Tire Curing Bladder

In this study, the effects of replacing N330 with N990 on the properties of butyl curing bladder compounds were evaluated. These compounds are essentially sealed flexible rubber bags which are inflated inside of uncured tires during the vulcanization process. The repeated cycles of inflation/deflation at curing temperatures necessitate the use of a compound with good heat, flex, and tear resistance. In addition, the compound should have:

1. Good mixing and processing qualities
2. Adequate physical properties
3. Excellent steam aging properties
4. Low tension set
5. Good thermal conductivity

The benefits of N990 found in the study were:

- Significant reduction in viscosity as N330 is replaced with N990
- Significant reduction in uncured small strain modulus and large strain modulus
- Reduction in room temperature tensile set
- Increase in thermal conductivity
- Reduction in compound cost due to higher filler loading

The butyl compound test formulations are provided in Table 1. The N330 was replaced with N990 at a level necessary to maintain a Shore A hardness of 60±5. Mooney, MDR, RPA, tensile, tensile set, tear, crack growth, compression set, thermal conductivity, and heat-aging properties were collected for each compound. Most of the compounding and testing were performed by Arlanxeo. Thermal conductivity testing was completed at Akron Rubber Development Laboratories (ARDL).

Table 1. Test Formulations

Ingredient	Control	A	B	C	D
X_Butyl RB301*	100	100	100	100	100
Baypren 210 M*	5	5	5	5	5
N330	50	40	30	20	-
Thermax® N990	**-**	**40**	**80**	**90**	**110**
Castor Oil	5	5	5	5	5
Resin SP-1045	10	10	10	10	10
Zinc Oxide	5	5	5	5	5
Total	**175**	**205**	**235**	**235**	**235**

*Butyl and CR polymers produced by Arlanxeo

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

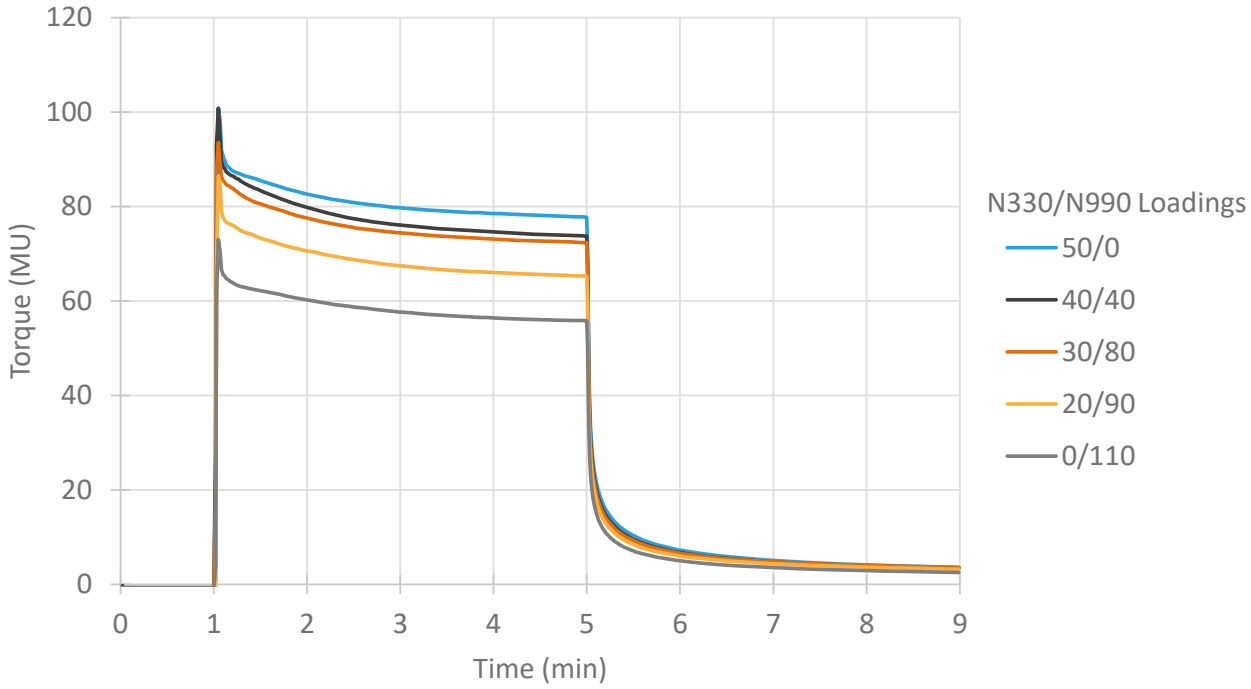

Figure 1. Mooney viscosity at a temperature of 100°C. Viscosity dropped considerably as N330 was replaced with N990.

