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TECHNICAL BULLETIN

Polyacrylates

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 heat, oil and chemical resistance and good 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. 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, IIR, EPDM, HNBR, CSM, ACM and ECO. High loadings of Thermax® are possible, while maintaining low compression set and high resiliency, thereby allowing manufacturers to reduce compound cost.

The combination of Thermax® N990 and polyacrylate rubber provides excellent heat and oil resistance for demanding applications. Amorphous elastomers such as polyacrylate rubber require reinforcement and therefore high structure blacks are required for tear strength and abrasion resistance. For applications such as engine gaskets and hoses, N990 can be blended with a reinforcing black to maintain low compression set and dynamic properties. High loadings of N990 can be utilized to improve heat and oil resistance. ACM compounds filled with Thermax® are used for applications such as engine gaskets, seals, brakes and TOC hose.

The following data shows the effect of increasing the amount of Thermax® N990 carbon black in a TOHPE ACRON AR-825 compound. The control compound has 75 phr of FEF N550 carbon black. The test compounds had varying levels of N990 and N550 and were designed to obtain a hardness level of 70 Shore A.

AR-825 is an easy-processing grade of Tohpe Corporation's Toa-Acron polyacrylate, used in automotive hose and gasket applications. It has an applicable temperature range of -40 ~ 170°C, with a halogen cure site. The cure system used in this test was a sodium stearate/potassium stearate/sulphur system.

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	Control	Test 1	Test 2	Test 3	Test 4	Test 5
AR-825	100	100	100	100	100	100
FEF N550	75	0	60	45	30	15
Thermax® N990	**0**	**175**	**35**	**70**	**105**	**140**
Stearic Acid	1	1	1	1	1	1
Struktol WB-212 Lubricant	1.5	1.5	1.5	1.5	1.5	1.5
Naugard #445* Antioxidant	2	2	2	2	2	2
TP-759 Plasticizer	6	6	6	6	6	6
NS Soap (NaSt) Curing Agent	2.5	2.5	2.5	2.5	2.5	2.5
Sulphur	0.2	0.2	0.2	0.2	0.2	0.2
Nonserl SK 1 (KSt) Curing Agent	0.2	0.2	0.2	0.2	0.2	0.2
TOTAL	**188.4**	**288.4**	**208.4**	**228.4**	**248.4**	**268.4**
TOTAL Black Loading	75	175	95	115	135	155
*Antioxidant, diphenylamine derivative						
Durometer (press cure)	**69**	**74**	**69**	**71**	**72**	**73**
Durometer (press & oven)	73	77	73	72	73	75
Specific Gravity	1.332	1.486	1.380	1.411	1.438	1.470

Vulcanizate Properties, ODR @ 177°C	**Control**	**Test 1**	**Test 2**	**Test 3**	**Test 4**	**Test 5**
ML, pts	12.0	11.0	12.0	12.0	12.0	11.0
ts2, minutes	2.00	1.40	1.95	1.80	1.70	1.50
MH @ 12 minutes, pts	39.5	54.0	43.0	48.0	51.5	55.5
Del Torque, pts	27.5	43.0	31.0	36.0	39.5	44.5
MDR @ 177°C						
ML, pts	3.49	3.95	5.15	4.27	3.69	3.76
MI, pts	3.72	3.86	5.20	4.06	3.63	3.62
MH @ 12 minutes, pts	8.76	11.09	10.45	10.50	9.81	10.10
Tc50, minutes	3.74	2.15	3.64	3.30	2.74	2.56
Tc90, minutes	9.01	6.09	9.14	8.82	7.90	7.34
Ts2, minutes	2.83	1.36	2.82	2.22	1.89	1.71
Del Torque, pts	5.27	7.14	5.30	6.23	6.12	6.34
Mooney Scorch @ 121°C						
ML, pts	53	42	53	54	48	47
M (1 + 10), pts	63	48	60	63	49	49
t5, minutes	8.2	9.6	9.2	8.7	9.8	9.4
t5, seconds	492	576	552	522	588	564

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The rheology delta torque values are an indication of crosslink density or efficiency of the cure system. The compounds containing N990 show higher crosslink density than the control compound with N550. Both the MDR and ODR curves show faster cure rates for the N990 compounds. The Mooney data indicate lower viscosity and better or longer scorch safety with the N990 compounds. Polyacrylate rubber is sensitive to the surface area, ash and pH levels of the carbon black. Higher surface area blacks generally slow the compound cure rate. As pH increases, the cure rate increases significantly.

