Thermax® N990 in NR Motor Mounts

The motor mount is a rubber part that is needed in vehicles to hold and support the motor, isolate vibration, and reduce noise transmission. Natural rubber is a common choice for this application due to its excellent dynamic properties. When looking at the current vehicle landscape, it should be noted that in comparison to internal combustion engine (ICE) vehicles, electric vehicles (EV) produce excitations at much higher frequencies (e.g., 1000s of Hz versus 20 Hz for ICE). This necessitates testing dynamic properties at high frequencies to evaluate NVH (noise, vibration, and harshness) performance in EVs.

The benefits of Thermax® N990 found in this study include:

- Improvement in dispersion as evidenced by reduction in Payne effect
- Increase in scorch safety
- Maintenance of physical properties
- Improvements in compression set and resilience
- Decrease in dynamic stiffness and dynamic to static stiffness ratio
- Potential cost reductions due to higher total filler loading

The natural rubber formulations can be found in Table 1. N990 replaced N774 at a replacement ratio of 1.6:1 to maintain a compound hardness of 65. Mooney viscosity, MDR, RPA, Shore A hardness, tensile, compression set, rebound, static stiffness, and DMA tests were run on all compounds. Testing results can be found in the figures on the following pages. The compounding and testing were completed at ACE Laboratories in Ravenna, Ohio.

Table 1. NR formulations

Ingredient	Control	A	B	C	D
NR (CV60)	100.0	100.0	100.0	100.0	100.0
N774	80.0	72.0	60.0	40.0	-
Thermax® N990	**-**	**14.0**	**34.0**	**68.0**	**136.0**
Calsol 8240	5.0	5.0	5.0	5.0	5.0
TMQ	1.0	1.0	1.0	1.0	1.0
6PPD	2.0	2.0	2.0	2.0	2.0
Zinc Oxide	3.0	3.0	3.0	3.0	3.0
Stearic Acid	1.0	1.0	1.0	1.0	1.0
CBTS	3.0	3.0	3.0	3.0	3.0
TMTD	0.5	0.5	0.5	0.5	0.5
Sulfur	0.3	0.3	0.3	0.3	0.3
Total	**195.8**	**201.8**	**209.8**	**223.8**	**251.8**

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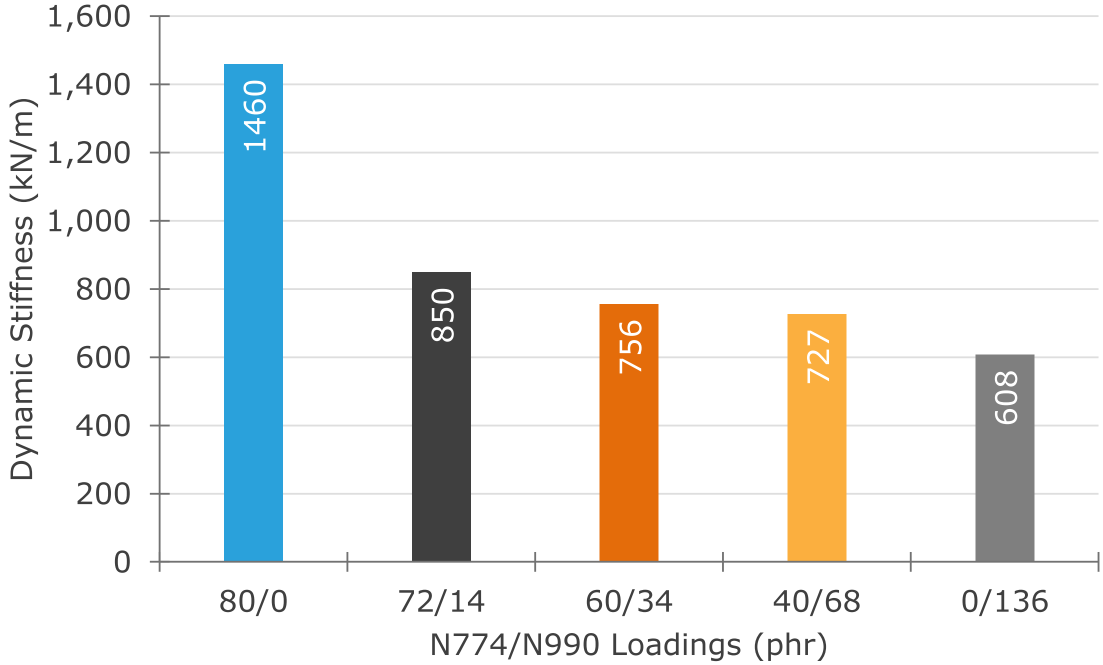

Figure 1. Dynamic stiffness of the compounds. Dynamic stiffness decreased as N990 replaced N774.

