BIMSM Inner Liner Compounds

In this study, Thermax® N990 is evaluated in tire inner liner compounds using Exxon's brominated isobutylene paramethyl styrene terpolymer (BIMSM). The BIMSM polymers have low air permeability like butyl polymers but are much more heat stable. Because they have no unsaturation in the backbone, they are resistant to attack by oxygen and ozone. These properties make BIMSM polymers ideal for use where inner liners see extreme environments of heat and flexing or where extended life is desired. Thermax N990 can be blended with GPF carbon black for application in tire inner liners. The high loadability of N990 allows for a reduction in compound permeability and cost.

The benefits of N990 found in the study were:

- **High loadability**
- **Reduction of compound cost** due to high carbon black loading
- **Improvement in impermeability** of up to 23.5%
- Loading of 60 phr **reduced crack growth at one million cycles by 50%**
- Loading of 60 phr led to **20% improvement in adhesion to the carcass**
- No change in dynamic properties

The BIMSM inner liner test formulations are provided in Table 1. The Thermax N990 carbon black loading was calculated to provide hardness equivalent to the control compound. Scorch, cure, tensile, hardness, FTF, crack growth, DMT, adhesion, and air permeability data were collected for each compound.

Table 1. Test Formulations

Ingredient	**1**	**2**	**3**
Exxpro 89-4	100	100	100
N660	**60**	**45**	**30**
Thermax® N990	**0**	**30**	**60**
Naphthenic oil	8	8	8
SP1068 Tackifier	2	2	2
Escorez 1102 Resin	2	2	2
Struktol 40 MS	7	7	7
Stearic Acid	2	2	2
Zinc Oxide	3	3	3
MBTS	1.5	1.5	1.5
Sulfur	0.5	0.5	0.5
Total loading	**186**	**201**	**216**
Shore A Hardness	**49**	**47**	**48**

Detailed compound test results are provided in the figures on the following pages.

