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TECHNICAL BULLETIN

EPDM Compounds

Thermax® medium thermal carbon black N990 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 dispersion, superior heat, oil and chemical resistance and demanding dynamic properties. The large particle size (low surface area) and low structure allow for low compression set, high rebound and low viscosity, maintaining the inherent elastomeric properties of the rubber compound. 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.

Thermax® can be used in all polymers and is commonly used in elastomers such as NBR, EPDM, HNBR, ACM, FKM and ECO. High loadings of Thermax® are possible, while maintaining low viscosity and physical properties such as low compression set, thereby allowing manufacturers to reduce compound cost.

In the case of EPDM, the inert surface chemistry and unique physical properties of Thermax® N990 provide for excellent chemical compatibility with EPDM, allowing for high loadability, good dispersion and excellent surface properties in extrusions. Thermax® N990 provides excellent oil and chemical resistance to EPDM and helps to improve the overall aging properties.

Benefits of Thermax® N990 in EPDM Compounds

- Compound extension – for cost reduction and improved aging properties
- Superior surface finishes – due to lowest grit contamination and excellent dispersibility
- Low viscosity compounds – beneficial in corner moldings and other difficult shapes
- Low gloss grey finish – arising from the methane gas feedstock and the thermal decomposition production process
- Low compression set and superior dynamic properties
- Excellent dispersibility resulting in consistent heat transfer throughout the extrusion and uniform curing

Applications

EPDM compounds filled with Thermax® N990 are used for applications such as:

- Extruded profiles – sponge and solid weather strip
- Tubing, hose
- Diaphragms, boots, molded goods, tarp straps
- Engine mounts, anti-vibration products
- Roofing membranes
- Roll coverings
- Cable insulation

Effect of Type of Carbon Black in EPDM at Equal Hardness

The following table (DuPont data) demonstrates the effect of four different types of standard carbon blacks in an EPDM compound at equal hardness. As shown, Thermax® N990 can be loaded at more than double the amount of FEF-N550 carbon black, while still maintaining lower Mooney viscosity at equivalent hardness.

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Table 1: Effect of Different Types of Carbon Black in EPDM at Equal Hardness[1]

(20 phr paraffinic oil)

Type of Carbon Black	MT – N990	SRF – N774	FEF – N550	HAF – N330
phr	130	85	60	50
M. Viscosity, ML, 1 + 4 @ 100°C	76	80	84	84
Hardness	66	67	65	62
300% Modulus, MPa	3.4	8.4	9.3	9.1
Tensile, MPa	5.3	11.2	13.8	19.3
Elongation (%)	520	420	430	460
Tear Strength, Die B, kN/m	19	29	32	28

Source: Dupont Dow, Cured 20 minutes @ 160°C, Formulation: Nordel 1070 – 100, Zinc Oxide –5, Stearic Acid – 1, Paraffinic Oil – 20, MBT – 0.5, TMTM – 1.5, Sulphur – 1.5

Highly Extended EPDM Compounds

The following data shows the effect of increasing the volume of Thermax® N990 carbon black in an EPDM compound.

[1]DuPont Dow Technical Information ND-330.1: Selecting a Filler, 1996

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Table 2: Effect of Thermax® N990 Loading in EPDM (40 phr oil)

Formulation					
Nordel 1070	100.0	100.0	100.0	100.0	100.0
Thermax® N990	80.0	100.0	150.0	200.0	250.0
Stearic Acid	1.0	1.0	1.0	1.0	1.0
Zinc Oxide	5.0	5.0	5.0	5.0	5.0
Circosol 4240	40.0	40.0	40.0	40.0	40.0
TMTM	1.5	1.5	1.5	1.5	1.5
MBT	0.5	0.5	0.5	0.5	0.5
Sulphur	1.5	1.5	1.5	1.5	1.5
Compound Properties					
Viscosity, ML 1 + 4 @ 100°C	46	48	61	74	90
Mooney Scorch, t5 @ 121°C	>30	>30	29	26	24
Rheometer, 166°C, 3°C arc, 1.7 Hz, 0 preheat					
MH	52.0	54.0	61.9	69.2	77.0
ML	9.0	9.4	11.2	13.0	15.1
Tc50	7.2	6.8	6.3	5.8	5.6
Tc90	13.3	12.8	12.6	12.3	12.2
Ts1	3.6	3.4	3.0	2.8	2.6
Vulcanizate Properties					
Cured, tc90 + 5 minutes @ 166°C	18	18	18	17	17
Hardness	51	52	61	69	70
100% Modulus, MPa	1.2	1.3	2.1	3.0	4.3
200% Modulus, MPa	2.0	2.2	3.5	4.6	5.6
300% Modulus, MPa	2.7	3.0	4.2	5.0	-
Tensile Strength, MPa	6.2	7.4	7.6	5.7	5.3
Ultimate Elongation (%)	610	640	620	515	285
Tear Strength, Die C, kN/m	15.5	19.0	24.8	30.4	27.3
Compression Set, Method B, 70 hours @ 100°C, cured + 15 minutes					
Compression Set (%)	12.5	12.1	11.2	12.8	11.3
Zwick Rebound, cured + 20 minutes, % rebound					
@ 0°C	56	53	48	40	33
@ RT	63	60	52	46	39
@ 100°C	68	67	62	59	54
Aged in Air, 168 hours @ 150°C					
Hardness, pts change	14	23	26	22	25
Tensile, % change	18	3	8	65	83
Elongation, % change	-61	-69	-85	-89	-88
Dynamic Properties, MER 1100, 5% static deformation, 2% dynamic deformation					
Tan Delta @ 0°C	0.146	0.172	0.219	0.267	0.329
Tan Delta @ 25°C	0.122	0.141	0.186	0.245	0.293
Tan Delta @ 100°C	0.080	0.099	0.129	0.167	0.209

