TECHNICAL BULLETIN

Thermax® in Taphole Clays

Thermax® N990 medium thermal carbon black is manufactured by the thermal decomposition of natural gas. The thermal process provides a unique carbon black characterized by a large particle size and low structure. Thermax® N990 is widely used in applications that require excellent dispersion as well as superior heat, oil and chemical resistance.

Carbon is used in taphole clays to increase resistance to thermal shock as well as corrosion and erosion resistance. Due to increasingly stringent health regulations, traditional binder tar, with carcinogenic and detrimental effects, is being replaced by a lesser carbon-containing binder, phenolic resin, decreasing carbon content of the taphole clay. Traditionally, graphite is used as this additional carbon source. Thermax® N990, at carbon purities above 99%, presents a high carbon-content alternative carbon source for taphole clays.

The following study conducted by Cancarb Limited demonstrates the benefits of using Thermax® N990 in taphole clays as an improved graphite replacement. It is recommended that up to 50% graphite replacement loading be used to improve taphole clay properties.

Benefits of using Thermax® in taphole clays:

- Decreased porosity
- High corrosion and abrasion resistance
- Limited shrinkage
- High flow of clay mixture
- Increased cold crushing strength
- Unaffected bulk density

Table 1. Taphole control mixture composition

Calcinated Bauxite	10%
Quartzite	12.5%
Silicon Carbide (SiC)	5%
Graphite	**20%**
Pyrophyllite Clay	10%
Silicon Nitride	5%
Raw Kyanite	10%
Sillimanite sand	20%
Kaolinite Clay	5%
Zirconia	2.5%
Si Metal	2.5%

Mechanical properties testing

The following table demonstrates the effects of graphite replacement with Thermax® N990 in dried and fired taphole clays. Up to 75% of the graphite was replaced with Thermax®.

Table 2. Mechanical properties of taphole clay containing N990

Dried Taphole Clay	**0% N990** / 20% Graphite	**5% N990** / 15% Graphite	**10% N990** / 10% Graphite	**15% N990** / 5% Graphite
Apparent Porosity, %	10.9	9.5	10.4	11.6
Bulk Density, g/cm^2	2.6	2.5	2.6	2.6
Cold Crushing Strength, kg/mm^2	220	380	450	390
Loose Packing Density	100	94	97	83
Fired Taphole Clay	**0% N990** / 20% Graphite	**5% N990** / 15% Graphite	**10% N990** / 10% Graphite	**15% N990** / 5% Graphite
Apparent Porosity, %	13.7	13.7	13.5	14.5
Bulk Density, g/cm^2	2.1	2.1	2.05	2.05
Cold Crushing Strength, kg/mm^2	120	160	200	220
Reheat Thermal Expansion, %	2.3	1.75	2.5	2.2
Volatile Matter, %	30	30	31	34

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As shown in Table 2, up to 50% graphite replacement presents an improvement (decrease) in apparent porosity characteristics as well as a significant increase in the cold crushing strength of the material. There is no significant change in bulk density at any Thermax® N990 loading. The loose packing density of the clay is not significantly impacted

After firing, similar properties are observed. Increasing Thermax® N990 content, up to 50% graphite replacement, decreases the porosity, does not change bulk density and increases the cold crushing strength of the taphole clay. Cold crushing strength is indicative of abrasion resistance and resistance to slag attack [1]. Additionally, thermal expansion remains under 2.5% and the volatile matter is unaffected. Volatile matter was determined using thermal volume expansion testing.

Comparison with N774 Furnace Black

Testing was also completed on the replacement of graphite with N774 Furnace Black to compare the effect of particle size. Identical testing was performed, replacing the 20% graphite content with up to 15% N774. For comparison, the 10% N990/10% Graphite mixture is shown.

Table 3. Mechanical properties of taphole clay containing N774, comparison with N990

Dried Taphole Clay	0% N774 / 20% Graphite	10% N774 / 10% Graphite	**10% N990 / 10% Graphite**
Apparent Porosity, %	10.9	9.9	**10.4**
Bulk Density, g/cm^2	2.6	2.1	**2.6**
Cold Crushing Strength, kg/mm^2	220	340	**450**
Loose Packing Density	100	89	**97**
Fired Taphole Clay	0% N774 / 20% Graphite	10% N774 / 10% Graphite	**10% N990 / 10% Graphite**
Apparent Porosity, %	13.7	17.8	**13.5**
Bulk Density, g/cm^2	2.1	1.95	**2.05**
Cold Crushing Strength, kg/mm^2	120	190	**200**
Reheat Thermal Expansion, %	2.3	-0.1	**2.5**
Volatile Matter, %	30	31	**31**

Thermax® N990 presents improved properties in fired taphole clay over that containing N774. The larger size particle offers better apparent porosity and bulk density, while improving the strength of the material. The extremely low levels of impurities in Thermax® ensures that it is one of the best carbon sources available.

Table 4. Typical Physico-Chemical Properties

ASTM Reference	**Test Description**	**Thermax® N990**
D1506	Ash Content (%)	0.1
D1509	Heat Loss (%)	0.0
	Toluene Extractables (%)	0.2
	Sulphur (ppm)	170
D3037	Nitrogen Surface Area (m^2/g)	9.8
D1513	Pour Density (lbs/ft^3)	40
	(g/cm^3)	0.64
D1508	Fines Content (%)	4.0
D1512	pH values	10
	Mean Particle Diameter (nm)	250
	Ultimate Specific Gravity	1.8-1.9

[1] Cole, S. (1932). RELATION OF CRUSHING STRENGTH OF SILICA BRICK AT VARIOUS TEMPERATURES TO OTHER PHYSICAL PROPERTIES*. *Journal of the American Ceramic Society, 15(11), pp.611-621*