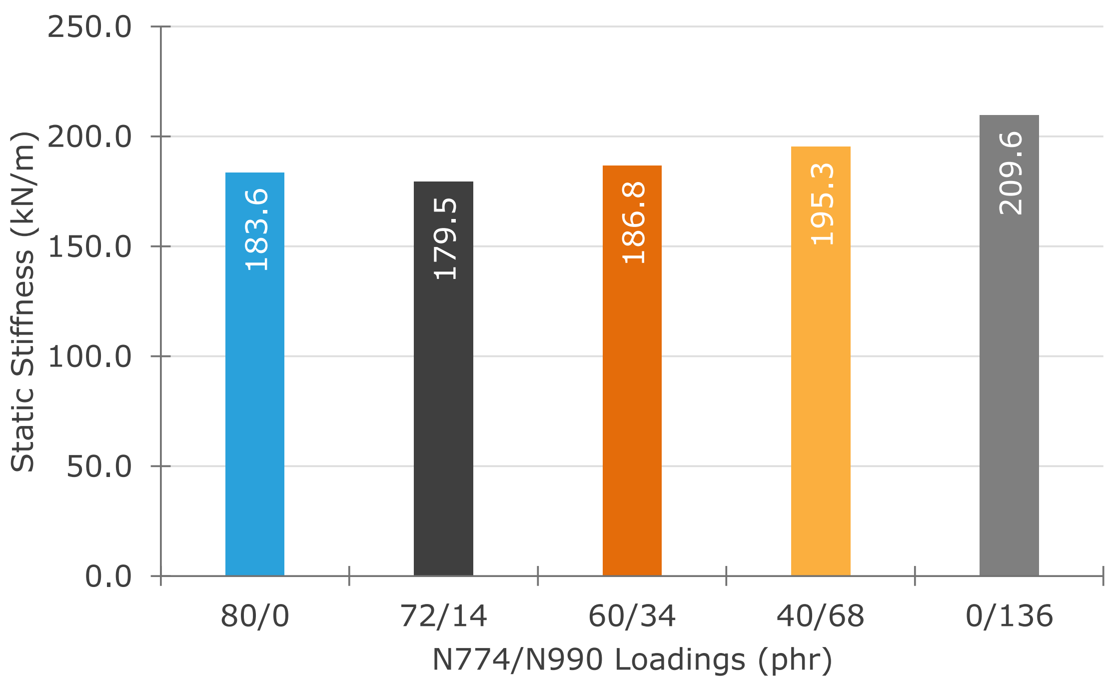

Figure 2. Static stiffness of the compounds. Static stiffness increased as N990 replaced N774. This is in line with the hardness results indicating that the replacement ratio could be lowered slightly.