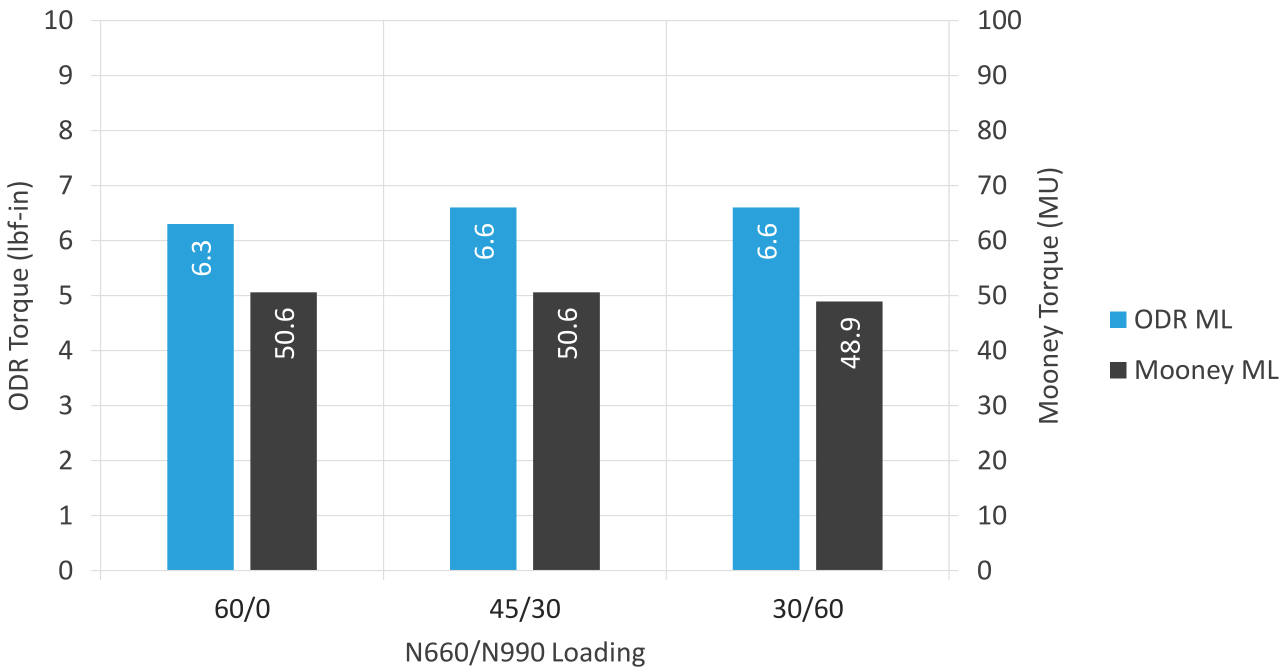

Figure 1. ODR and Mooney ML values for the compounds. ODR data was measured at 160°C and 1° arc. Mooney data was measured at 125°C. No significant differences were observed.

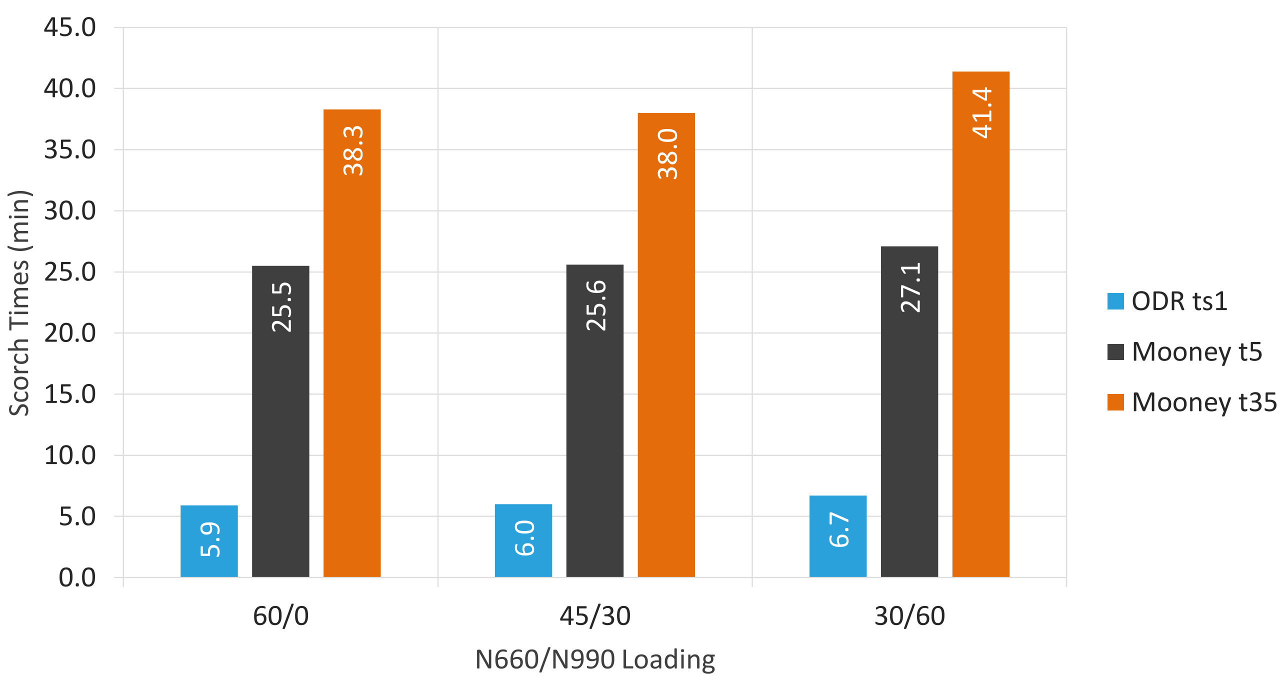

Figure 2. Scorch times for the compounds. Slight increase in scorch times as N990 replaced N660.