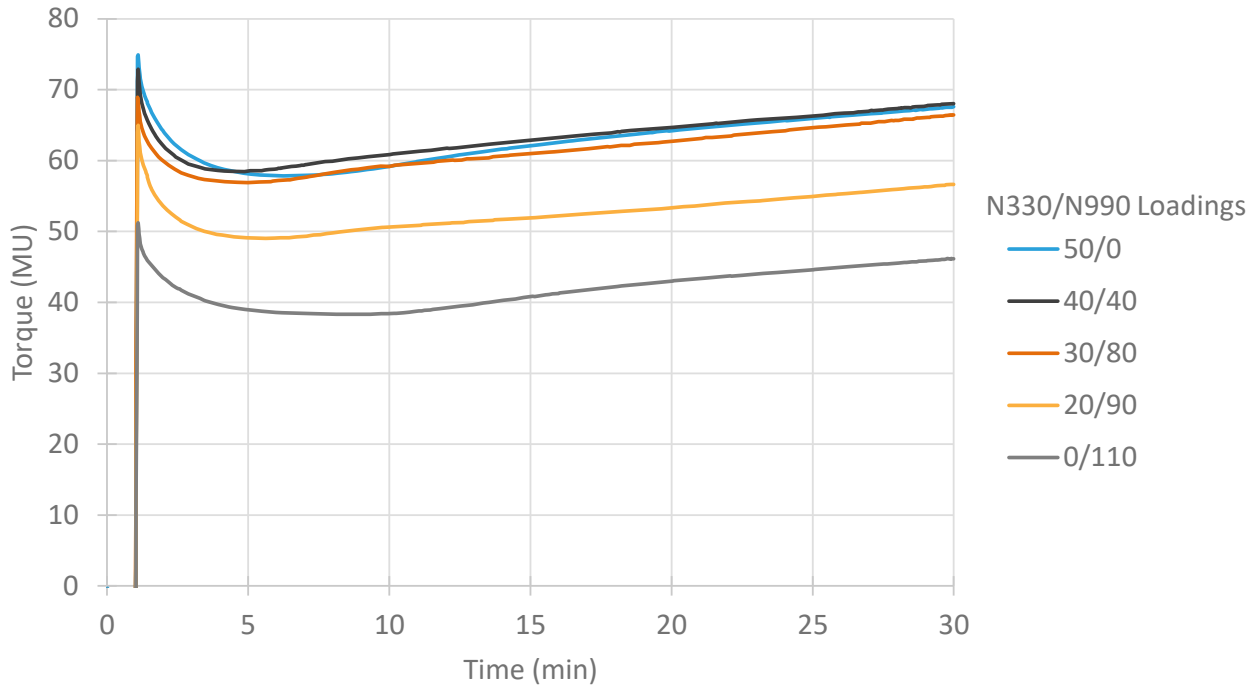

Figure 2. Mooney scorch at a temperature of 138°C. Scorch time increased at high loadings at N990.

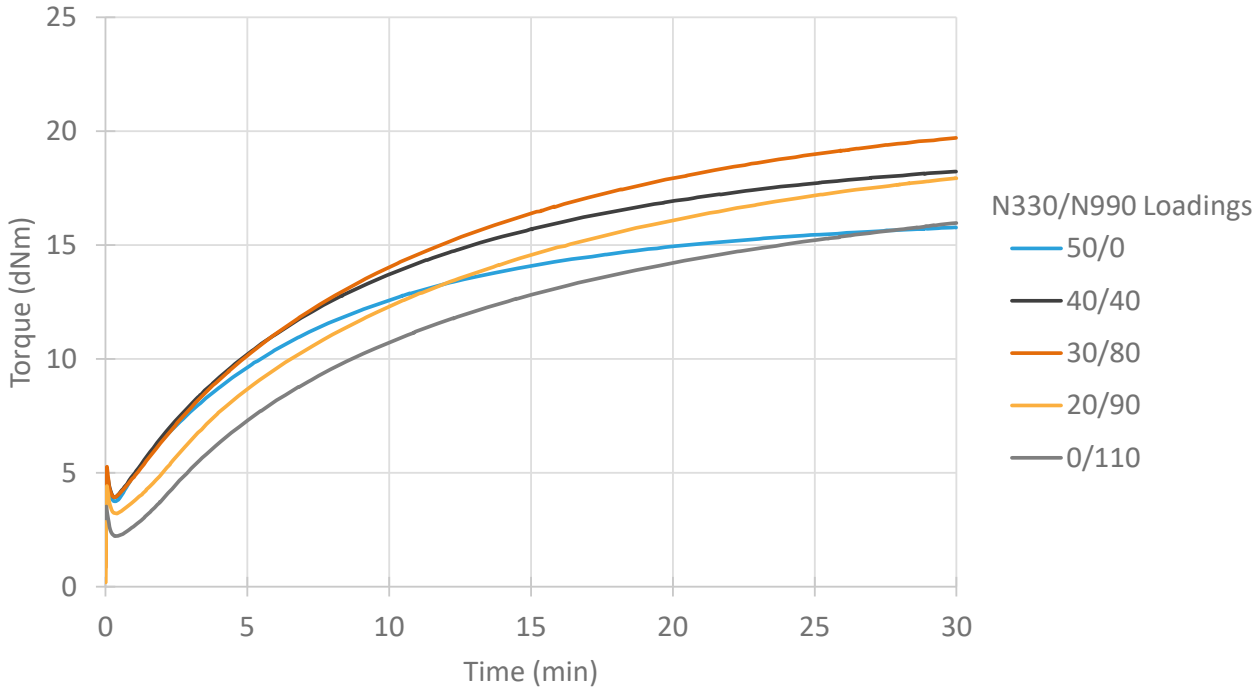

Figure 3. MDR cure curves at 190°C and 1° arc. Marching modulus was evident. A slight increase in scorch times at high loadings of N990 was observed.

