Thermax® N990 in EPDM Sponge Compound

Due to its excellent weathering and processing properties along with its relatively low cost, EPDM sponge compound remains a material of choice for low-density automotive profiles which are found in door, trunk, and hood seals. To produce EPDM sponge, a blowing agent is added to the rubber formulation. Blowing agents fall under two main classifications: physical (e.g., liquid carbon dioxide) and chemical (e.g., azodicarbonamide). A chemical blowing agent, such as the one used in this study, will decompose at processing temperatures generating gases such as N_2, CO_2, CO, and NH_3. Both the rubber formulation and the processing conditions will contribute to the overall foam quality.

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

- Reduction in mixing power consumption which can lead to lower electricity costs
- Excellent surface finish
- Maintenance of physical properties
- Improvement in elongation

The EPDM sponge rubber formulations can be found in Table 1. Thermax® N990 replaced a furnace grade at a replacement ratio of 2.3:1.0. While this replacement ratio would likely be satisfactory for dense profiles, we can see from the results that the replacement ratio was too high for sponge rubber as there was a significant increase in hardness. Mooney viscosity, Garvey Die, MDR, Type OO hardness, tensile, density, compression-deflection, compression set, and microscopy were run on all compounds. Testing results can be found in the tables and figures on the following pages. The compounding and testing were completed at Akron Rubber Development Laboratories in Barberton, Ohio.

Table 1. EPDM formulations

Ingredient	Control	A	B
Royalene 535	100.0	100.0	100.0
Spheron 5000	100.0	75.0	50.0
Thermax® N990	**-**	**58.0**	**117.0**
Sunpar 2280	100.0	100.0	100.0
Zinc Oxide	5.0	5.0	5.0
Stearic Acid	2.0	2.0	2.0
Hubercarb Q 325	50.0	50.0	50.0
Struktol WB 222	3.0	3.0	3.0
Acticell U	3.0	3.0	3.0
Cellogen OT	7.0	7.0	7.0
Sulfur	2.0	2.0	2.0
MBT	2.0	2.0	2.0
TDEC	1.0	1.0	1.0
ZDBC	2.0	2.0	2.0
DPTT	2.0	2.0	2.0
Total	**379.0**	**412.0**	**446.0**

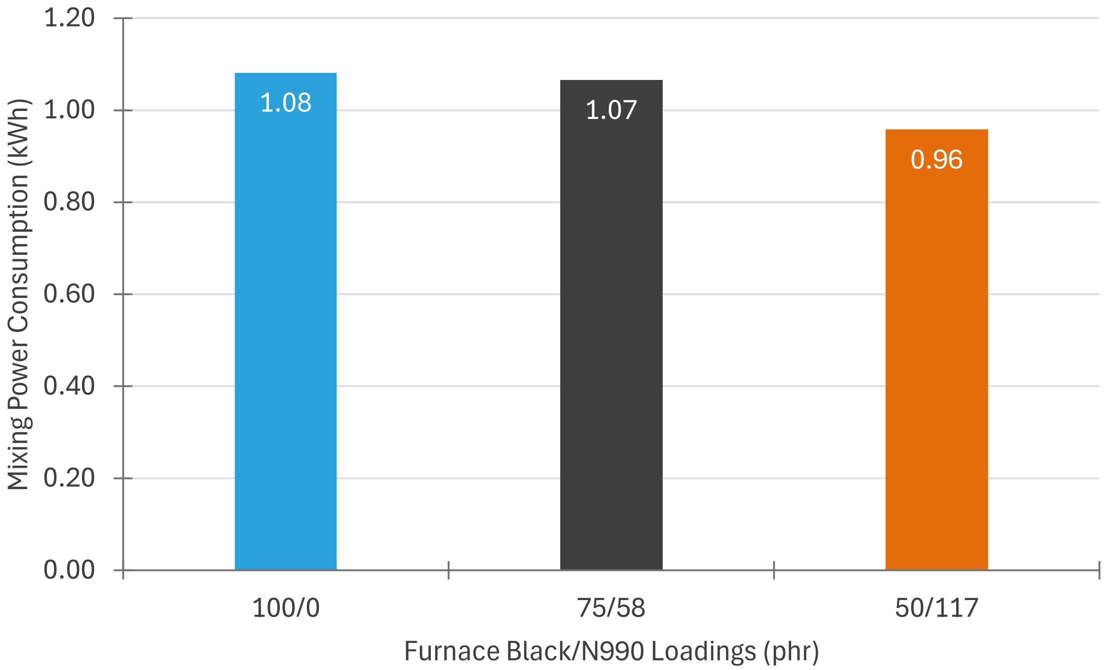

Figure 1. Mixing power consumption of the compounds. Mixing power consumption decreased as N990 replaced the furnace black.

