, correct or scrap the part

The erratic thermal expansion of silica sand causes instability in the mold. The rapid expansion leading to the alpha-beta transformation followed by a secondary expansion due to a tridymite phase transformation.

Green Sand Thermal Expansion

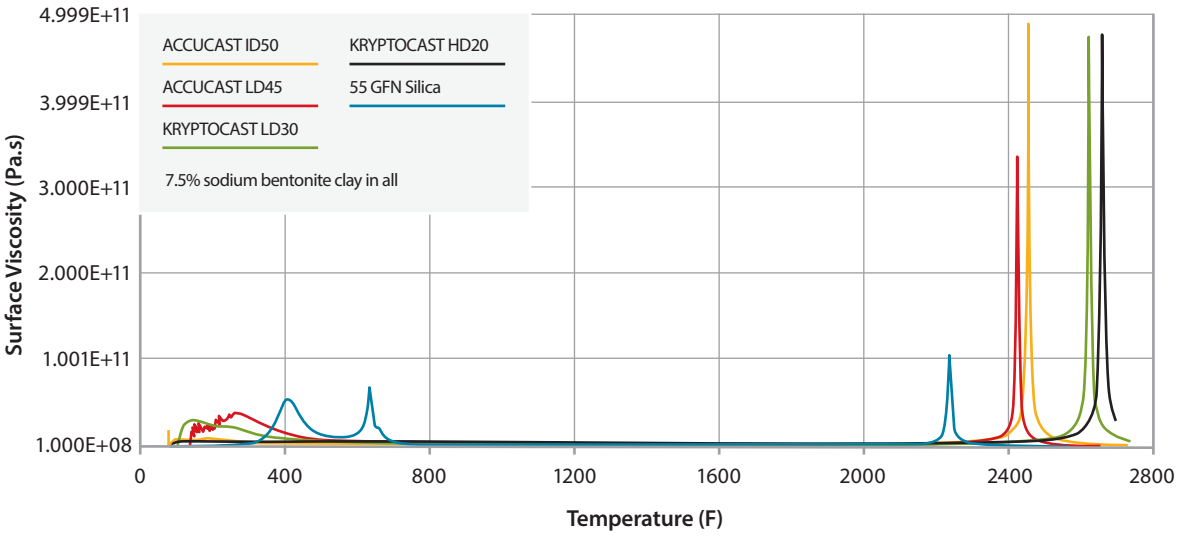


Maintaining integrity at higher temperatures in the mold

In addition to its low thermal expansion, ceramic media exhibits a surface viscosity change at a higher temperature versus silica sand, indicating a higher stability and product sintering temperature. The sinter temperatures of the ACCUCAST samples were measured at above 2,400°F, and the KRYPTOCAST products were even higher at more than 2,600°F.

By comparison, the 55 GFN silica sample measured a significantly lower sinter temperature of 2,237°F.

Green Sand Surface Viscosity



Chemically inert for increased compatibility

CARBO ceramic media is compatible with various metals, resins and additives used in metal casting.

Virtually silica-free for reduced HSE risks and PEL concerns

In a separate study, rigorous testing was conducted to evaluate the degree of employee exposure to crystalline silica during handling of CARBO lightweight ceramic media. The study monitored employees in very similar conditions and equipment to those that would be experienced by customers.

Personal and area monitoring included samples from a variety of normal production activities, conveying/handling equipment and baghouse dust collector material. All samples were analyzed using NIOSH Method 7500 by XRD. For this test, the quartz non-detectable threshold was 0.0056 mg/m^3 – roughly 10 times less than the new permissible exposure limits (PEL) of 0.05 mg/m^3.

The testing revealed that there was no detectable crystalline silica (quartz, cristobalite or tridymite) in any of the collected samples.

Unlike silica sand, CARBO ceramic casting media produces absolutely no carcinogenic quartz silica dust. It poses no hazards and reduces health, safety and environmental (HSE) concerns and complies with silica PEL.

Conclusions

As the metal casting industry seeks ways to comply with increasingly rigorous HSE regulations and protect its workers from the dangers of silicosis, CARBO ceramic media provides an alternative that is measurably superior to silica sand in nearly every way and also poses virtually no health risks.

ACCUCAST and KRYPTOCAST media:

- Improve casting dimensional accuracy, reproducibility and capability
- Reduce the incidence of defects such as burn-on, veining, penetration, gas and pattern distortion
- Improve product reclamation and recycling, reducing solid waste generation

The unique physical, chemical and thermal properties of ACCUCAST and KRYPTOCAST combine to improve casting quality while reducing health, environmental and safety concerns.

For additional information, please contact:

Claude A. Krause

Claude.Krause@carboceramics.com

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