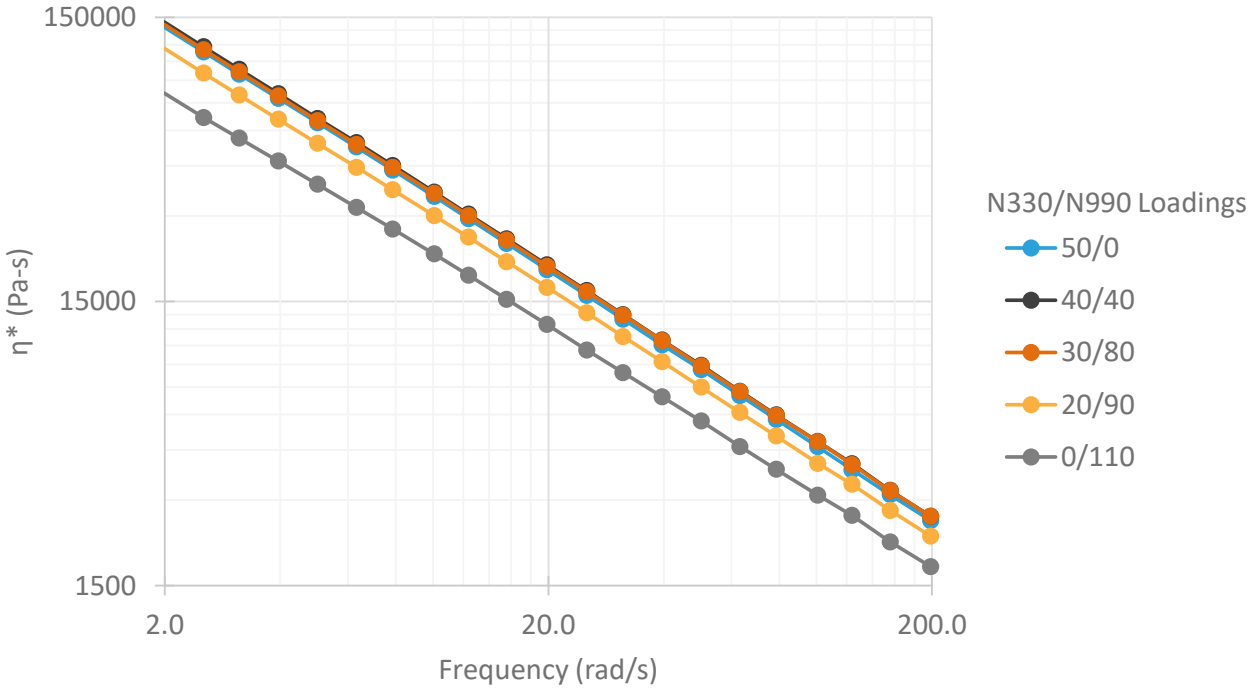

Figure 4. Complex dynamic viscosity as a function of frequency at a temperature of 100°C and strain amplitude of 7.0%. The viscosity decreased significantly as N990 replaced N330.

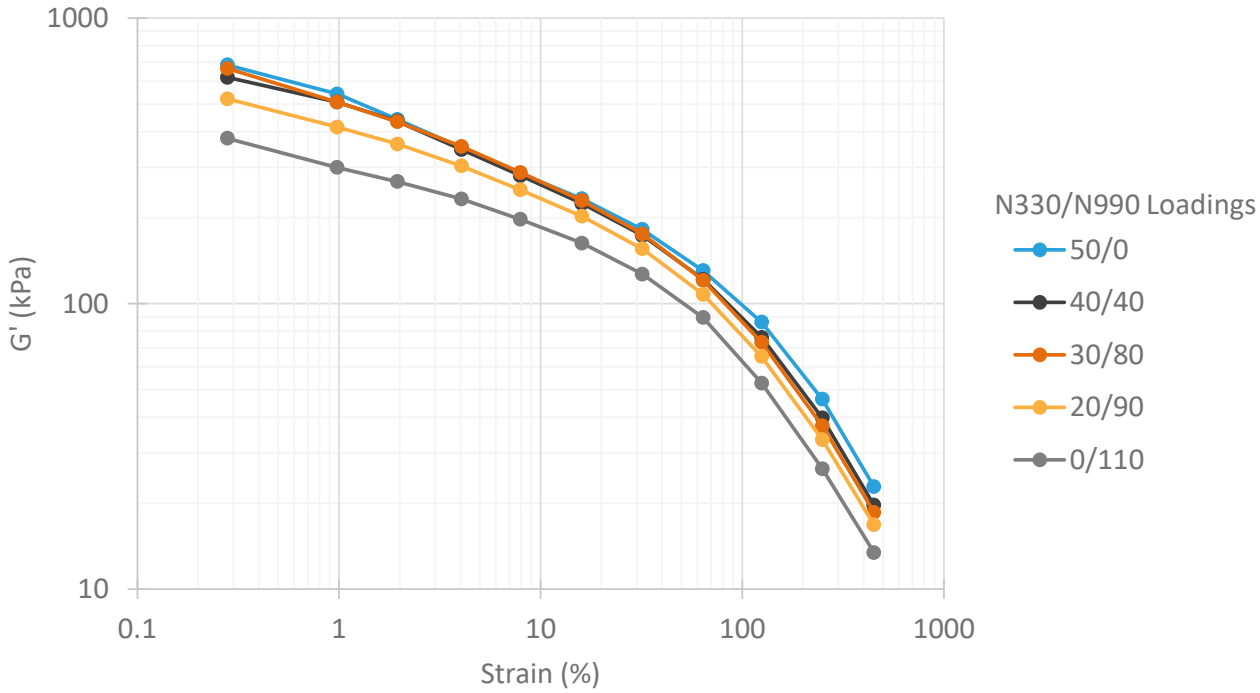

Figure 5. Storage modulus as a function of strain amplitude at a temperature of 60°C and frequency of 0.63 rad/s. Significant reduction in modulus as N990 replaced N330.