Table 2. Garvey Die ratings of the compounds measured according to ASTM D2230.

Furnace Black/N990 Loadings	**100/0**	**75/58**	**50/117**
Surface, rating	9	9	9
Edge, rating	A	A	A

Figure 2. Pictures of Garvey Die extrudate.

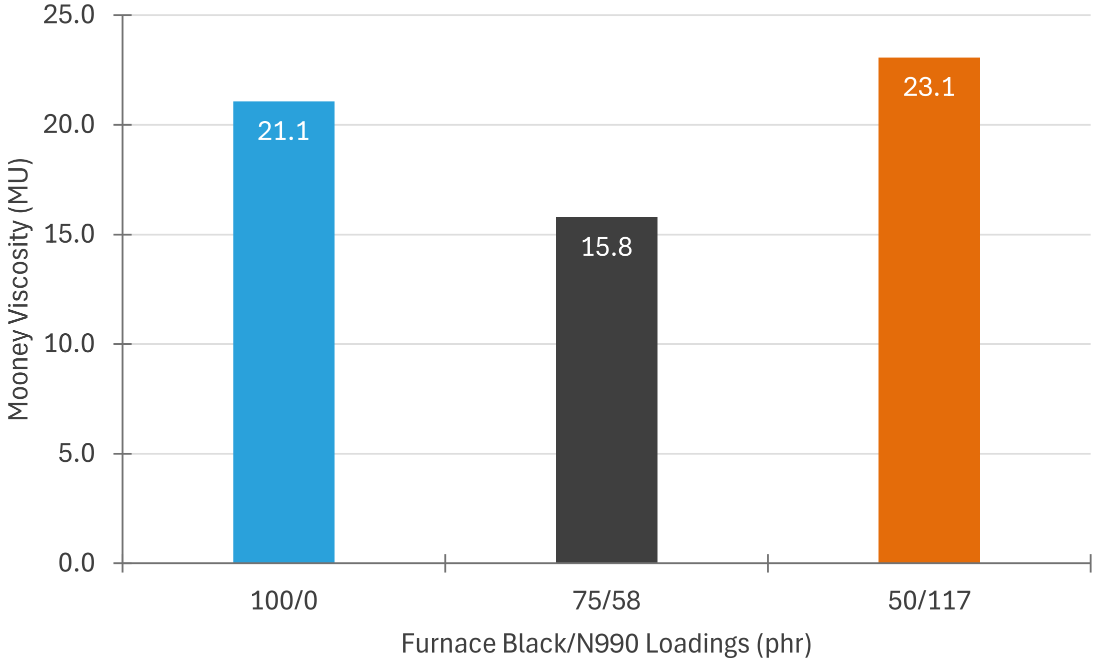

Figure 3. Mooney viscosity of the compounds measured at 100°C according to ASTM D1646. There was a drop in viscosity at the 25% replacement level.