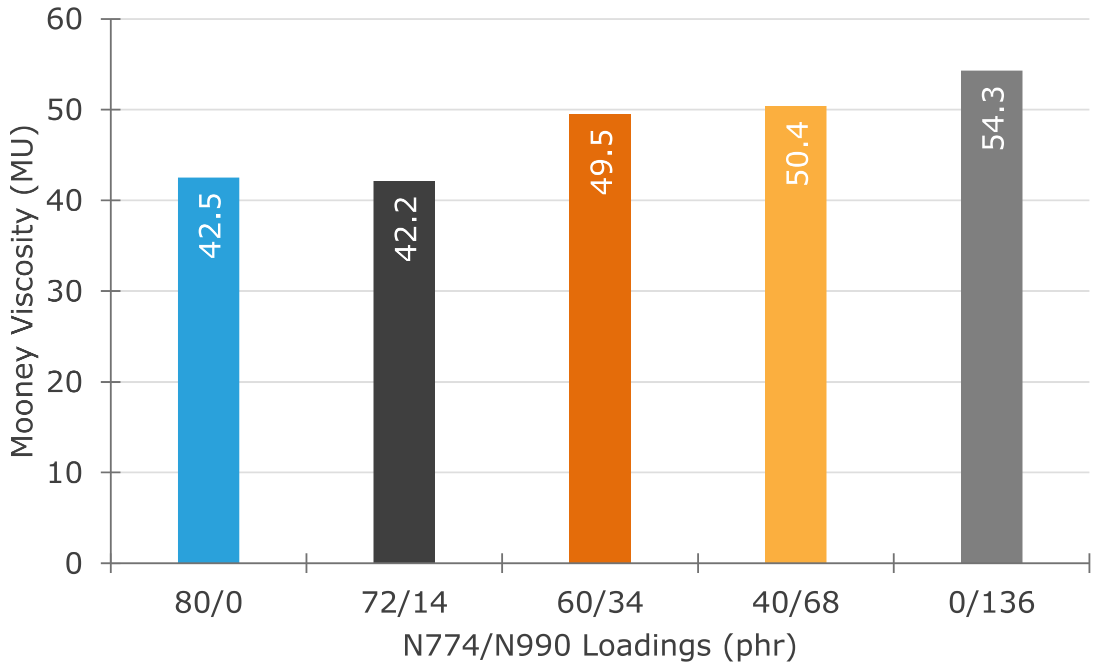

Figure 3. Mooney viscosity of compounds measured at 100°C according to ASTM D1646. Viscosity increased as N990 loading increased.

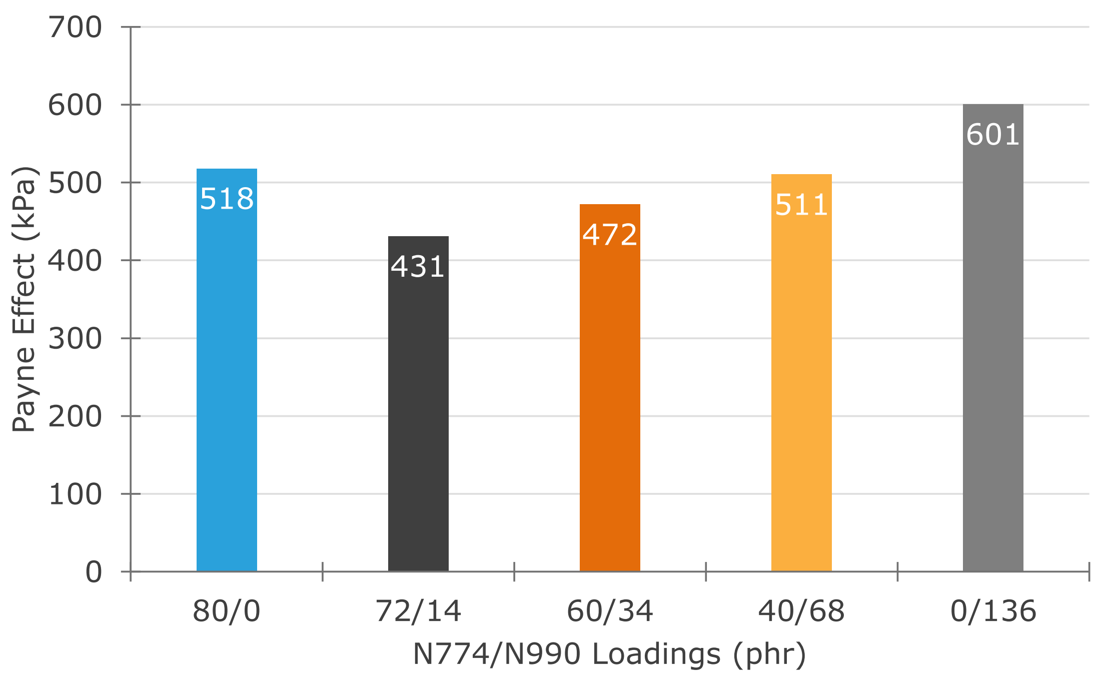

Figure 4. Payne effect, change in shear modulus from 0.1% to 100% strain, measured at 70°C and 1Hz according to ASTM D8059. Small replacements of N774 with N990 led to a reduction in Payne effect indicating an improvement in dispersion.