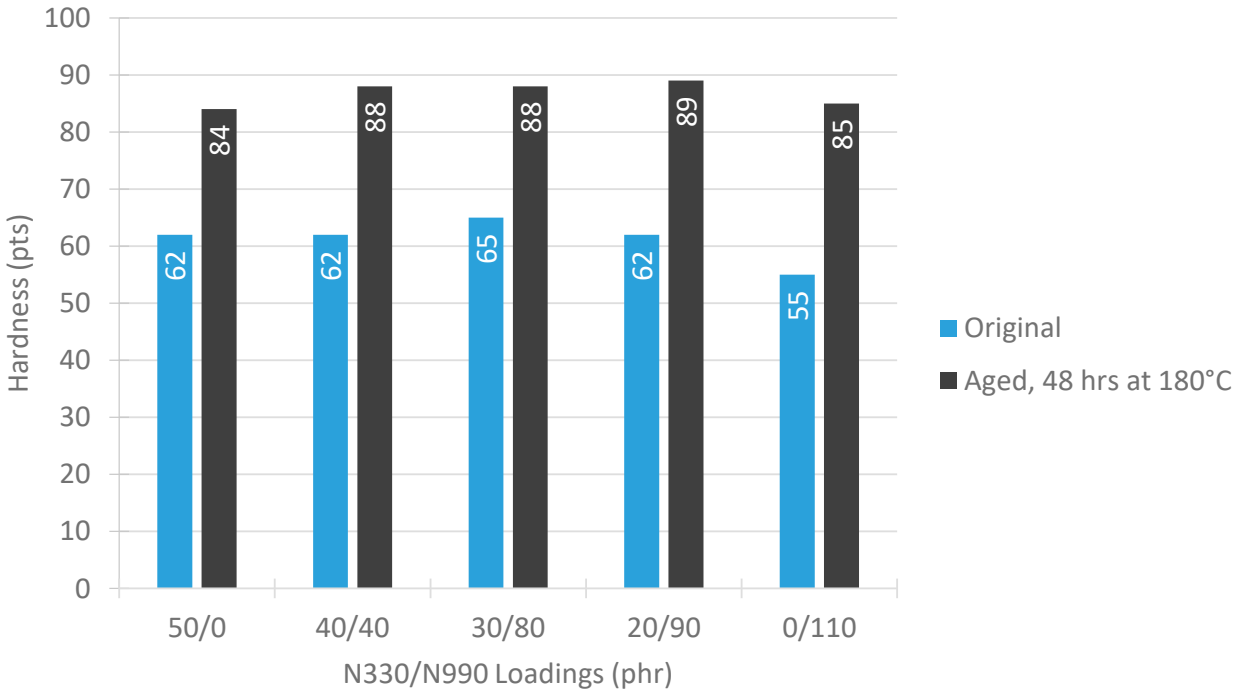

Figure 6. Hardness, original and air oven aged 48 hours at 180°C, for each compound. All compounds met the 60±5 durometer specification. There was no significant difference in aged hardness.

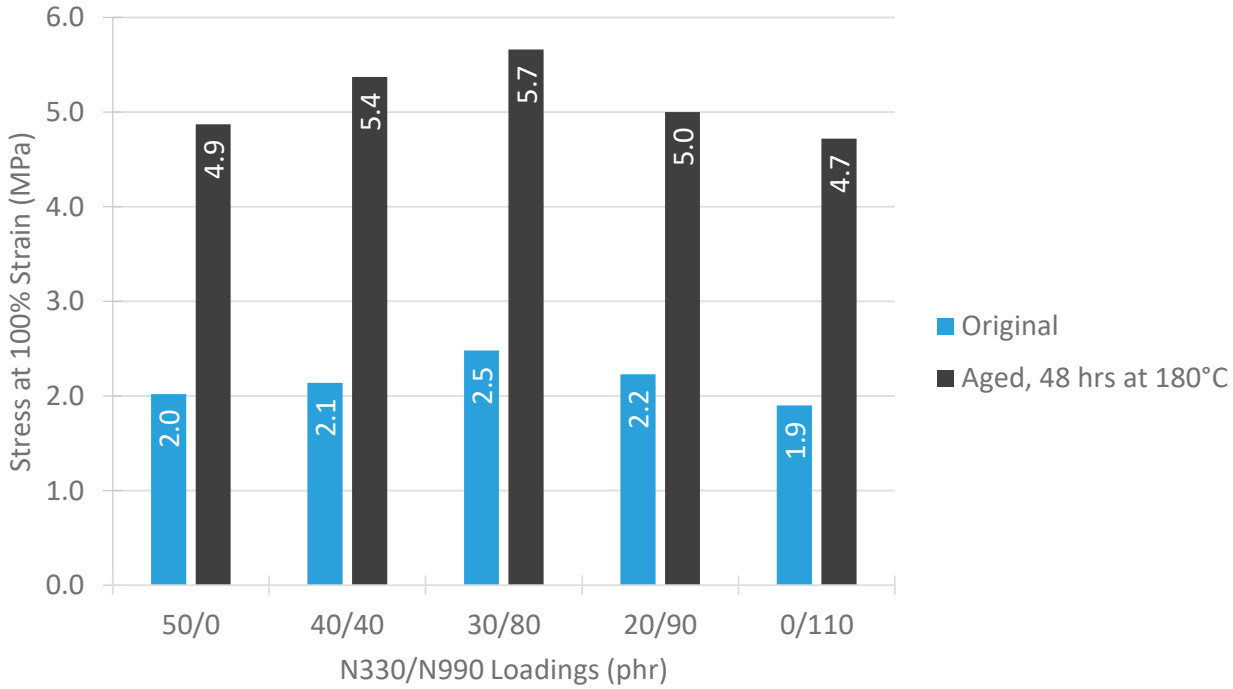

Figure 7. Stress at 100% strain, original and air oven aged 48 hours at 180°C, for each compound.

