TECHNICAL Bulletin

Subject: Dynamic Properties of EPDM and NR

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THERMAX® MEDIUM THERMAL CARBON BLACK N990 IN ANTI-VIBRATION MOUNTINGS

Rubber has a unique behaviour while responding to mechanical deformation as compared to other materials. It can be stretched to very high elongation, for instance up to 1,000% in the case of natural rubber and then return to almost its original length upon release. In addition to elastic properties, it also has energy absorbing properties characteristic of a viscous liquid. It is this combination of properties that gives rubber its uniqueness. These viscoelastic properties allow a rubber product to retain the original shape after repeated deformation, while simultaneously absorbing mechanical energy.

In an engine mount for example, the elastic properties of rubber store and return to the engine most of the input energy from the high frequency vibrations generated during operation. This reduces the transmission of these vibrations to the passenger compartment. On the other hand, the viscous properties dampen the low frequency vibrations generated during idling of the engine. These vibrations have frequency similar to the natural frequency of the system and because of resonance, increase in amplitude unless dampened out. The same is true for other automobile parts that function as vibration dampeners.

Filler plays an important role in the dynamic properties of a rubber compound. The large particle size and low structure of Thermax® N-990, Medium Thermal (MT) Carbon Black manufactured by Cancarb, allow for high resilience and low hysteresis, thereby maintaining the inherent elastomeric properties of the rubber compound. It is widely used in natural rubber and EPDM rubber based anti-vibration mountings in the automobile industry.

Effects of Thermax® on Dynamic Properties of EPDM and Natural Rubber

The following study, conducted on behalf of Cancarb Limited at the Indian Rubber Manufacturers Research Association, Thane, India, demonstrates that dynamic properties can be improved through the use of MT black. Compounds of three different Shore A hardness namely 50, 60 and 70 are studied for both EPDM and natural rubber. In the case of EPDM, control compounds are based on an FEF (N550) and SRF (N774) blend whereas for the natural rubber control compounds are based on FEF alone. The experimental compounds replace SRF with MT black in the case of EPDM, while for the natural rubber compounds MT black is used to replace FEF.

Dynamic properties are measured using Metvavib RDS Viscoanalyzer VA4000. Parameters of various dynamic properties obtained are given in Tables A to C for EPDM and Tables D to F for natural rubber. Tan Delta values (Tables C and F) are considered important for application in anti-vibration mounting. Tan Delta values are observed to increase with the incorporation of MT black (N990) for each respective hardness compound of both EPDM and natural rubber. Higher Tan Delta values indicate better dampening effect on engine vibration.

EPDM Test Compounds

	Hardness 50 SH		Hardness 60 SH		Hardness 70 SH	
	A1	A2	B1	B2	C1	C2
EPDM Keltan 512	100	100	100	100	100	100
N550 (FEF)	60	60	80	80	120	120
N774 (SRF)	40	-	50	-	50	-
Thermax® N990 (MT)	-	80	-	100	-	100
Paraffinic Oil	90	90	90	90	90	90
ZnO	5	5	5	5	5	5
Stearic Acid	1	1	1	1	1	1
ZDBC	2	2	2	2	2	2
TMTD	0.5	0.5	0.5	0.5	0.5	0.5
MBT	0.5	0.5	0.5	0.5	0.5	0.5
Sulphur	1.2	1.2	1.2	1.2	1.2	1.2

EPDM Test Compound Properties

Compound	A1	A2	B1	B2	C1	C2
Compound viscosity ML (1+4)@100°c (MU)	14.5	15	19	18	29	30
Mooney Scorch t5 @125°c (min.)	13.33	11	11.33	9.26	7.48	8.11
Rheometric Properties @ 160°c						
ML(lbf.inch)	2.51	2.6	2.43	2.62	3.76	3.71
MH(lbf.inch)	35.32	35	37.18	38.94	47.62	41.79
TS2(minutes)	3.15	2.8	2.73	2.4	2.27	2.44
T90(minutes)	22.91	18	20.56	23.18	20.73	19.91

Dynamic Testing of EPDM Compounds

50 to 100Hz, 10 Hz interval, 0.1 %dynamic, 0.5% static @ Room Temperature using Metravib RDS Viscoanalyzer VA 4000

Test Specimen thickness 2 ± 0.2 mm, width 5 ± 0.2 mm, length 30 ± 0.2 mm cured at 160°C @ t90 minutes

Table A: Storage Young's Modulus, E' (Pa)

Frequency	A1	A2	B1	B2	C1	C2
50	5.85×10^{6}	6.68×10^{6}	1.56×10^{7}	1.34×10^{7}	3.25×10^{7}	2.91×10^{7}
60	5.90×10^{6}	6.83×10^{6}	1.61×10^{7}	1.47×10^{7}	3.35×10^{7}	3.02×10^{7}
70	5.83×10^{6}	6.94×10^{6}	1.65×10^{7}	1.44×10^{7}	3.42×10^{7}	3.10×10^{7}
80	5.91×10^{6}	7.01×10^{6}	1.67×10^{7}	1.43×10^{7}	3.42×10^{7}	3.11×10^{7}
90	5.92×10^{6}	7.10×10^{6}	1.67×10^{7}	1.45×10^{7}	3.42×10^{7}	3.10×10^{7}
100	5.88×10^{6}	7.05×10^{6}	1.67×10^{7}	1.49×10^{7}	3.50×10^{7}	3.16×10^{7}

Table B: Loss Young's Modulus, E" (Pa)