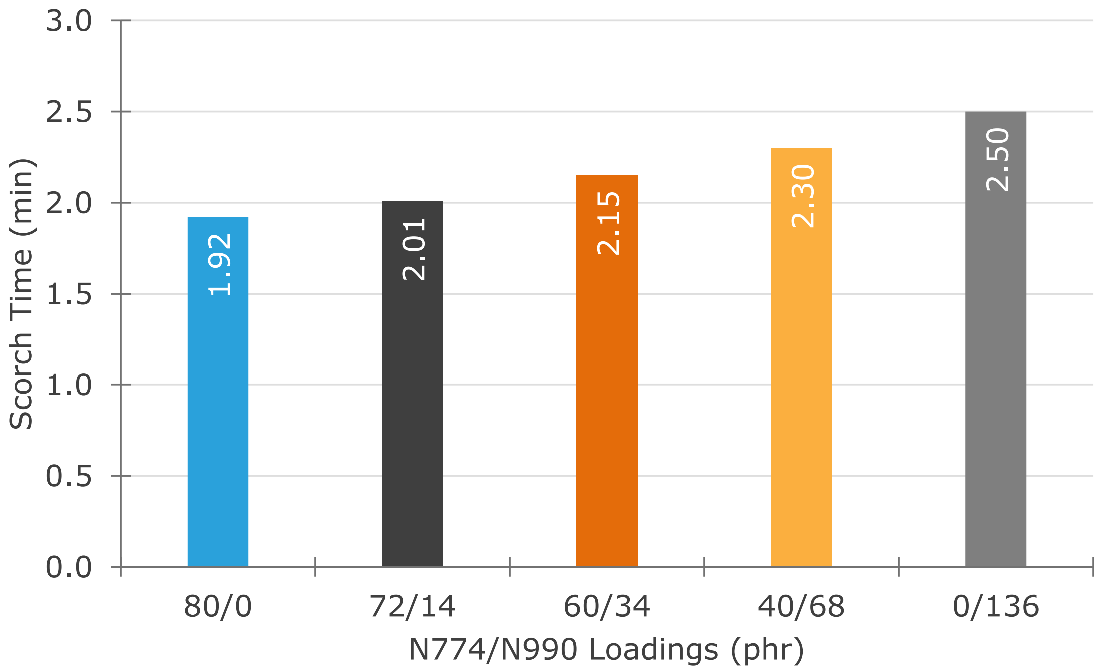

Figure 5. Scorch time, ts2, of the compounds measured at 160°C according to ASTM D5289. Scorch time increased as N990 replaced N774.

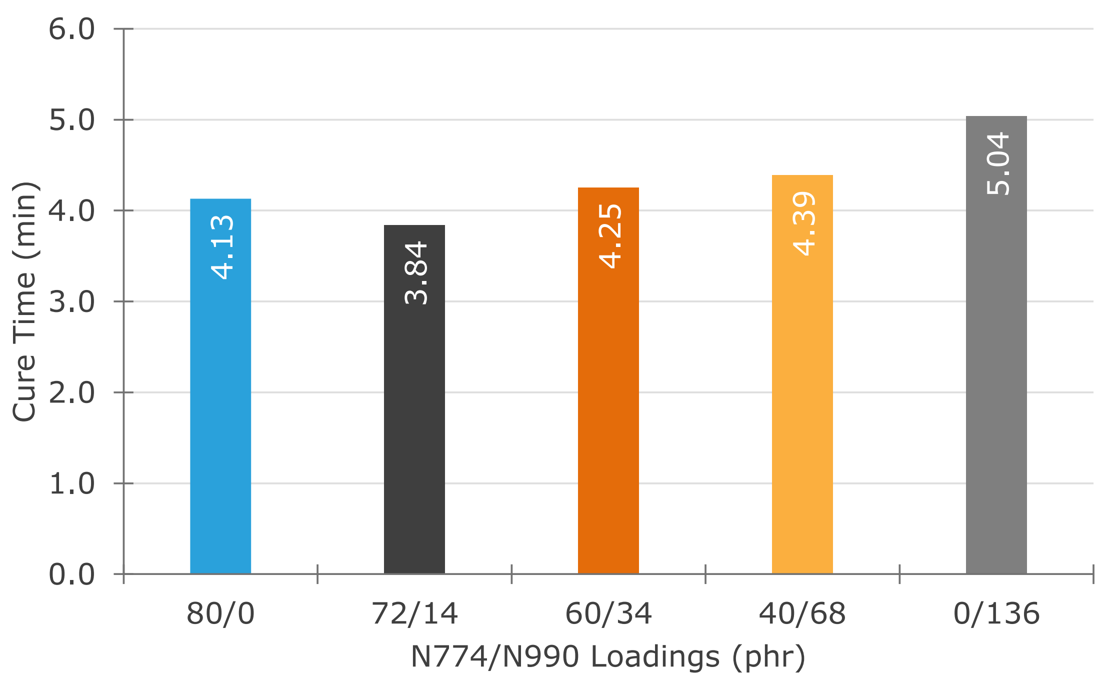

Figure 6. Cure time, t'90, of the compounds measured at 160°C according to ASTM D5289. Cure time increased at highest loading of N990.

