cancarb

TECHNICAL BULLETIN

Natural Rubber Automotive Bushings

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 while providing exceptional dynamic properties.

Carbon black is typically added to natural rubber as a filler and because of its low surface area, Thermax® N990 allows rubbers to maintain their dynamic properties even at high loadings. Replacing your carbon black of choice with Thermax® N990 can greatly improve dynamic properties. These beneficial properties have been confirmed in engine mounts but can also be applied to bushings used to dampen automotive vibrations. Along with dynamic properties, rubber-to-metal adhesion increases with Thermax® N990 loading.

The following study conducted by Cancarb Limited demonstrates the benefits of using Thermax® N990 in natural rubber bushings to improve dynamic damping properties of the rubber. Replacing N660 carbon black with Thermax® N990 reduced tan δ values and increased the rebound resilience of rubber. The dynamic stiffness of the bushing was also reduced.

Benefits of using Thermax® in automotive rubber bushings

- Increased rebound resilience
- Decreased tan δ
- Lower dynamic stiffness
- Lower dynamic to static modulus ratio
- Improved rubber to metal adhesion
- Lower compression set

Table 1. Test formulations at equal hardness

Compound #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
N660/N990	40/0	35/10	30/19	25/29	20/39	15/48	10/58	5/68	0/77
Loading in phr									
Natural rubber RSS1	100	100	100	100	100	100	100	100	100
N660	**40**	**35**	**30**	**25**	**20**	**15**	**10**	**5**	**0**
N990	**0**	**10**	**19**	**29**	**39**	**48**	**58**	**68**	**77**
Aromatic process oil	5	5	5	5	5	5	5	5	5
Antioxidant	1	1	1	1	1	1	1	1	1
Zinc Oxide	5	5	5	5	5	5	5	5	5
Stearic Acid	3	3	3	3	3	3	3	3	3
Accelerator	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Sulfur	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25
Total loading	**157**	**162**	**166**	**171**	**176**	**180**	**185**	**190**	**194**
Hardness	57	57	57	58	57	58	59	58	58
Hardness after aging	62	62	62	62	63	63	64	63	63

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Table 2. Static rubber properties

Compound #	1	2	3	4	5	6	7	8	9
N660/N990	40/0	35/10	30/19	25/29	20/39	15/48	10/58	5/68	0/77
Tensile, MPa	26.5	25.7	24.6	23.8	23.2	21.8	22.0	20.8	20.8
Tensile after aging, MPa	19.8	18.0	17.9	17.3	16.4	16.4	15.5	15.5	15.7
Tensile Stress Before Aging									
25% Elongation, MPa	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
100% Elongation, MPa	2.0	1.9	2.0	1.9	1.9	1.9	2.0	1.9	1.9
200% Elongation, MPa	4.9	4.6	4.9	4.5	4.6	4.5	4.7	4.5	4.5
300% Elongation, MPa	8.6	8.5	8.9	8.5	8.9	8.6	8.9	8.6	8.5
Tensile Stress After Aging at 100°C for 72 hours									
100% Elongation, MPa	2.8	2.7	2.6	2.7	2.7	2.7	2.7	2.7	2.7
200% Elongation, MPa	6.9	6.7	6.6	6.7	6.8	6.8	6.8	6.8	6.7
300% Elongation, MPa	11.6	11.7	11.6	11.8	12.1	11.8	11.7	11.8	11.4
Ultimate Elongation, %	480	440	440	440	400	440	420	430	460
Rebound Resilience, %	68.7	69.5	70.5	70.0	70.5	70.8	71.8	70.8	71.8
Ultimate Elongation after aging, %	620	620	600	610	590	580	590	580	600
Compression Set									
%, 70° for 24 hours	26.5	24.8	25.6	25.7	26.0	26.4	26.5	28.0	28.2
%, 100° for 24 hours	57.7	56.5	56.7	56.3	55.4	55.4	56.5	56.2	55.7

Table 3. Dynamic to static modulus ratio

Compound #	1	2	3	4	5	6	7	8	9
N660/N990	40/0	35/10	30/19	25/29	20/39	15/48	10/58	5/68	0/77
0.2% dynamic strain	2.04	1.85	1.87	1.77	1.76	1.8	1.66	1.65	1.65
1% dynamic strain	1.76	1.87	1.63	1.63	1.61	1.58	1.59	1.60	1.62
2% dynamic strain	1.67	1.77	1.56	1.57	1.55	1.53	1.53	1.54	1.56
5% dynamic strain	1.53	1.62	1.42	1.45	1.43	1.40	1.42	1.43	1.45
10% dynamic strain	1.40	1.49	1.32	1.34	1.33	1.32	1.32	1.32	1.33