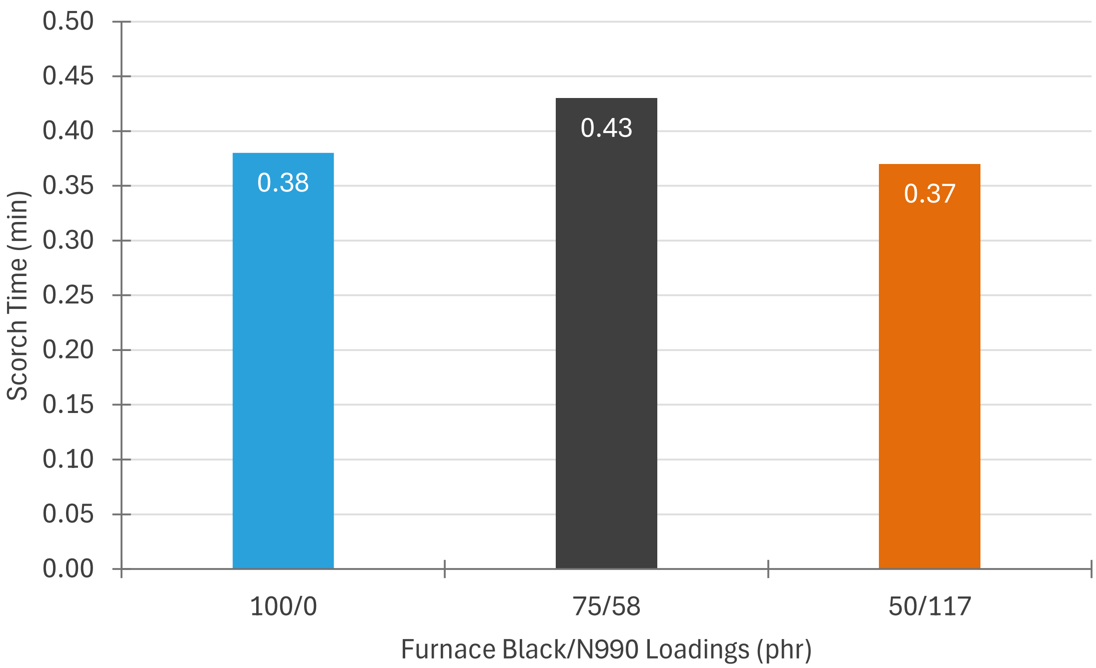

Figure 4. Scorch time, ts1, of the compounds measured at 175°C according to ASTM D5289.

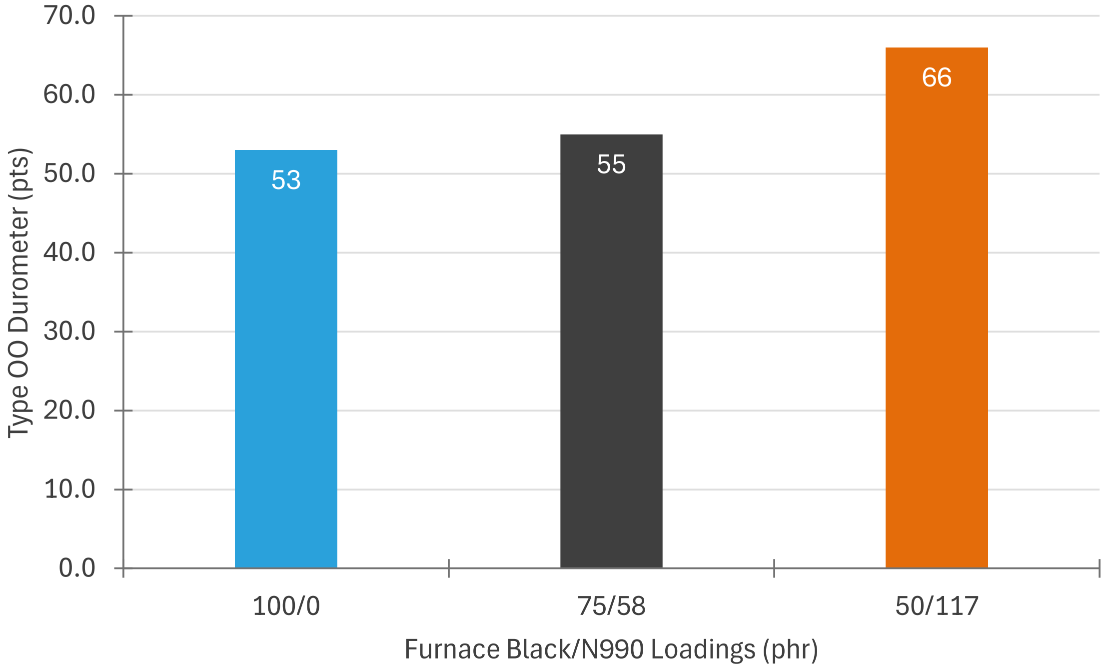

Figure 5. Type OO durometer of the compounds measured according to ASTM D2240. There was a significant increase in hardness indicating that the replacement ratio used was too high. Reducing the replacement ratio and thus the level of N990 would decrease the hardness and affect other compound properties.

