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TECHNICAL BULLETIN

Electrical Resistivity

All carbon blacks, under normal conditions have some capability to conduct electricity. However, this conductivity varies substantially with the grade. Thermax® N990 medium thermal carbon black, characterized by its large particle size and low degree of particle agglomeration, is used in rubber products where the lowest possible level of conductivity is desired. The low structure of the N990 thermal black inhibits conductivity and helps to minimize the level of conductivity imparted to the rubber compound.

This technical bulletin provides a comparison of the electrical resistivity of EPDM compounds filled with different carbon blacks. The dry electrical resistance of the carbon blacks is also reported.

In the EPDM compound evaluation, Thermax® N990 was compared against N762, N650 and N550. Due to its high loadability and limited reinforcement potential, the N990 loading was set at 75 phr, with 50 phr for the N762, N650 and N550. Testing was performed at Akron Rubber Development Laboratory. Royalene 525 was selected as this grade is commonly used in automotive extrusions.

The formulation used was a standard EPDM test formulation as shown in Table 1.

Table 1: EPDM Test Formulation

Royalene 525	100.00	
Zinc Oxide	5.00	
Stearic Acid	1.00	
ASTM Type 103 Oil	50.00	
Carbon Black	50.00	(75 phr for Thermax® N990)
Accelerator MBT	0.50	
Accelerator TMTD	1.00	
Sulphur	1.50	
TOTAL	**209.00**	

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Table 2: Compound Properties

	N990 – 75 phr	N762 – 50 phr	N650 – 50 phr	N550 – 50 phr
Mooney Viscosity (Initial Viscosity)	32.0	26.0	35.8	37.5
Viscosity @ 4 minutes	19.3	15.3	21.1	16.9
Cure Time, t90, minutes	14.13	11.67	10.96	11.79
Mooney Scorch, t5, minutes	29.64	28.46	25.80	25.47
Hardness	46	48	54	54
Tensile, MPa	3.9	3.65	8.2	5.86
100% Modulus, MPa	1.0	1.37	2.0	2.06
Elongation (%)	429	230	346	260

The physical properties display the typical reinforcement of the various forms of carbon black. The N990 compound, even at 75 phr, had low viscosity, lower hardness and tensile properties. The semi-reinforcing N762 provided low viscosity at 50 phr, low tensile and slightly higher hardness. The N650 and N550, with smaller particle sizes and high structure, have higher viscosity, hardness and tensile strength.

Evaluation of Compound Resistivity

ASTM D991 is the normal and standard test method for rubber property – volume resistivity of electrically conductive and antistatic products. However, D991 could not be followed in this experiment because the resistivity of the N990 compound was too high. Volume resistivity was therefore evaluated according to ASTM D257 – DC resistance or conductance of insulating materials. The furnace black compounds could have been measured by ASTM D991, but were also evaluated by D257 for consistency.

Table 3: Compound Resistivity

Compound ID	Voltage, VDC	Resultant Current	Resistivity, ohm.cm
Thermax® N990 - 75 phr	501.1	3.27×10^{-11}	4.05×10^{15}
N762	500.1	1.83×10^{-4}	7.14×10^{8}
N650	500.0	2.31×10^{-3}	5.62×10^{7}
N550	7.55*	1.99×10^{-3}	9.75×10^{5}

***Due to the low resistivity of the N550 the test voltage had to be lowered from 500 VDC as specified in ASTM D 257**

The Thermax® N990 – 75 phr compound had the highest volume resistivity of all the blacks. The resistivity for the standard furnace grades declined correspondent to their particle size. The N550, having the lowest resistivity, also has the highest structure.

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Evaluation of Dry Resistance of Carbon Blacks

A method and test for measuring dry resistance were prepared at Experimental Services Inc., Suffield, Ohio. Carbon black samples were dried for one hour at 105°C in a Blue M convection air oven. Three samples of each black were weighed to 5.00 +/- 0.01 grams. An MTS load frame was utilized, with a Wheatstone-Bridge Ohmeter. A 15 cm. high HDPE cylindrical column with a 645 sq. mm. cross-sectional area was packed with carbon black. Stainless steel base platen, base plug and plunger were utilized. The plunger diameter was 1.128", equivalent to a compression set button. Load forces were applied continuously by the MTS controller at a rate of 12.5 mm/minute. Lead wires were attached from the ohmeter to the plunger and the base plate. Resistance across the sample was measured using a data acquisition system at a sampling rate of 10 Hz. The initial resistance was calibrated to zero, so that the residual resistance of the cylinder was removed. An interpolated calculation was used to obtain ohmeter readings at 5,000 gram intervals. All tests were conducted at 23°C and 50% RH.