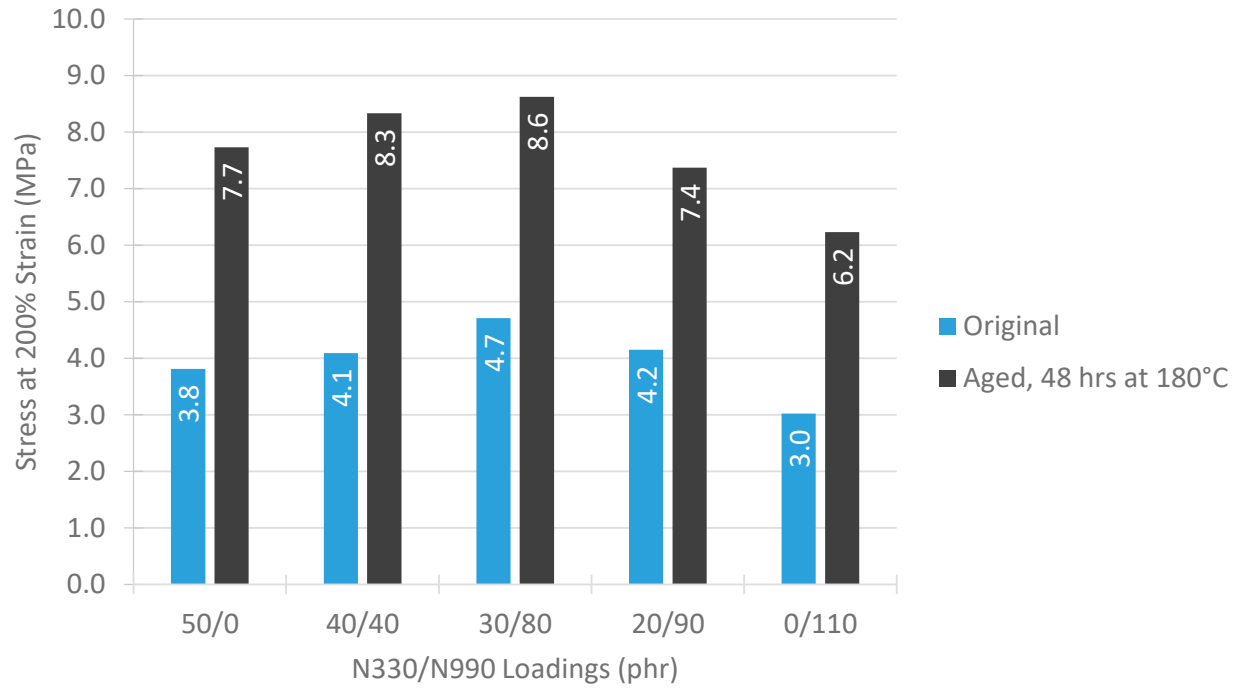

Figure 8. Stress at 200% strain, original and air oven aged 48 hours at 180°C, for each compound.

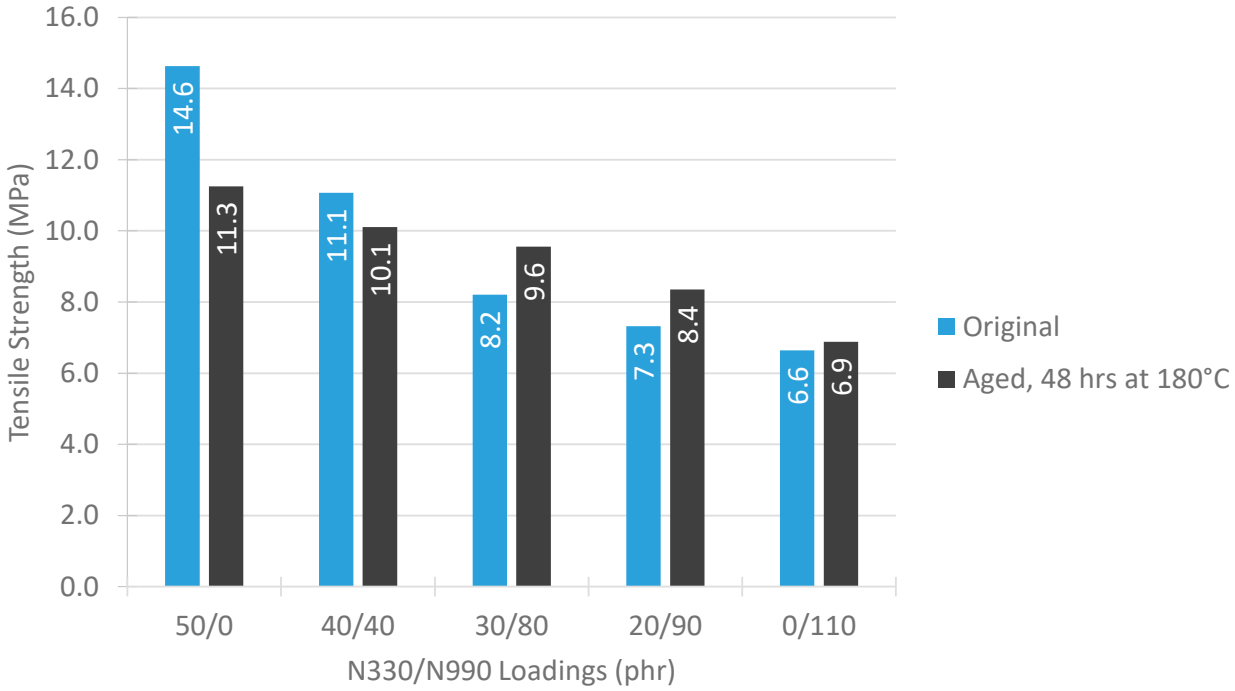

Figure 9. Tensile strength, original and air oven aged 48 hours at 180°C, for each compound. Tensile strength decreased as N990 loading was increased.