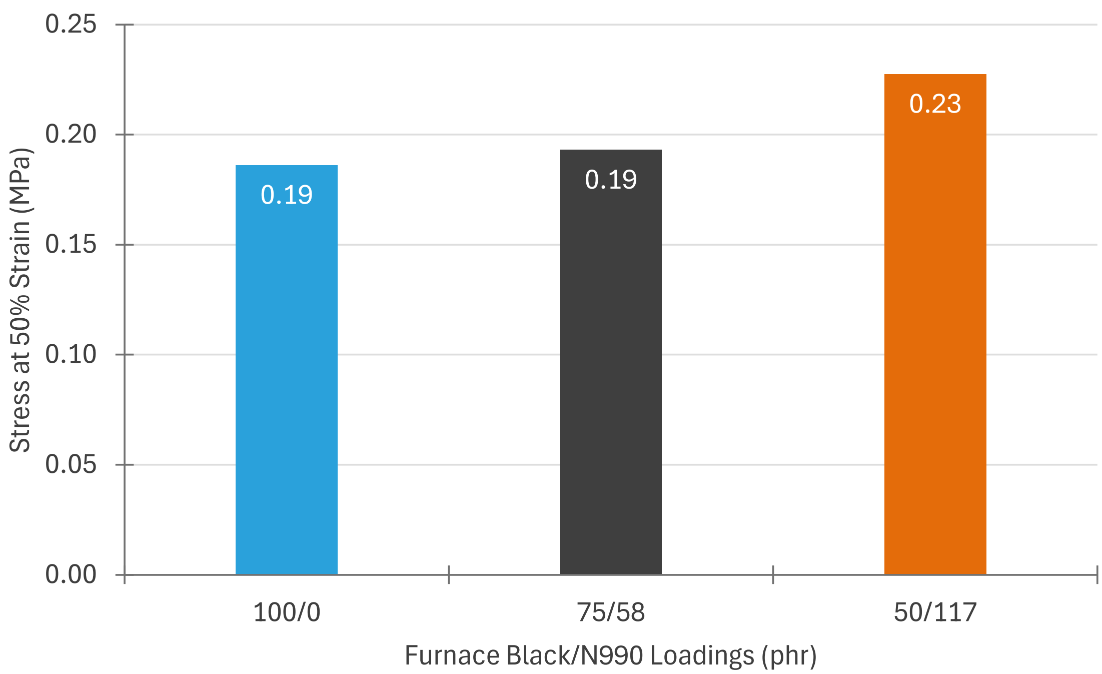

Figure 6. Stress at 50% strain of the compounds measured according to ASTM D412. 50% modulus was higher for the compound with 50% replacement level.

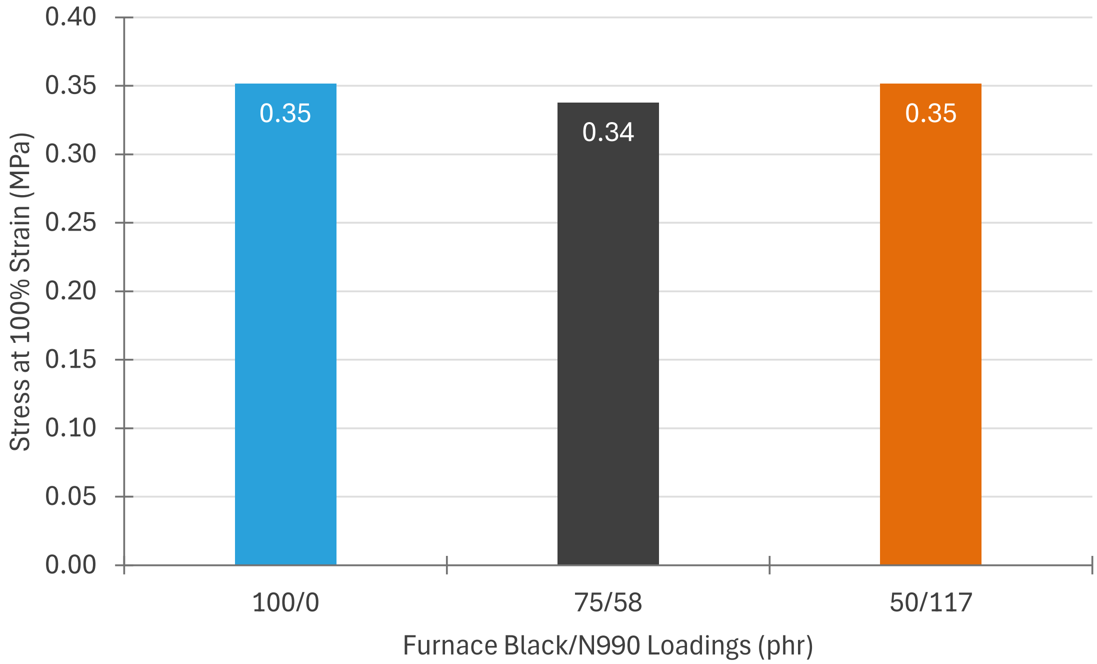

Figure 7. Stress at 100% strain of the compounds measured according to ASTM D412. There were no significant differences in 100% modulus.