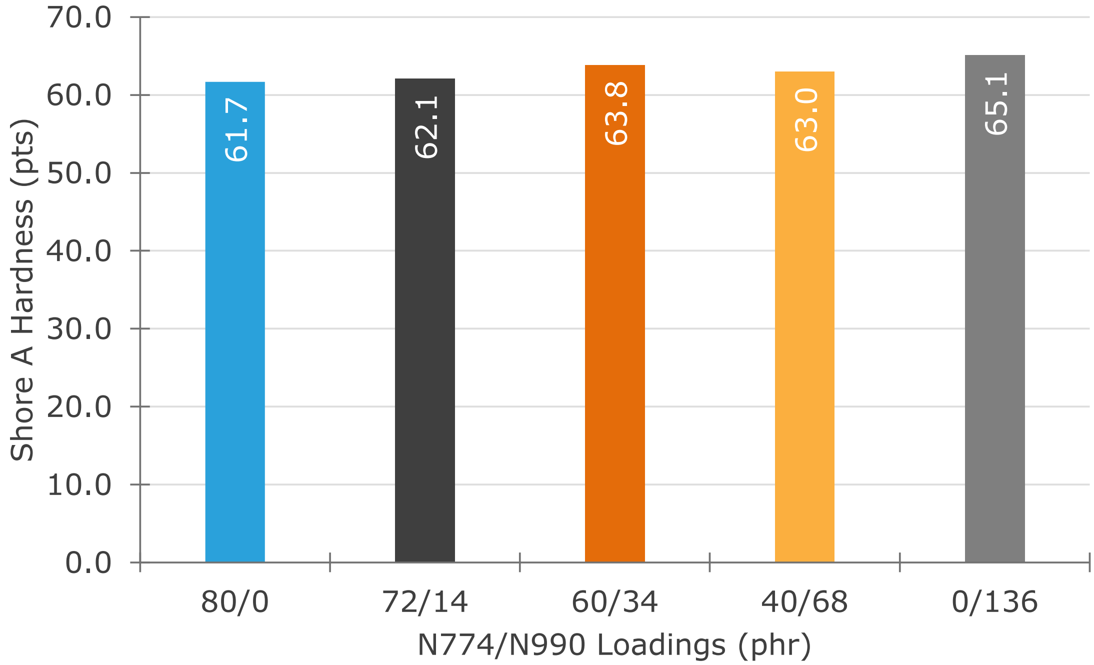

Figure 7. Shore A hardness of the compounds measured according to ASTM D2240. All compounds had hardness values of 65±5.

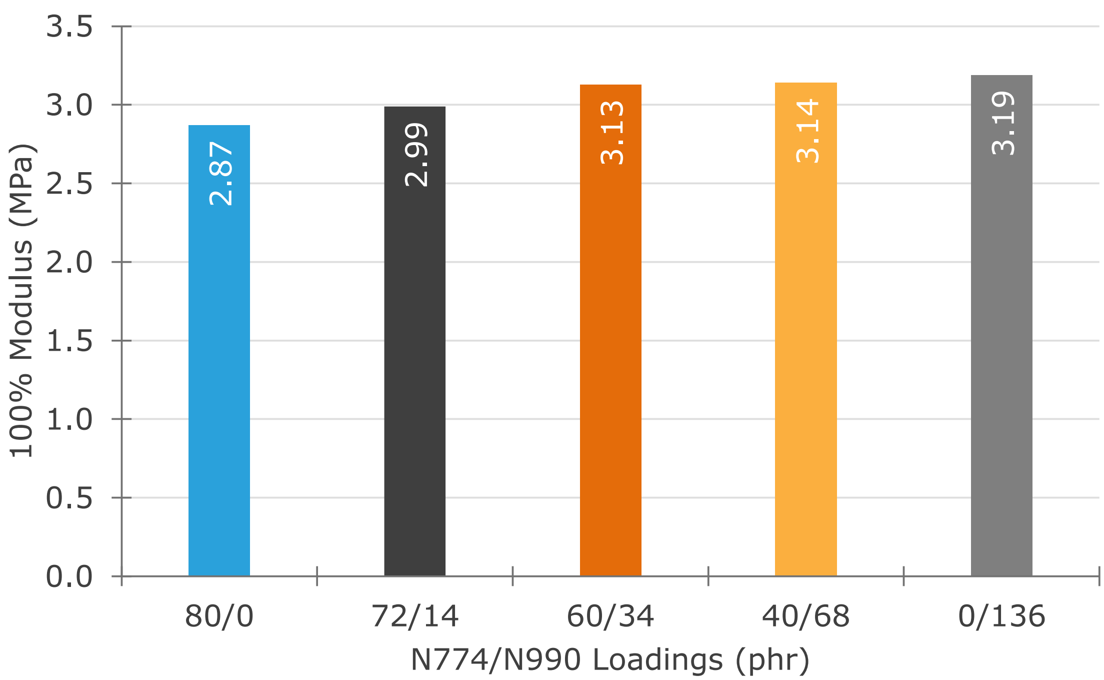

Figure 8. Stress at 100% strain of the compounds measured according to ASTM D412. The 100% modulus increased as N990 replaced N774.