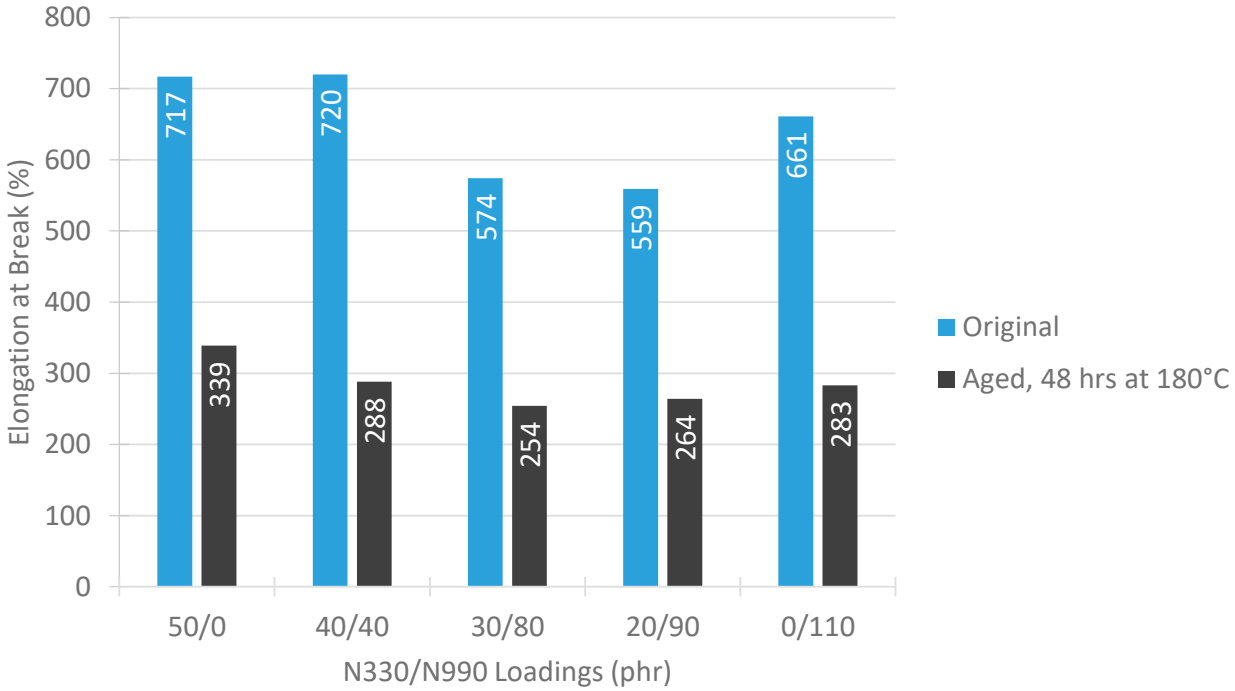

Figure 10. Elongation at break, original and air oven aged 48 hours at 180°C, for each compound. No clear trend in elongation was observed.

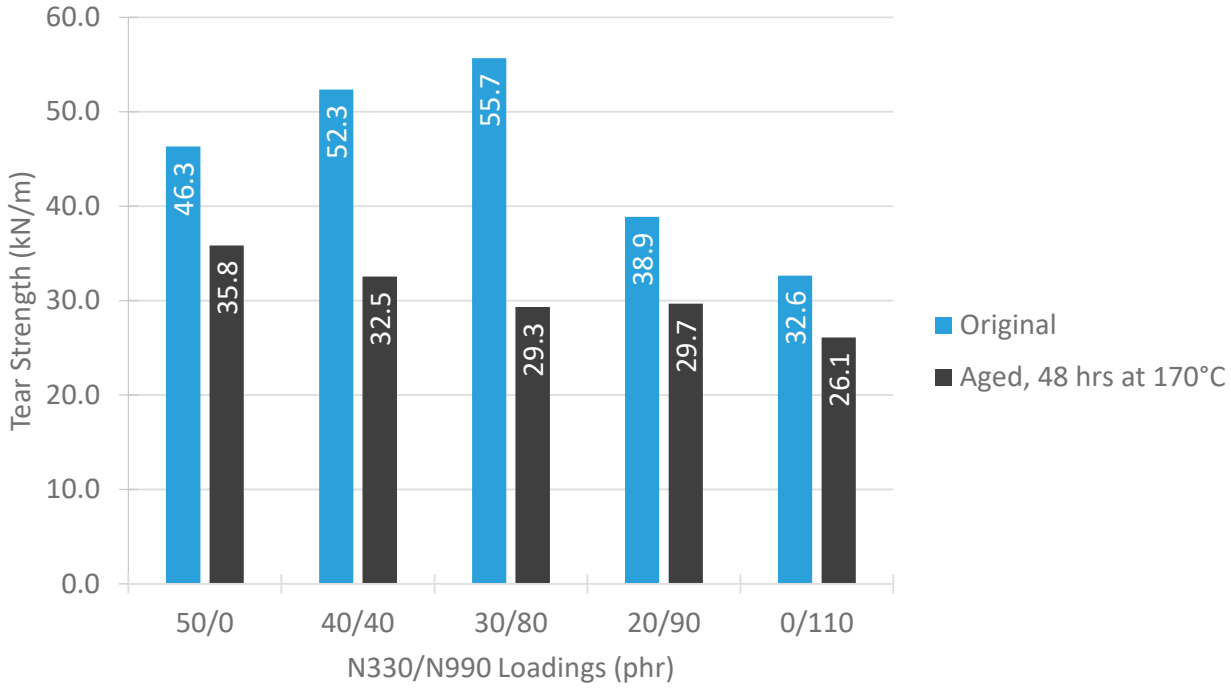

Figure 11. Die C tear strength, original and air oven aged 48 hours at 170°C, for each compound. Aged tear strength decreased as N990 loading was increased.