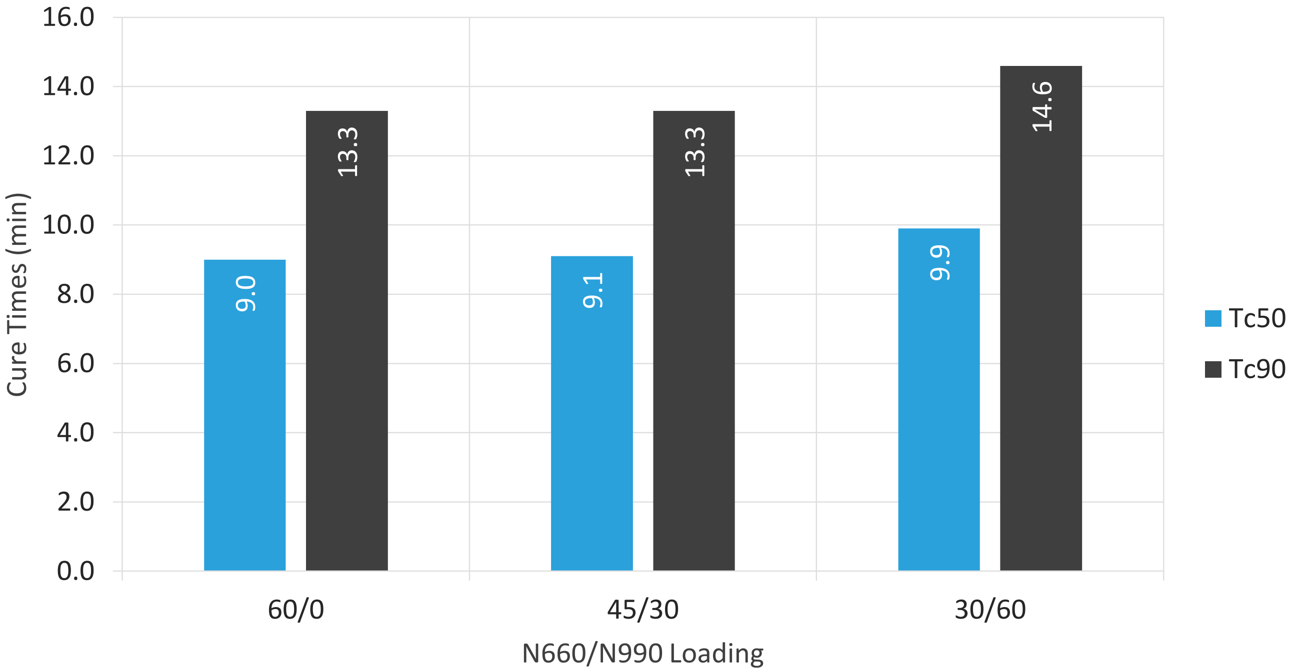

Figure 3. Cure times for the compounds. Slight increase in cure times as N990 replaced N660.