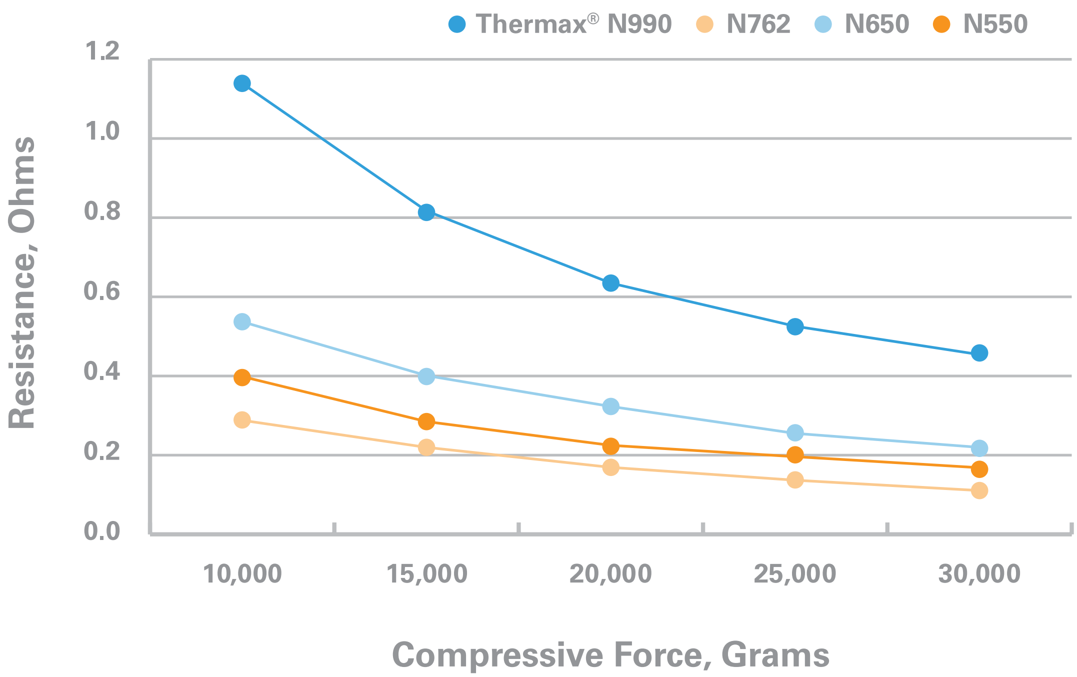
The results are reported in the following table and are also shown in the chart.

Table 4: Carbon Black Resistance (ohms), corrected, average of 3 samples

Grams	N990	N762	N650	N550
10,000	1.1393	.2881	.5371	.3987
15,000	.8170	.2197	.4010	.2848
20,000	.6347	.1692	.3230	.2248
25,000	.5257	.1367	.2550	.1962
30,000	.4541	.1106	.2197	.1683

The first column refers to the load force (grams) applied to the cylinder to compress the carbon black. Force increments below 10,000 grams resulted in values that were not consistent within the sample and therefore are not included in the table above and the chart below. This was likely due to carbon particle aggregates and agglomerates breaking up as the pressure increased.

Chart: Dry Resistance of Carbon Blacks at Increasing Compressive Loads (Average of 3 samples).



It should be noted that the above measurements provide the dry resistance of the carbon black and not the volume resistivity. The results therefore provide the relative hierarchy of the resistivity of the carbon blacks and are indicative of how the carbon black would perform relatively when incorporated into an elastomer. Caution is needed in interpreting the performance of the carbon black in a rubber compound, as the loading, the polymer type and cure system, degree of dispersion, oil content and other factors can influence the final resistivity result.

The above is summarized from a paper given by P. Donnelly at the ACS Rubber Division Meeting, Cincinnati on October 20, 2000