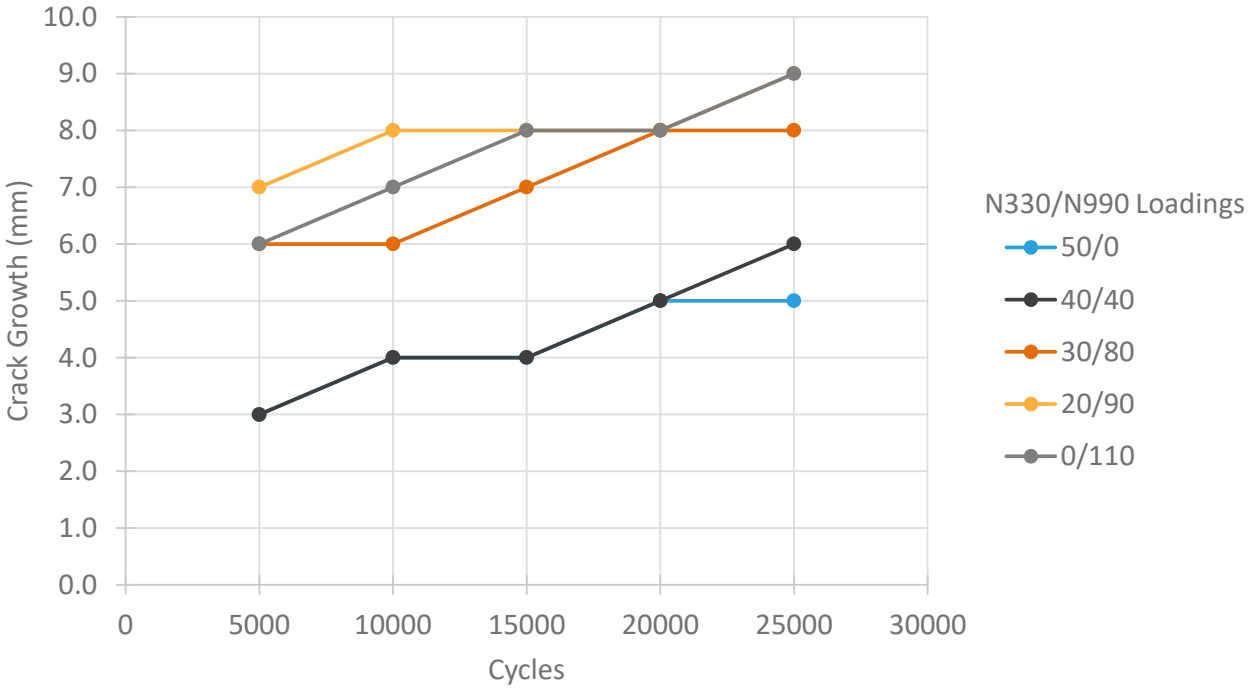

Figure 12. DeMattia crack growth for each compound. Crack growth increased when N990 loading was increased to 80 phr. There was no change in crack growth at N990 loading of 40 phr.

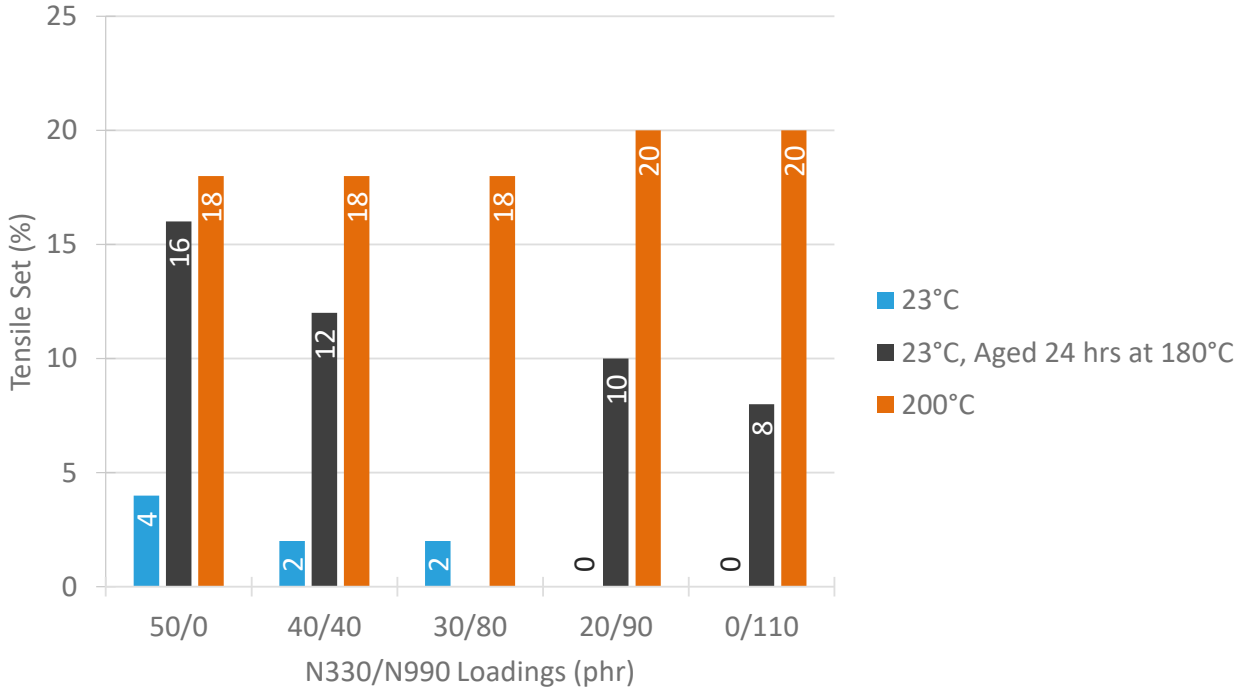

Figure 13. Tensile set, original at room temperature and 200°C and air oven aged 24 hours at 180°C at room temperature, for each compound. Room temperature tensile set decreased with increased N990 loading. High temperature tensile set showed no significant change.