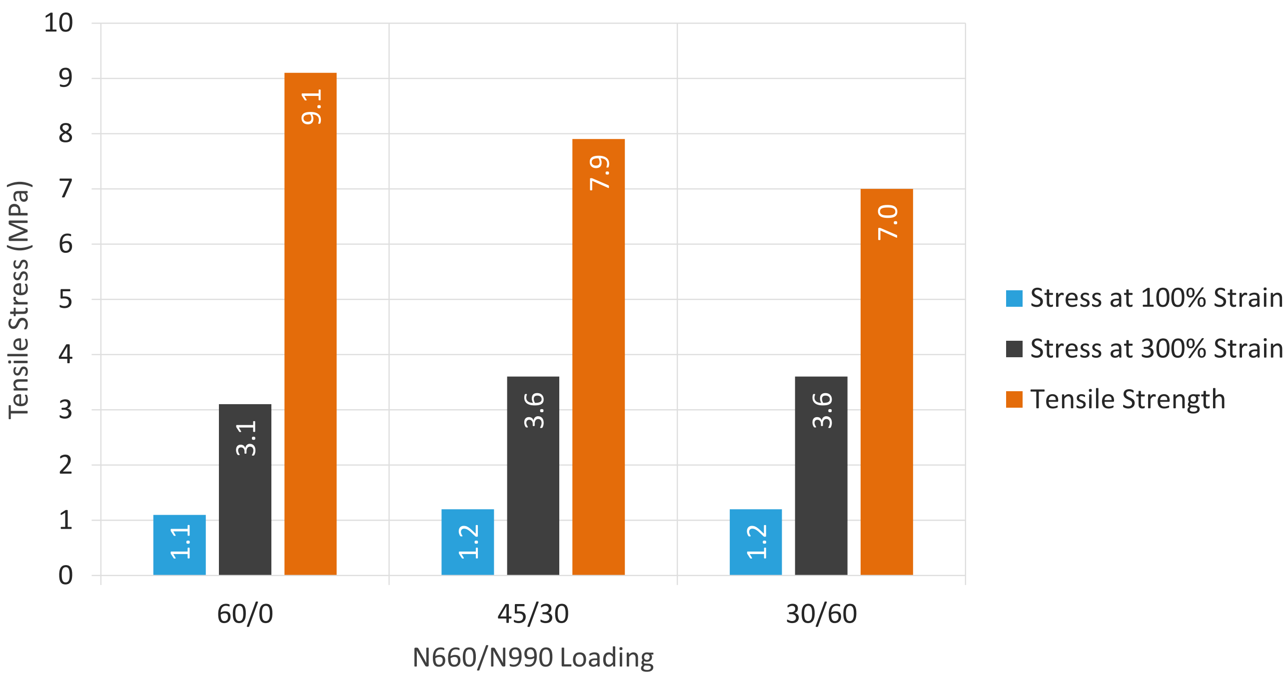

Figure 4. Tensile moduli and strength for the compounds. Moduli increased and tensile strength decreased as N990 replaced N660.

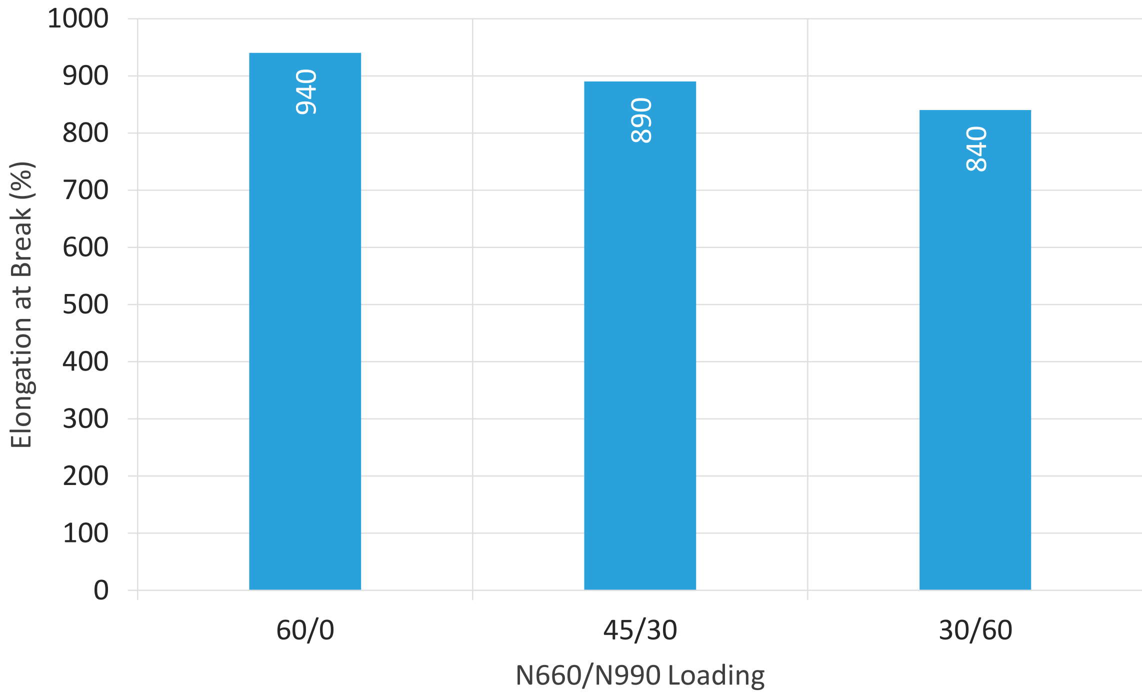

Figure 5. Elongation at break for the compounds. Elongation decreased as N990 replaced N660.