Frequency	A1	A2	B1	B2	C1	C2
50	1.12×10^{6}	1.37×10^{6}	2.54×10^{6}	2.47×10^{6}	5.57×10^{6}	5.23×10^{6}
60	1.15×10^{6}	1.38×10^{6}	2.56×10^{6}	2.57×10^{6}	5.57×10^{6}	5.29×10^{6}
70	1.20×10^{6}	1.42×10^{6}	2.57×10^{6}	2.47×10^{6}	5.62×10^{6}	5.33×10^{6}
80	1.20×10^{6}	1.47×10^{6}	2.60×10^{6}	2.53×10^{6}	5.70×10^{6}	5.50×10^{6}
90	1.21×10^{6}	1.49×10^{6}	2.65×10^{6}	2.54×10^{6}	5.85×10^{6}	5.65×10^{6}
100	1.23×10^{6}	1.50×10^{6}	2.61×10^{6}	2.51×10^{6}	5.62×10^{6}	5.55×10^{6}

Table C: Tan Delta E"/E'

Frequency	A1	A2	B1	B2	C1	C2
50	1.91×10^{-1}	2.05×10^{-1}	1.63×10^{-1}	1.84×10^{-1}	1.71×10^{-1}	1.79×10^{-1}
60	1.96×10^{-1}	2.02×10^{-1}	1.59×10^{-1}	1.75×10^{-1}	1.66×10^{-1}	1.75×10^{-1}
70	2.05×10^{-1}	2.05×10^{-1}	1.56×10^{-1}	1.72×10^{-1}	1.64×10^{-1}	1.72×10^{-1}
80	2.04×10^{-1}	2.10×10^{-1}	1.56×10^{-1}	1.77×10^{-1}	1.67×10^{-1}	1.77×10^{-1}
90	2.04×10^{-1}	2.10×10^{-1}	1.59×10^{-1}	1.76×10^{-1}	1.71×10^{-1}	1.82×10^{-1}
100	2.10×10^{-1}	2.13×10^{-1}	1.56×10^{-1}	1.69×10^{-1}	1.61×10^{-1}	1.76×10^{-1}

Natural Rubber Test Compounds

	Hardness 50 SH		Hardness 60 SH		Hardness 70 SH	
	A1	A2	B1	B2	C1	C2
NR (RSS I X)	100	100	100	100	100	100
N550 (FEF)	25	-	50	40	70	50
Thermax® N990 (MT)	-	50	-	25	-	50
Napthenic Oil	3	3	5	5	5	5
ZnO	5	5	5	5	5	5
Stearic Acid	1.5	1.5	1.5	1.5	1.5	1.5
Sulphur	2	2	2	2	2	2
CBS	1	1	1	1	1	1
TMTD	0.1	0.1	0.1	0.1	0.1	0.1
A.O. 4020	1	1	1	1	1	1
Batch weight	138.6	163.6	165.6	180.6	185.6	215.6

Natural Rubber Test Compound Properties

Compound	A1	A2	B1	B2	C1	C2
Compound viscosity ML (1+4)@100°c (MU)	23	25	48	55	58	66
Mooney Scorch time(min.) T5 @125°c	19	15	9.6	9.9	8	9
ML(lbf.inch)	4.81	4.93	10.36	10.6	12.42	14.36
MH(lbf.inch)	59.4	65.74	71.43	73.58	78.13	81.93
TS2(minutes)	6.69	5.31	3.8	3.83	2.93	2.98
T90(minutes)	9.47	7.96	6.06	5.97	6.42	5.96

Dynamic Testing of Natural Rubber Compounds

5 to 25 Hz, 5 Hz interval, 0.1% dynamic, 0.5% static @ Room Temperature using Metravib RDS Viscoanalyzer VA 4000

Test Specimen thickness 2 ± 0.2 mm, width 5 ± 0.2 mm, length 30 ± 0.2 mm cured at 160°C @ t90 minutes

Table D: Storage Young's Modulus, E' (Pa)						
Frequency	A1	A2	B1	B2	C1	C2
5	1.95X106	2.49X106	7.89X106	7.28X106	1.27X107	1.88X107
10	1.97X106	2.54X106	8.73X106	7.68X106	1.32X107	1.98X107
15	1.98X106	2.54X106	8.24X106	7.61X106	1.34X107	2.02X107
20	2.01X106	2.57X106	8.36X106	7.68X106	1.36X107	2.14X107
25	2.06X106	2.62X106	9.21X106	7.88X106	1.37X107	2.00X107

Table E: Loss Young's Modulus, E" (Pa)						
Frequency	A1	A2	B1	B2	C1	C2
5	4.43X104	6.97X104	5.88X105	5.40X105	1.07X106	1.86X106
10	5.29 X104	8.12 X104	6.50X105	6.29X105	1.11X106	1.86X106
15	6.11 X104	9.57 X104	6.58X105	6.21X105	1.15X106	1.90X106
20	6.29 X104	1.00 X104	6.82X105	6.47X105	1.19X106	2.12X106
25	3.06 X104	6.87 X104	6.60X105	6.13X105	1.21X106	2.24X106

Table F: Tan Delta E"/E'						
Frequency	A1	A2	B1	B2	C1	C2
5	2.27X10-2	2.79X10-2	7.45X10-2	7.41X10-2	8.40X10-2	9.90X10-2
10	2.69X10-2	3.20X10-2	7.45X10-2	8.18X10-2	8.41X10-2	9.39X10-2
15	3.08X10-2	3.76X10-2	7.99X10-2	8.16X10-2	8.58X10-2	9.41X10-2
20	3.13X10-2	3.90X10-2	8.15X10-2	8.43X10-2	8.75X10-2	9.95X10-2
25	1.49X10-2	2.62X10-2	7.16X10-2	7.79X10-2	8.84X10-2	11.20X10-2