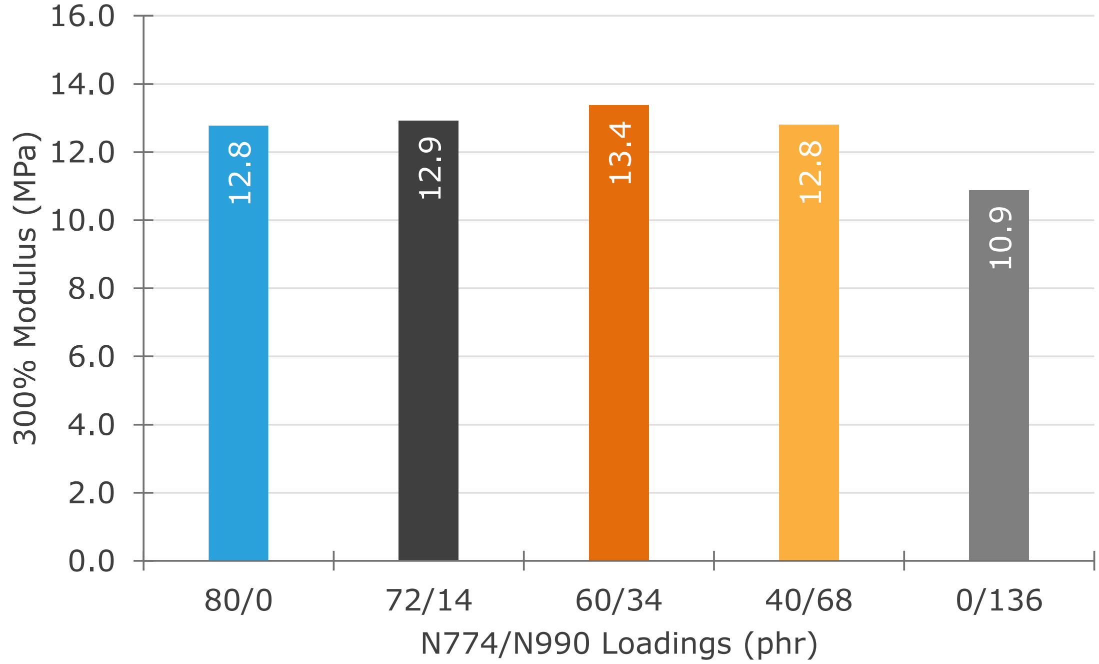

Figure 9. Stress at 300% strain of the compounds measured according to ASTM D412. The 300% modulus decreased when N774 was fully replaced with N990.