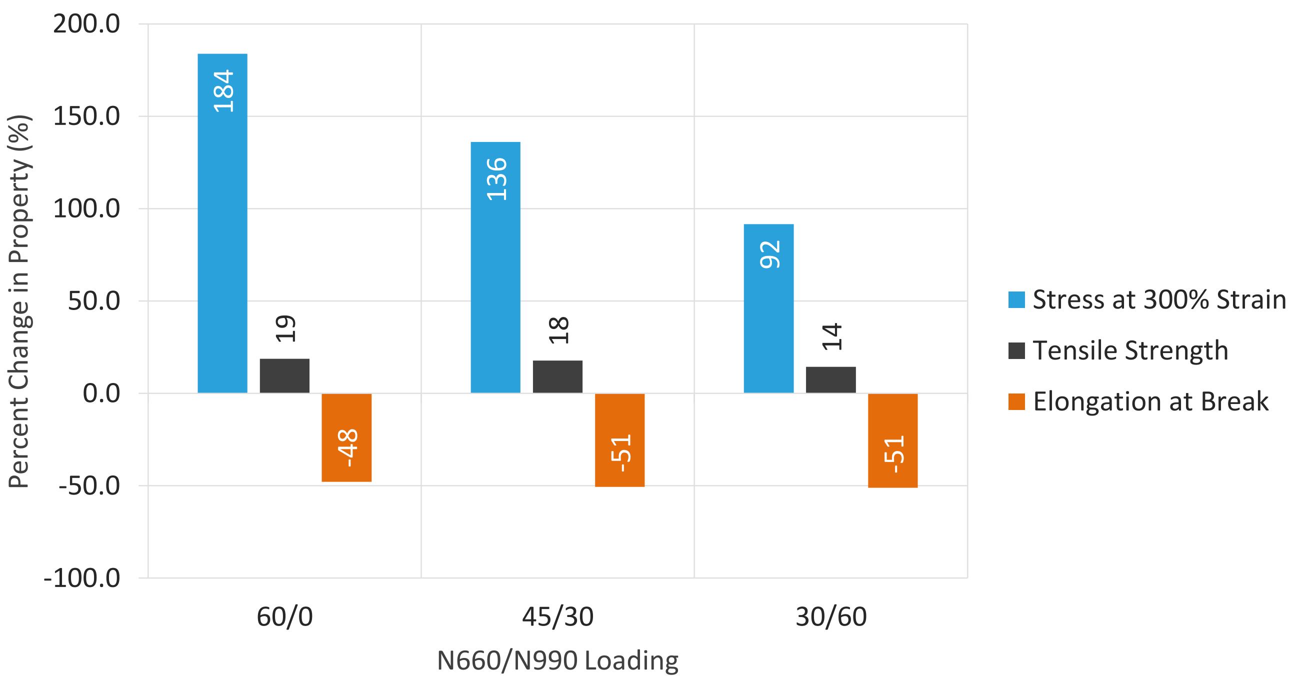

Figure 6. Percent change in tensile property after aging 7 days at 150°C. Change in moduli and tensile strength decreased as N990 replaced N660. Change in elongation remained the same.