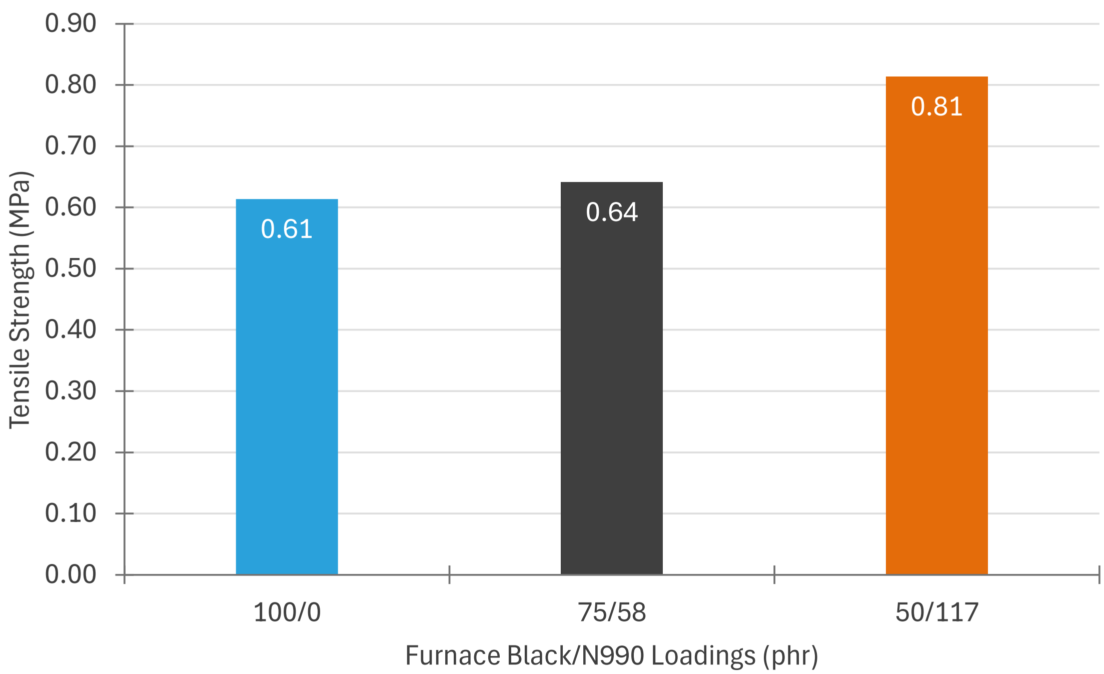

Figure 8. Tensile strength of the compounds measured according to ASTM D412. Tensile strength increased as N990 replaced furnace black likely due to the high replacement ratio used.

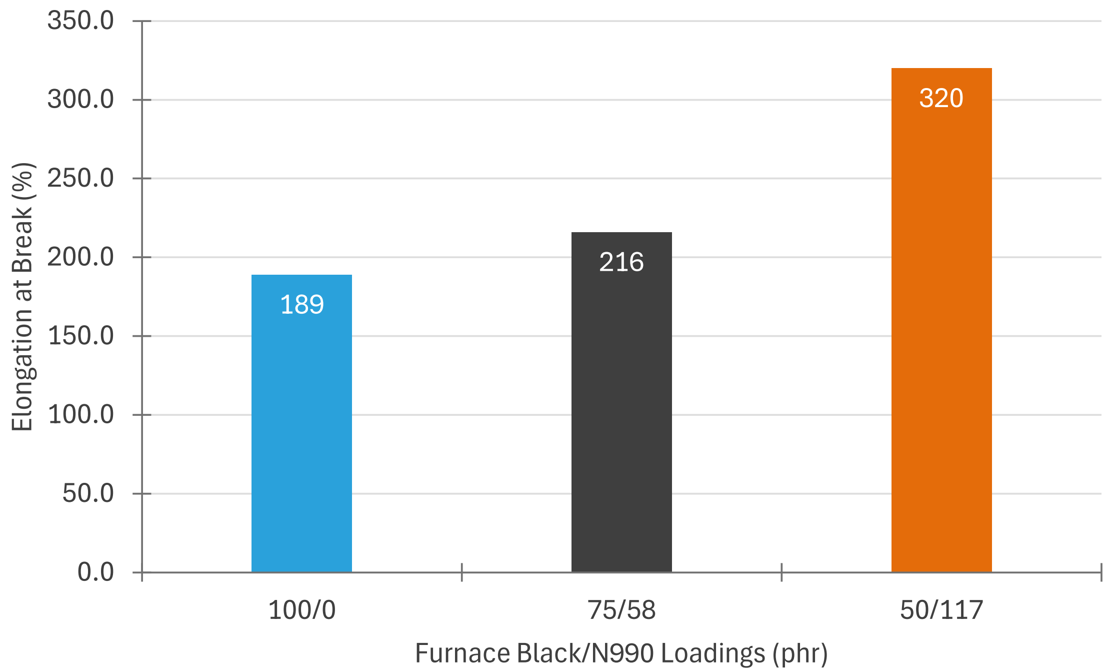

Figure 9. Elongation at break of the compounds measured according to ASTM D412. Elongation increased as N990 replaced the furnace black.