Original Properties	**Control**	**Test 1**	**Test 2**	**Test 3**	**Test 4**	**Test 5**
Thermax® N990	**0**	**175**	**35**	**70**	**105**	**140**
FEF N550	**75**	**0**	**60**	**45**	**30**	**15**
Press cured 10 minutes @ 180°C, oven cured 3 hours @ 180°C						
Modulus @ 50%, MPa	2.85	4.46	3.33	3.24	3.63	4.20
Modulus @ 100%, MPa	5.97	6.69	6.88	6.42	6.52	7.02
Ultimate Elongation	192	93	177	154	139	126
Tensile Strength, MPa	8.83	6.47	8.75	7.91	7.30	7.30
Die C Tear, kN/m	24.0	16.5	22.2	20.6	18.6	18.9

The physical properties reflect the proportions of reinforcing FEF versus non-reinforcing thermal black. This is particularly evident in the control compound with 75 phr N550, which has high tensile, versus test 1 compound, which has 175 phr of N990 and significantly lower tensile strength and lower tear strength. These two compounds clearly demonstrate the different options of compounding for reinforcement versus compounding for cost reduction.

Aged Properties	**Control**	**Test 1**	**Test 2**	**Test 3**	**Test 4**	**Test 5**
Thermax® N990	**0**	**175**	**35**	**70**	**105140**	
FEF N550	**75**	**0**	**60**	**45**	**30**	**15**
Heat Aged, 70 hours @ 150°C						
Durometer, pts change	*4*	*2*	*4*	*4*	*3*	*2*
Ultimate Elongation, % change	-9%	6%	-17%	-11%	-1%	1%
Tensile Strength, % change	5%	11%	-1%	-5%	5%	1%
Heat Aged, 70 hours @ 162°C						
Durometer, pts change	*4*	*2*	*5*	*3*	*4*	*1*
Ultimate Elongation, % change	-17%	9%	-14%	-1%	8%	8%
Tensile Strength, % change	-2%	7%	-11%	-7%	2%	2%
Texaco Dextron III, 70 hours @ 175°C						
Durometer, pts change	*-8*	*-7*	*-10*	*-10*	*-8*	*-10*
Ultimate Elongation, % change	-8%	30%	-20%	-8%	-13%	-6%
Tensile Strength, % change	12%	17%	8%	13%	9%	14%
Volume Change	9%	5%	8%	9%	8%	7%
Weight Change	0.04	0.85	0.75	0.21	0.29	0.41

Havoline 5W30, 70 hours @ 150°C

Durometer, pts change	*0*	*-2*	*-7*	*-4*	*-3*	*-5*
Ultimate Elongation, % change	-23%	-4%	-29%	2%	-16%	-10%
Tensile, % change	6%	7%	-8%	-3%	9%	0%
Volume Change	0.92%	0.89%	2.95%	1.80%	0.74%	1.23%

Overall the Test 2 compound with 60 phr of N990 and 35 phr of N550 had very similar properties to the control compound, demonstrating the potential for cost savings with an additional 20 phr of carbon black. The ability of the N990 to impart lower hardness per part may have advantages in heat and oil aging and in compounding costs. A combination of the two carbon blacks, N990 and N550, such as in Test 2 compound, would appear to be the optimal filler loading.

Based on the data generated in this study, any of the above compounds would meet the physical property, heat and oil resistance requirements of GM6260M transmission oil cooler hose specification. It should be pointed out that low temperature testing was not performed for this test.