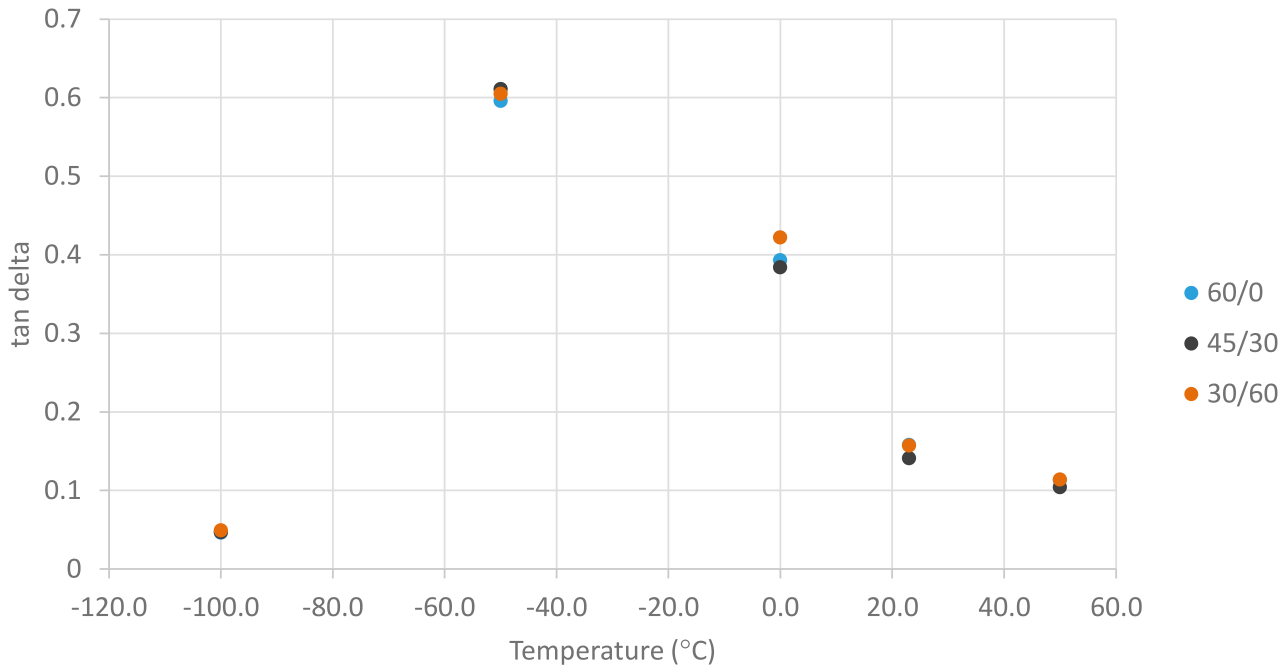

Figure 7. Tan delta versus temperature for the compounds measured at 1 Hz. No significant differences in tan delta were observed.

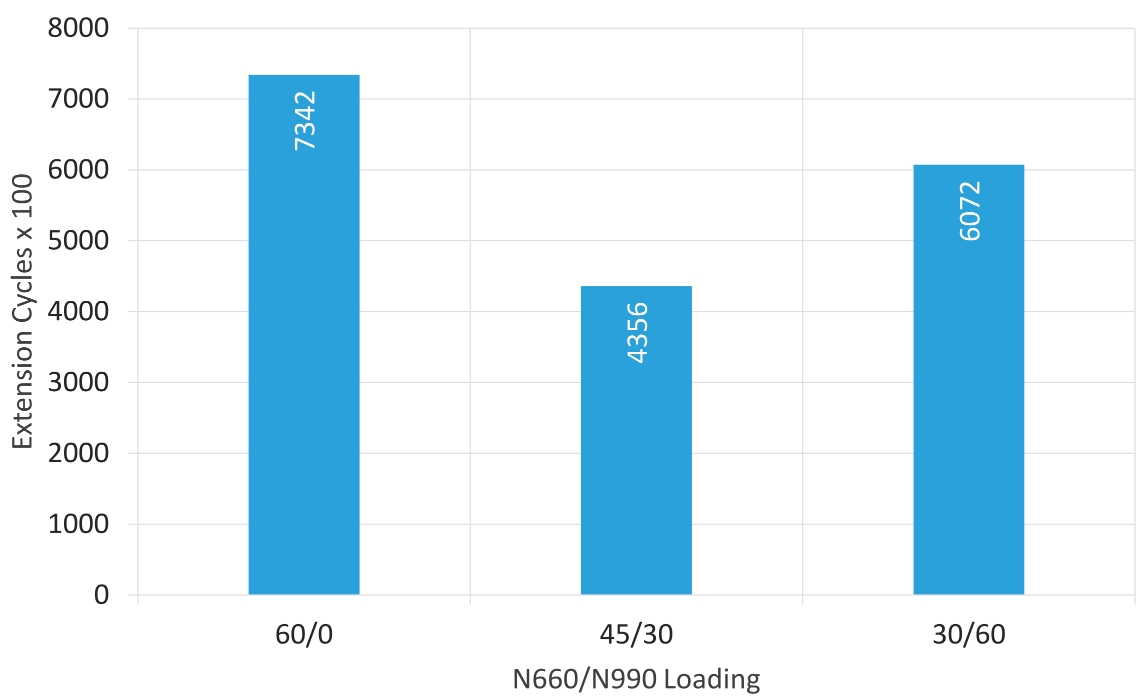

Figure 8. Extension cycles to failure (FTF) for the compounds measured at 23°C according to ASTM D4482. Cycles tended to be lower for the compounds with N990 added.