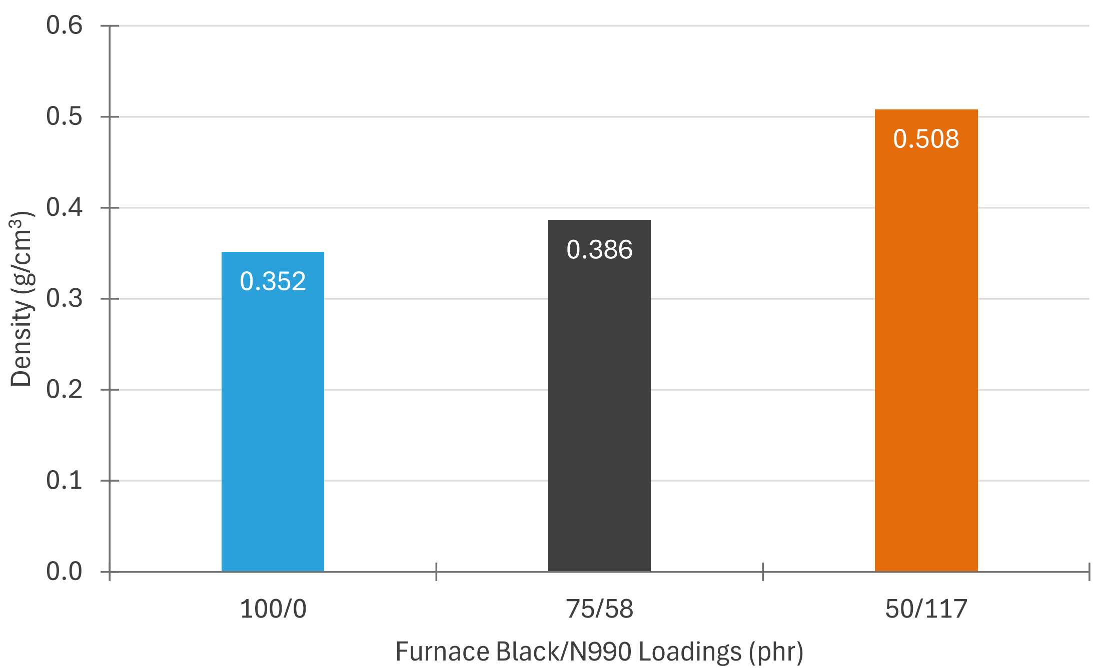

Figure 10. Density of the compounds measured according to ASTM D1056. Density increased as N990 replaced furnace black. A lower replacement ratio would lead to a lower change in density.