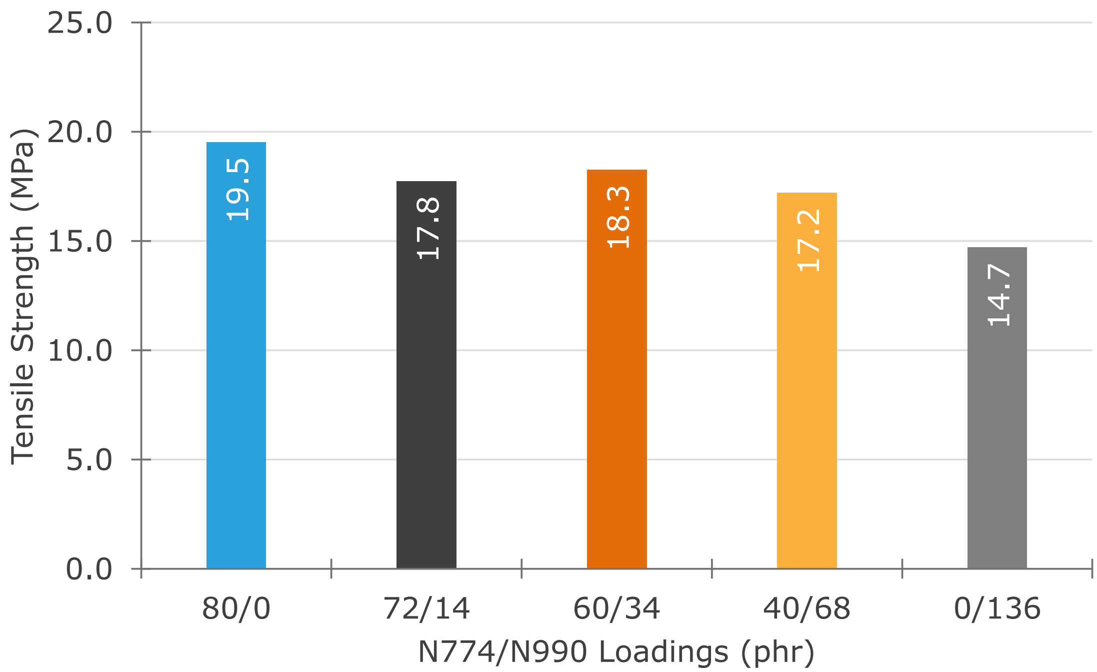

Figure 10. Tensile strength of the compounds measured according to ASTM D412. Tensile strength tended to decrease as N990 replaced N774.

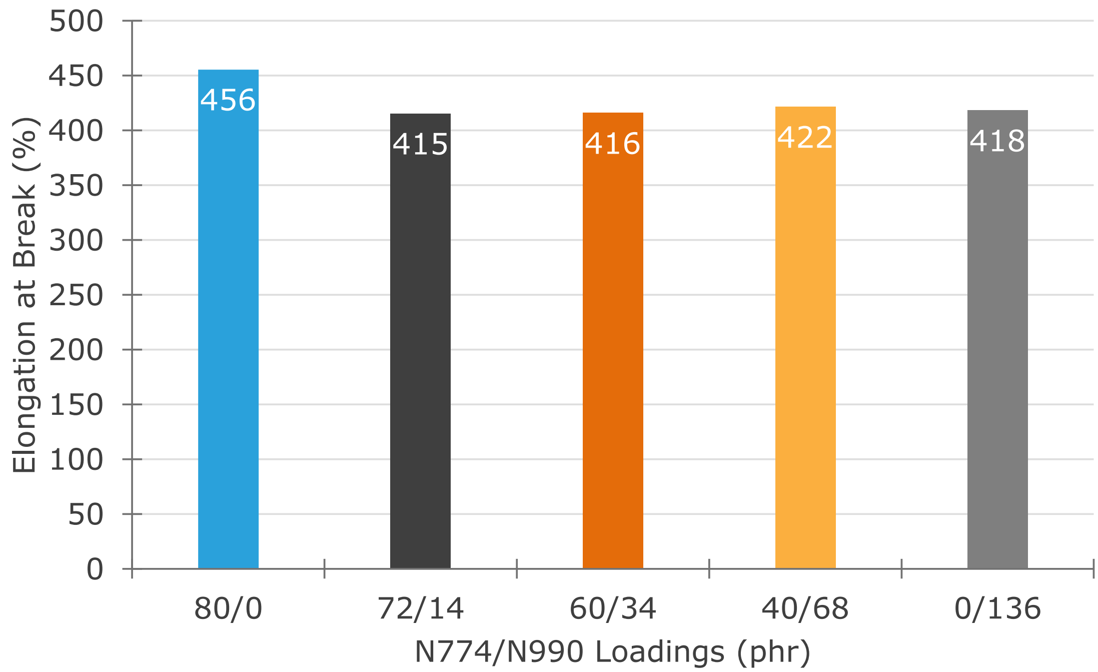

Figure 11. Elongation at break of the compounds measured according to ASTM D412. There were no significant changes in elongation.