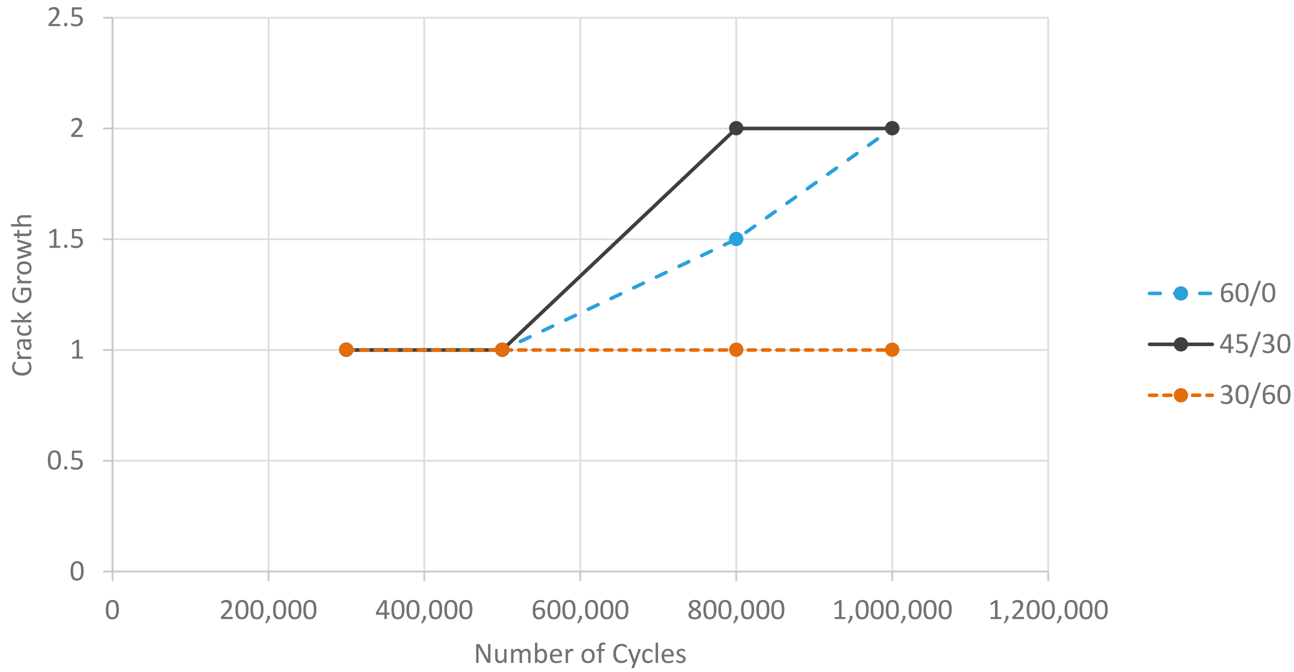

Figure 9. Crack growth for the compounds measured on pierced samples at 23°C according to ASTM D813. Performance was best for compound with 60 phr N990.

