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TECHNICAL BULLETIN

Butyl Rubber Condenser Packings

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® is widely used in applications that require excellent heat, oil and chemical resistance and superior dynamic properties. The large particle size (low surface area) and low structure allow for low compression set, high rebound and low hysteresis, maintaining the inherent elastomeric properties of the rubber compound. These unique properties also help to maintain low viscosity, provide excellent dispersion and reduce heat build-up in processing. High loadings of Thermax® are possible, while maintaining low viscosity, low compression set and high resiliency, thereby allowing manufacturers to reduce compound cost. As a non-reinforcing black, thermal black is often blended with furnace carbon blacks and/or mineral fillers to achieve cost reduction and specific physical properties in the rubber compound. Thermal carbon blacks are often blended into high tensile stocks containing furnace blacks to give resilience and lower heat build-up.[1]

Butyl rubber is known for its special properties, including low rates of gas permeability, thermal stability, ozone and weathering resistance, vibration damping and higher coefficients of friction and chemical and moisture resistance.[2] For most butyl compounds used in the rubber industry, reinforcing fillers are specified to achieve smooth processing and appropriately high modulus and strength properties in the vulcanizate. Carbon black, together with an appropriate quantity of process oil, gives the best balance in processing, and in the physical properties of the vulcanizate.[3] Applications where butyl rubber is filled with thermal black include body mounts, condenser packings, gaskets, tank linings, roll coverings, curing bladders, cable and hose.

This technical bulletin provides the results of Cancarb's evaluation of Thermax® N990 in butyl condenser packings. The objective was to increase the filler loading, for cost savings, while maintaining or improving the desired physical properties. Condenser packings are a very demanding application and require the following:

- good dynamic properties to allow for expansion of the electrolyte
- high sealing properties and gas impermeability to prevent leakage of the electrolyte
- low sulphur and chloride levels, to prevent chemical reaction
- high insulating values

Exxon Butyl 268 is commonly used in this application due to the high levels of chemical resistance and gas impermeability provided by this polymer. The control formulation was taken from the Exxon Butyl Rubber, Compounding and Applications brochure (see endnotes).

[1]H. Nagano, Exxon Butyl Rubber Compounding and Applications, Exxon Chemical Publication, p. 19
[2]J.V. Fusco and P. Hous, "Butyl and Halobutyl Rubbers," in The Vanderbilt Rubber Handbook, 13th edition, 1990, p. 101
[3]Bayer-Polysar Butyl Website – Section 9.3, Compounding, p.5

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Test Formulations

	Control	#2	#3
Exxon Butyl 268	100	100	100
Thermax® N990	**20**	**95**	**66**
N762 Carbon Black	45	-	20
Translink #37	90	90	90
Stearic Acid	1	1	1
Zinc Oxide	3	3	3
SP 1045 Resin	20	20	20

The filler loadings were calculated for 70 Shore A Hardness.

Compound Data

Processing Properties

Compound	Control	#2	#3
Carbon Black Loading N990/N762	20/45	95/0	66/20
Specific Gravity	1.3955	1.4367	1.4236
Mooney Viscosity, 100°C			
Initial	100.47	97.65	101.07
@ 4 minutes	79.43	78.94	81.22
Mooney Scorch, M_L, 125°C			
Minimum Torque	59.15	58.29	59.10
Ts1, Minutes to 1pt. rise	14.25	12.00	13.25
Ts5, Minutes to 1pt. rise	37.75	33.25	34.00
Ts10, Minutes to 1pt. rise	68.00	59.00	60.00
Ts35, Minutes to 1pt. rise	147.75	139.00	140.00

The viscosity of the three compounds is essentially similar, in spite of the higher loadings of carbon black in test compounds #2 and #3. The rheometer data indicates little difference in processing properties.

Oscillating Disk Rheometer, ASTM D2084, 1° arc, 190°C			
Minimum (dN-m)	6.3	5.9	6.2
Maximum (dN-m)	31.3	32.4	32.0
T_c50	18.9	19.2	19.1
T_c90	28.8	29.7	29.5

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Vulcanizate Properties, ASTM D412 Originals	Control	#2	#3
Carbon Black N990/SRF	20/45	95/0	66/20
Shore A Hardness	69	71	71
100% Modulus (MPa)	3.52	3.58	3.70
200% Modulus (MPa)	5.31	5.07	5.35
300% Modulus (MPa)	6.26	5.31	5.78
Tensile Strength (MPa)	6.65	5.02	5.60
Elongation (%)	426	485	442

The filler loadings were designed for a Shore A Hardness of 70, which has been achieved. The compound properties are essentially equal and indicate that the carbon black can be loaded 46% more than the control compound, for equivalent hardness. This would provide substantial cost savings. Compounds with thermal carbon black generally have slightly lower tensile strength due to the non-reinforcing properties of the large particle, low structure black.

Aged Properties, 168 hours @ 125°C	Control	#2	#3
Shore A Hardness	74 (+7.2%)	77 (+8.4%)	76 (+7.0%)
100% Modulus (MPa)	4.19 (+19%)	3.87 (+8.1%)	4.17 (+12.7%)
200% Modulus (MPa)	5.38 (+1.3%)	4.13 (-18.5%)	ND
300% Modulus, (MPa)	ND	ND	ND
Tensile Strength (MPa)	5.44 (-18.1%)	4.68 (-6.7%)	5.02 (-10.3%)
Elongation (%)	209 (-51%)	197 (-59%)	181 (-59%)

Compression Set, ASTM D395, Method B, 25% compression, 70 hours @ 125°C

Compression Set (%)	24.1	24.8	24.5

Resilience by Vertical Rebound, ASTM D2632, @ 23°C

Rebound (%)	5	5	4

Rebound Resistance of Rubber, DIN 53512 (Zwick Rebound Tester), @ 23°C

Rebound Resistance (%)	6.5	6.5	6.4

Dynamic properties are maintained in spite of the higher loading of carbon black in test compounds #2 and #3.

Volume Resistivity, ASTM D257, 100 VDC, @ 23°C

DC Resistance, Ohms, average of 3	2.26×10^{8}	3.20×10^{10}	2.16×10^{9}
*Volume Resistivity (ohms-cm), average of 3	7.61×10^{9}	1.12×10^{12}	7.55×10^{10}

*Volume Resistivity (ohms-cm) = electrode area/sample thickness (cm) x volume resistance (Ohms)

The insulating properties of the compound are critical for this application. Due to the low level of agglomeration of the carbon particles in Thermax® N990, substantially higher volume resistivity is obtained in the compound. The resistivity increases proportionally to the increasing loading of Thermax® N990.

The presence of sulphur and chloride in the carbon black is a concern for condenser packing manufacturers. Thermax® N990 has typical sulphur levels of 100 ppm and 30 ppm for chloride. This is reduced to average levels of 3 ppm for both S and Cl for the Thermax® Ultra Pure N990UP grade.

Summary

The filler loading can be increased by roughly 45% over the control compound when using Thermax® N990 as the sole filler, while maintaining hardness, compression set and dynamic properties. This will provide substantial costs savings as the filler displaces the more expensive polymer. Significantly higher levels of volume resistivity are also achievable. As fillers such as carbon black are generally impermeable, the compounds with higher loadings will also have enhanced impermeability.