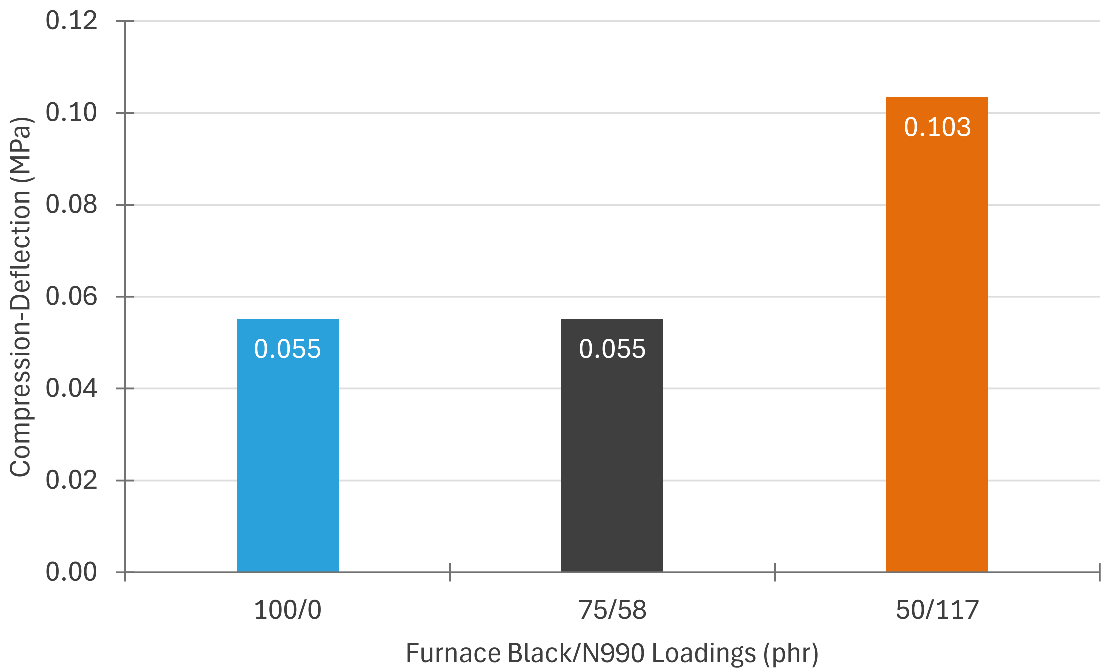

Figure 11. Compression-Deflection results of the compounds measured according to ASTM D1056. The value increased for the 50% replacement level compound.

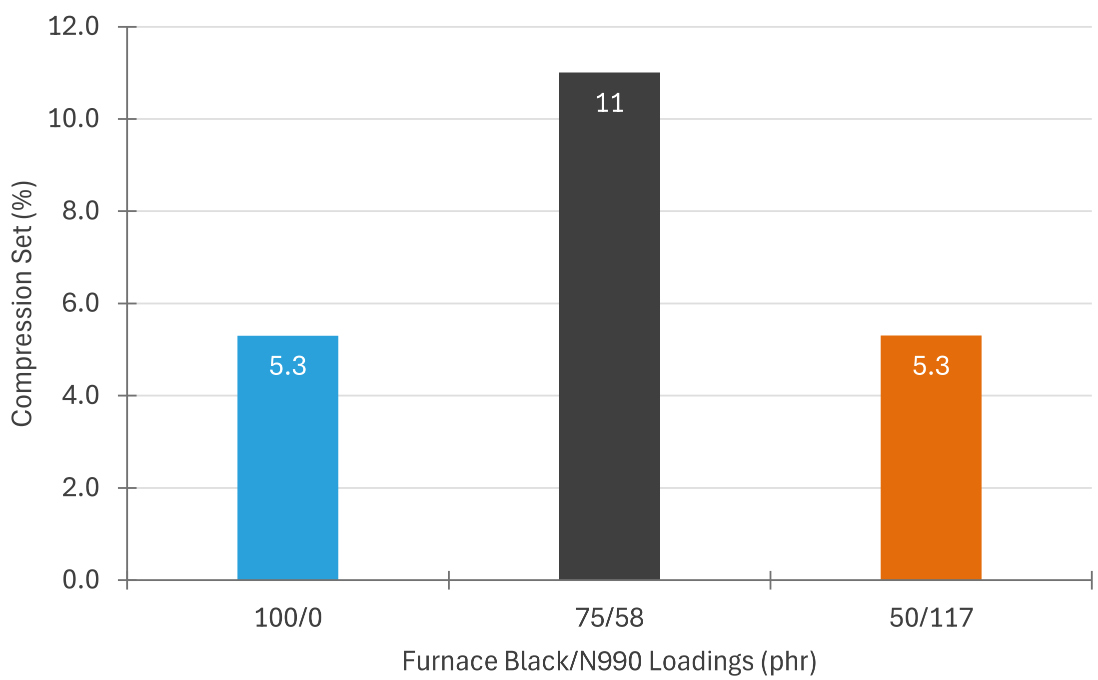

Figure 12. Compression set of the compounds measured at room temperature according to ASTM D1056. All compounds had low compression set values.

Table 3. Cell size in x- and y-directions of the compounds measured by microscopy.

Furnace Black/N990 Loadings	Direction	Adjusted Cell Size, mm
100/0	X	0.89
100/0	Y	0.56
75/58	X	0.79
75/58	Y	0.56
50/117	X	1.14
50/117	Y	0.51