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Electrical Conductivity and Thermax® N990 in EPDM

A large average particle size and a low level of particle agglomeration characterize Thermax® N990. These unique properties result in the lowest amount of inherent conductivity in the carbon black. Thermax® N990 is therefore used in applications that require higher levels of volume resistivity, such as radiator hose, weather strip and gaskets. Table 3 provides the results of an evaluation of the dry resistance in ohms of four different grades of carbon black.[2]

Table 3: 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 N990 carbon black is shown to have substantially higher electrical resistance as compared to the other blacks. This is due to the lower level of particle agglomeration, which prevents electron tunneling along particle chain paths. Resistance for the N650 and N550 is significantly lower as these are very high structure blacks characterized by chain-like agglomeration. The N762 showed abnormally low levels of resistance in spite of it having a lower level of agglomeration than the N650 and N550.

It should be noted that the results 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 blacks in a rubber compound, as the loading, the polymer and cure system, degree of dispersion, oil content and other factors can all influence the final resistivity result.[3]

[2]Donnelly, P., "Effect of Type of Carbon Black on the Volume Resistivity of EPDM Compounds," ACS Rubber Division Paper #123, Cincinnati, October 2000
[3]Katz, H.S and Milewski, J.V., eds., Handbook of Fillers for Plastics, Van Nostrand Reinhold, New York, 1987, pp. 401 – 403

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Evaluation of Volume Resistivity of EPDM Compounds

The volume resistivities of EPDM compounds filled with N990, N762, N650 and N550 carbon black were evaluated. Royalene 525 was selected for the EPDM compound evaluation as this grade is commonly used in automotive extrusions. The formulation used was a standard EPDM test formulation, as shown below.

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 N990)
Accelerator MBT	0.50
Accelerator TMTD	1.00
Sulphur	1.50
TOTAL	**209.00**

For the N990 black, the loading was set at 75 phr, with 50 phr only for the N762, N650 and N550. This is due to the high loadability and limited reinforcement potential of the N990 carbon black. This is a common practice for compound tests comparing N990 with smaller particle blacks. (ASTM 3192 recommends 75 phr for N990 and 50 phr for other carbon blacks for evaluation in natural rubber).

Compound Properties

The physical properties, as shown in Table 4, display the typical reinforcement of the various forms of carbon black. Both the N990 compound, at 75 phr, and the semi-reinforcing N762 at 50 phr, had low viscosity, lower hardness and tensile properties. The reinforcing grades N650 and N550, with smaller particle sizes and high structure, had high viscosity, hardness and tensile strength.

Table 4: Compound Properties

	N990 – 75 phr	N762	N650	N550
Mooney Viscosity				
Initial	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 at break (%)	429	230	346	260

Compound Volume Resistivity Test

ASTM D 991 is the standard test method for rubber property – volume resistivity of electrically conductive and antistatic products. However, D 991 could not be followed in this experiment because the resistivity of the N990 compounds was too high. Volume resistivity was therefore evaluated according to ASTM D 257 - DC resistance or conductance of insulating materials. The furnace black compounds (N762, N650, N550) could have been measured by ASTM D 991, but were also evaluated by D 257 for consistency.

Table 5: Compound Resistivity

Compound ID	Voltage, VDC	Current, Amperes	Resistivity, ohm.cm
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 best voltage had to be lowered from 500 VDC as specified in ASTM D 257 to 7.55 VDC.

As shown in Table 5, the N990 – 75 phr compound had the highest volume resistivity of all the blacks. The resistivity for the standard furnace grades declined with decreasing particle size. The N550, having the highest structure and smallest particle size, also had the lowest resistivity. The N762 had normal readings relative to the N990 and N650. The results suggest that high loading of carbon black, for cost-reduction and reinforcement, while maintaining resistivity, is possible with the large particle, low structure black. However, as the N990 is normally used in a blend with a reinforcing black, the optimal balance of reinforcement and resistivity must be determined for each application.

Thermax® Stainless N907 for Low-Staining Specifications

Thermax® Stainless N907 is a low-oil content specialty grade of Cancarb's medium thermal carbon black. Produced using proprietary technology to reduce the presence of staining oils, this grade is commonly used in EPDM weather strip applications for light-coloured cars. This grade is particularly useful in helping weather strip producers meet demanding specifications for minimal staining on painted surfaces.

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Highly Extended EPDM Weather Strip Compound

Medium thermal carbon black does not provide significant levels of reinforcement to EPDM and therefore can be highly loaded, for cost reduction and added aging resistance. Following is one example of a highly extended EPDM weather strip compound.

Vistalon 3708	100.00
Thermax® N990	**100.00**
N550 FEF Carbon Black	100.00
N774 SRF Carbon Black	30.00
Flexon 580 Oil	115.00
Paraffin Wax	3.00
Zinc Oxide	5.00
Stearic Acid	1.00
Sulphur	1.50
MBT	1.50
TMTD	4.00
TOTAL	**461.00**
Specific Gravity	1.23
Compound Viscosity, ML 1 + 8 @ 100°C	32
Mooney Scorch time, t3 @ 132°C	13
Vulcanizate Properties, cured 30 minutes @ 160°C	
Hardness, Shore A	72
100 Modulus, MPa	4.5
Tensile Strength, MPa	10.3
Ultimate Elongation (%)	330
Compression Set, Method B, 22 hours @ 66°C, cured 35 minutes	
(%) Set	22

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