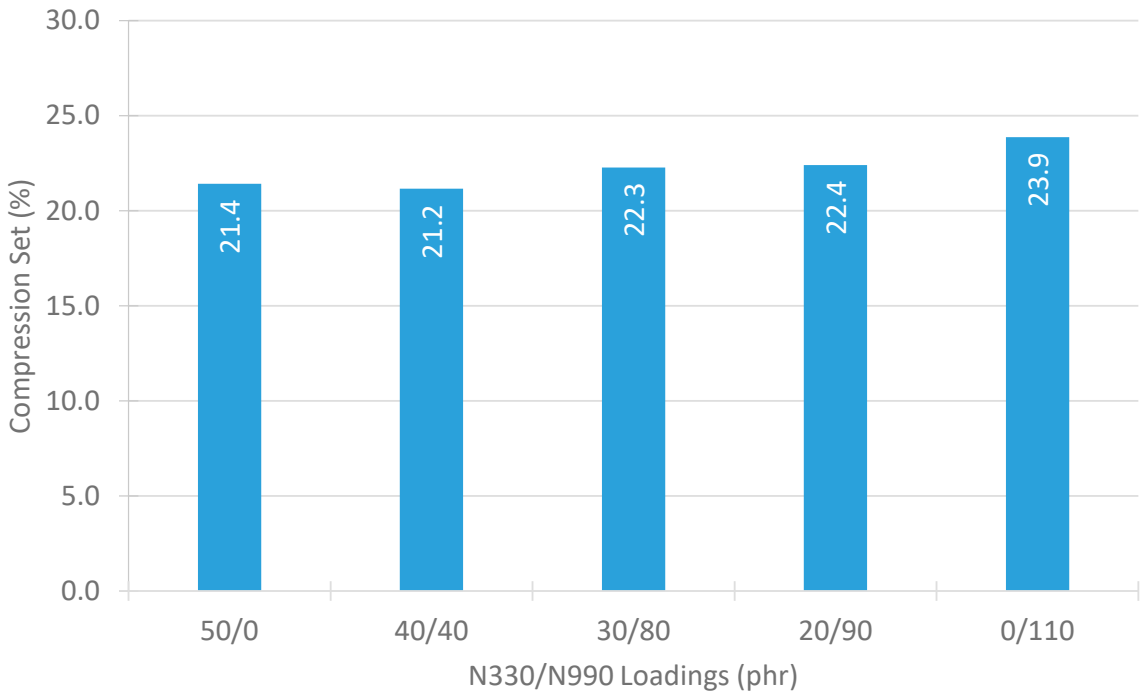

Figure 14. Compression set after 70 hours at 100°C for each compound. No significant change was observed.

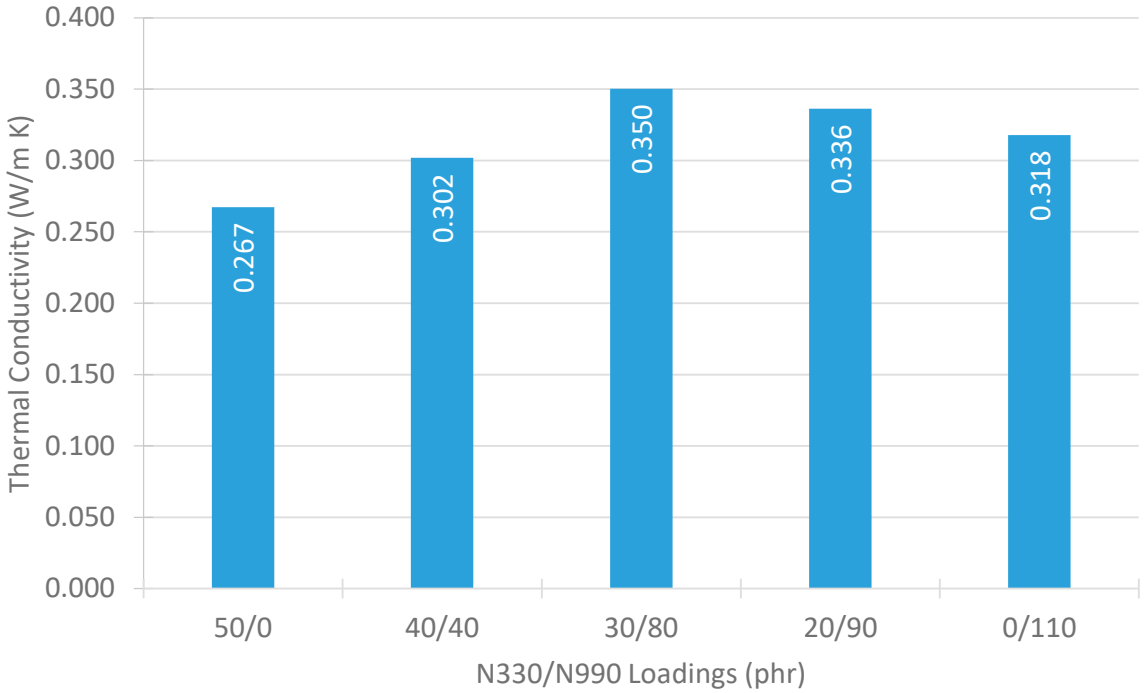

Figure 15. Thermal conductivity for each compound. Higher thermal conductivity was observed for the compounds with N990 compared to the control compound.