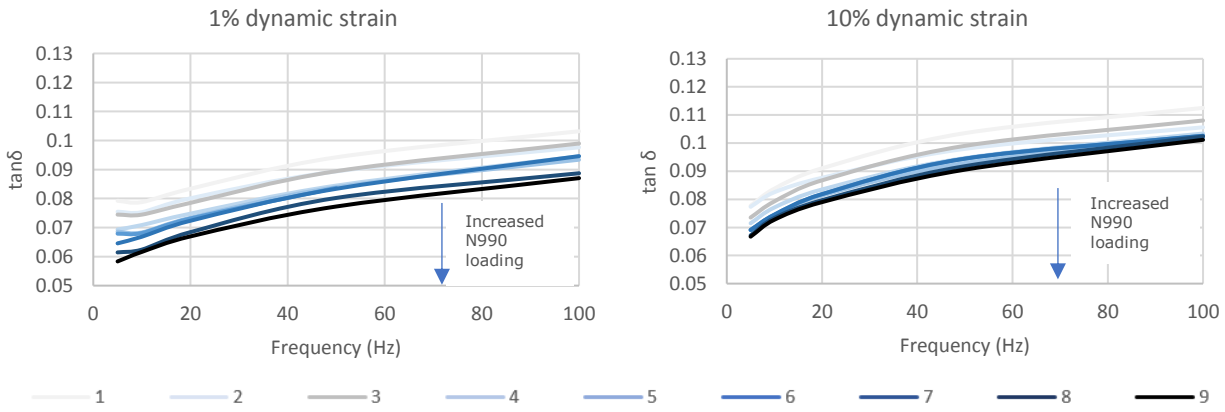

Figure 1. Dynamic tan δ of rubber bushing at 1% and 10% dynamic strain

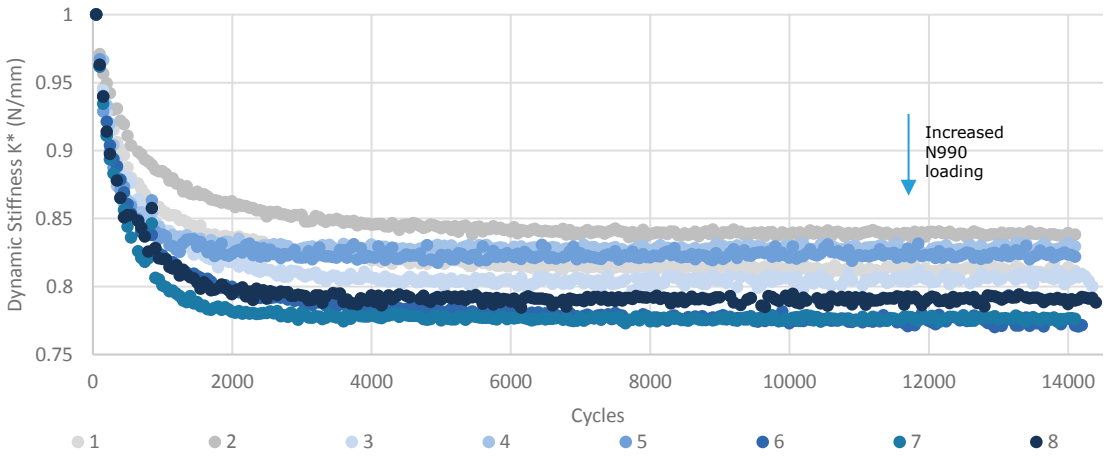

Figure 2. Dynamic stiffness of rubber bushing

Table 4. Adhesion of steel to rubber using Chemlok 205 as primer and Chemlok 6250 as top coat (ASTM 429 method B)

Compound #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
N660/N990	40/0	35/10	30/19	25/29	20/39	15/48	10/58	5/68	0/77
Maximum Load, lb_f	135.2	107.4	136.1	155.1	142.6	144.1	137.0	146.7	79.1
Failure mode	Rubber	Rubber	Rubber	Rubber	Rubber	Rubber	Rubber	Rubber	Rubber

Table 5. Rheological properties

Compound #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
N660/N990	40/0	35/10	30/19	25/29	20/39	15/48	10/58	5/68	0/77
M_H, lb_f·in	8.2	8.6	8.5	8.7	8.7	8.7	8.6	8.7	9.3
M_L, lb_f·in	0.8	0.9	0.9	0.8	0.9	0.8	0.9	0.8	0.9
ts 0.40, minutes	4.5	4.4	4.4	4.4	4.5	4.6	4.8	5.0	4.9
t10, minutes	4.8	4.8	4.7	4.8	4.8	5.0	5.2	5.3	5.2
t50, minutes	6.1	6.0	6.0	6.0	6.0	6.2	6.4	6.6	6.4
t90, minutes	8.5	9.0	8.3	8.3	8.4	8.6	8.5	8.3	8.7
tM_H, minutes	12.0	15.0	12.3	12.6	13.0	13.2	13.1	13.3	13.6

Table 6. Typical Physico-Chemical Properties of Thermax® N990

ASTM Reference	**Test Description**	**Thermax® N990**
D1506	Ash Content, %	0.1
D3037	Nitrogen Surface Area, m^2/g	9.8
D2414	Oil Absorption Number (OAN), $cm^3/100g$ (max)	44.0
D1513	Pour Density, lbs/ft^3	40
	kg/m^3	640
D1508	Fines Content, %	4.0
D1512	pH values	10
	Mean Particle Diameter, nm	250
	Ultimate Specific Gravity	1.8-1.9