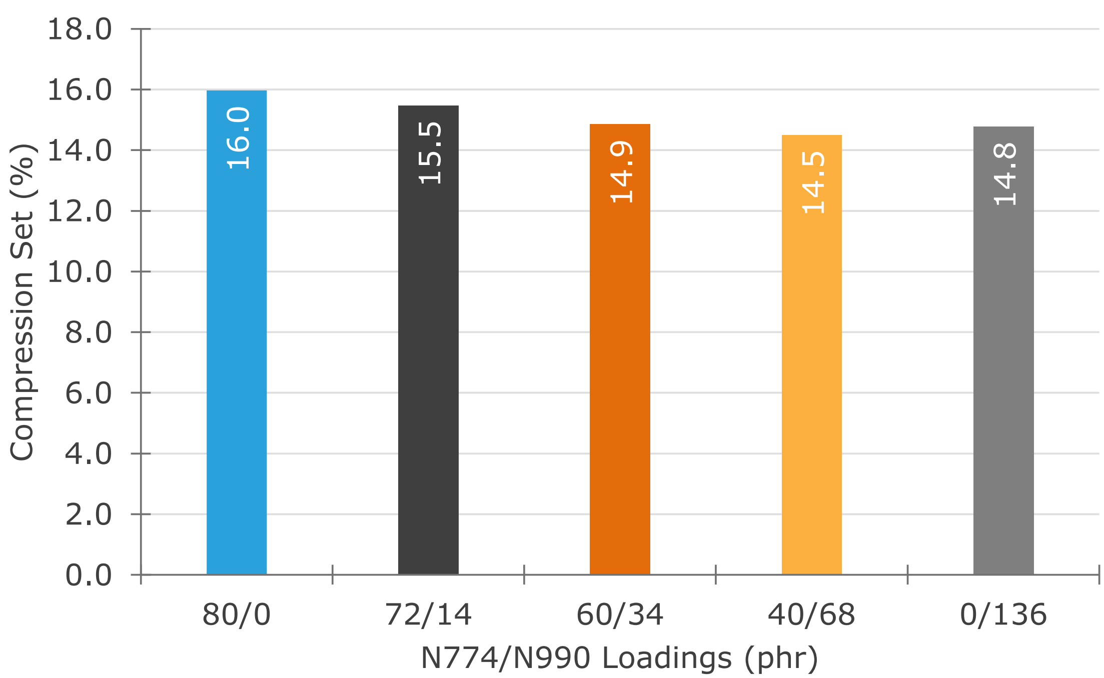

Figure 12. Compression set of the compounds measured after 22 hours at 70°C according to ASTM D395. There was a slight reduction in compression set as N990 replaced N774.

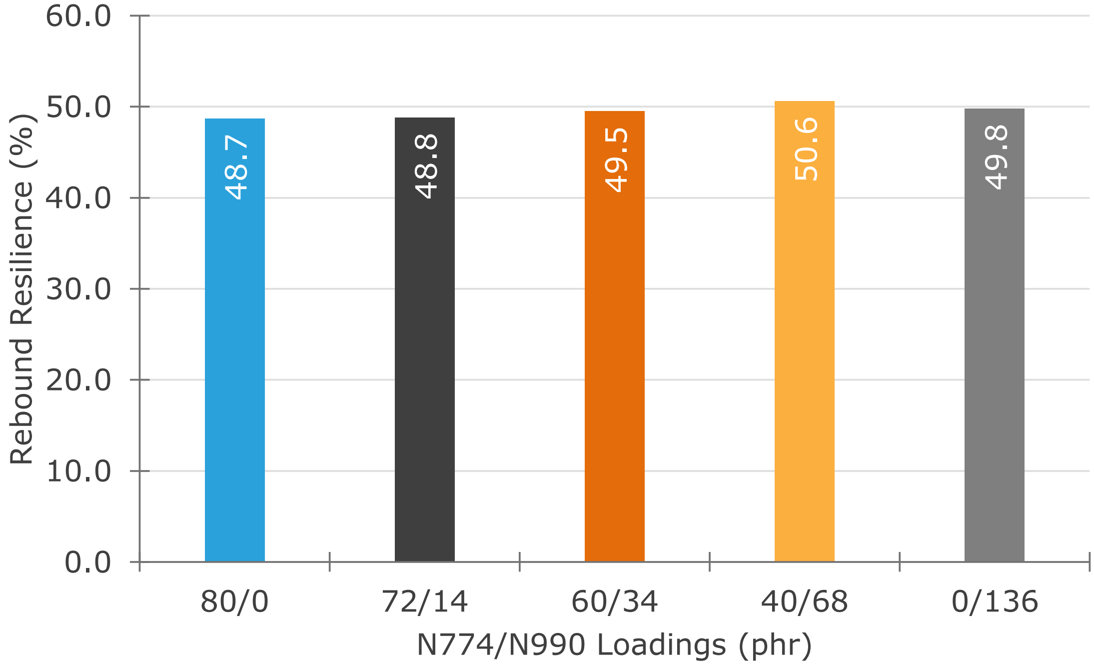

Figure 13. Rebound resilience of the compounds measured according to ASTM D7121. There were no significant differences in rebound resilience.