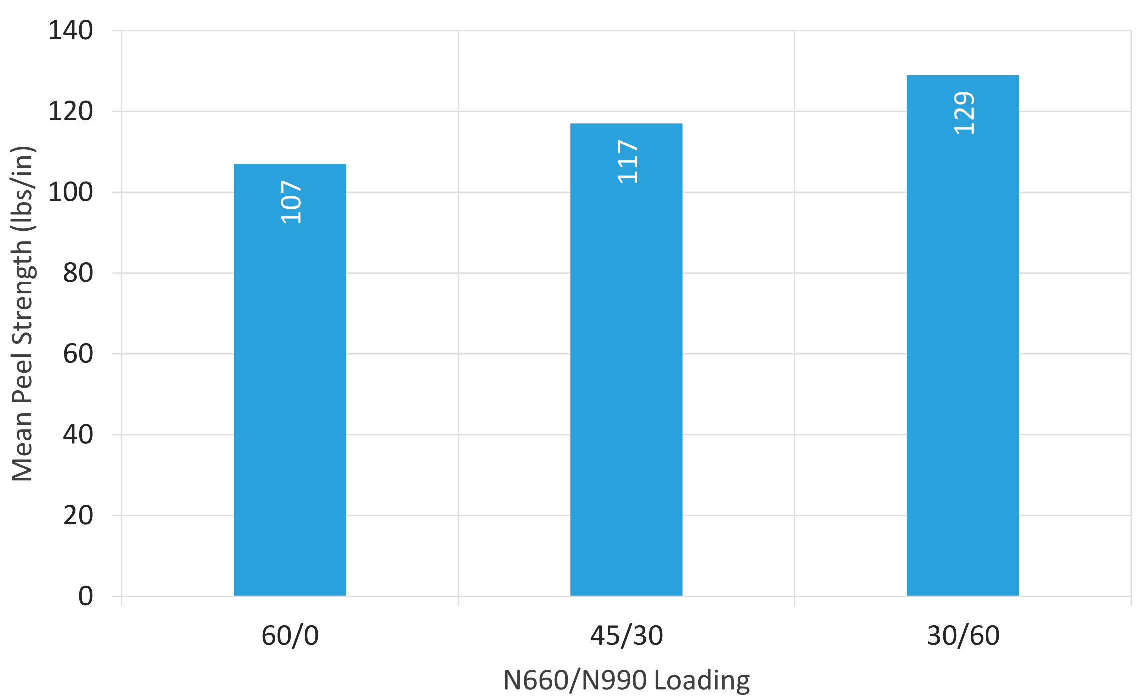

Figure 10. Mean peel strength for the compounds to carcass ply measured at 23°C. Adhesion tended to increase as N990 replaced N660.

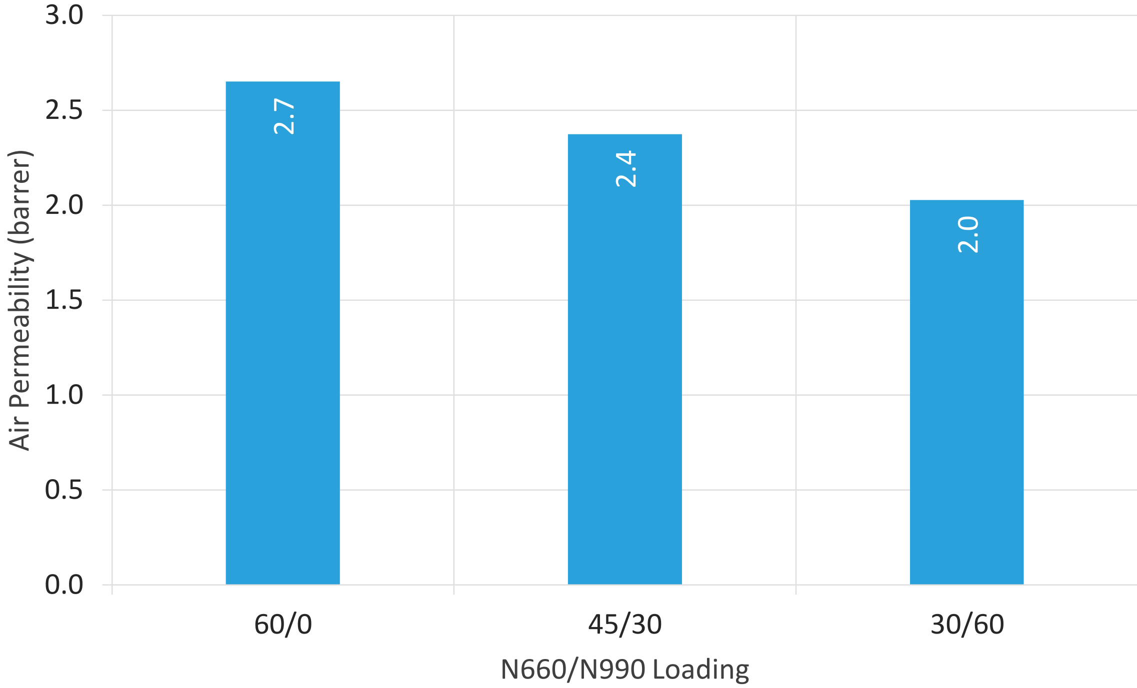

Figure 11. Air permeability for the compounds. Permeability tended to decrease as N990 replaced N660.