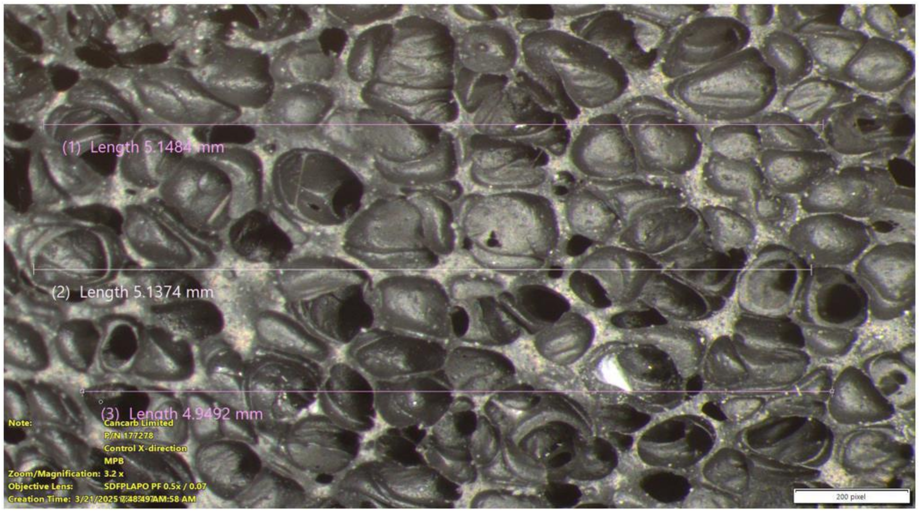

Figure 13. Picture of cells in compound with 100/0 furnace black/N990 loadings.

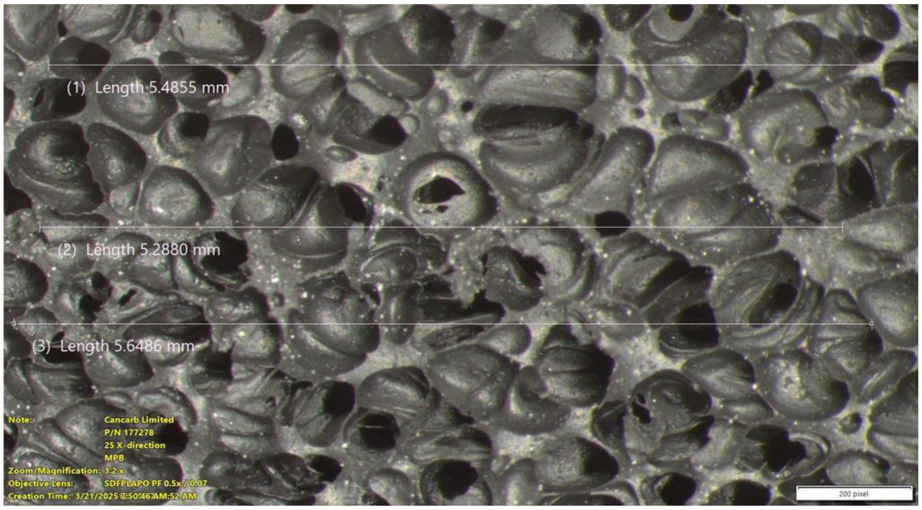

Figure 14. Picture of cells in compound with 75/58 furnace black/N990 loadings.

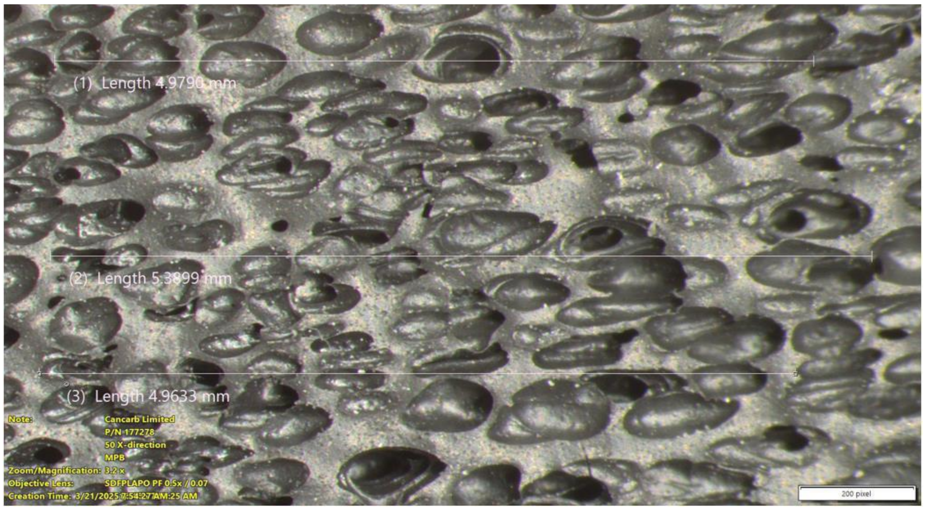

Figure 15. Picture of cells in compound with 50/117 furnace black/N990 loadings. Cells appear more elongated. A lower replacement ratio would likely result in less elongated cells.