# VMX5015 / VMX5020

Vamac® Ethylene Acrylic Elastomer Compound - Technical Data

## Description

**VMX5000 Series Pre-Compounds for Improved Heat Resistance**
For demanding applications requiring high heat resistance, the VMX5000 series of Vamac® pre-compounds offer superior performance.

Until the introduction of the VMX5000 series, AEM compounds relied on fillers like carbon black or silica to provide strength and stiffness for a finished article. These fillers, however, accelerate oxidative degradation. VMX5000 series pre-compounds eliminate this problem by utilizing a novel filler system that actively extends the life of AEM articles exposed to hot air. As a result, finished parts based on VMX5000 series pre-compounds last up to three times longer at any given temperature compared to AEM compounds containing conventional fillers. Compounds based on the VMX5000 series are also lighter weight, with up to 15% lower specific gravity.

The improved heat ageing performance of VMX5000 series pre-compounds benefits automotive applications such as turbocharger hose and molded air ducts, with specific advantages for seals and gaskets. Compounds made with VMX5000 grades exhibit significantly improved compressive stress relaxation properties in air, as well as in long term compression set.

While VMX5000 series pre-compounds may be extended with AEM elastomer, plasticizer or small amounts of conventional filler like carbon black, in some cases no additional filler may be required. VMX5000 compounds also provide a route to bright colored finished articles having superior physical properties and heat ageing resistance compared to mineral filled AEM compounds.

## Handling Precautions

Because Vamac® ethylene-acrylic elastomers contain small amounts of residual methyl acrylate monomer, adequate ventilation should be provided during storage and processing to prevent worker exposure to methyl acrylate vapor. Additional information may be found in the respective product Safety Data Sheet (SDS), and DuPont™ bulletin, *Safe Handling and Processing of Vamac®*.





VME-A11215-00-C0321

# VMX5015 / VMX5020

Vamac® Ethylene Acrylic Elastomer Compound - Technical Data

## VMX5000 Series Product Range

| Grade | ML (1+4) at 100 °C | Tg (by DSC) °C[1] | Density, g/cc | Key Feature |
|---|---|---|---|---|
| VMX5015 | 57 | -30 | 1.07 | Compression molding pre-compound[2] |
| VMX5020 | 43 | -30 | 1.07 | Injection molding pre-compound[2] |

[1] Tg of compounds with Vamac® may be extended typically – 10°C lower with the addition of plasticizer.
[2] Not suitable for steam autoclave cure.

VMX5000 series products are available in bale form, and the natural color is opaque creamy white to light pink. Bales are packaged in 23kg units with a blue strippable wrap in individual boxes. The strippable wrap must be completely removed prior to using the product. A full pallet will hold thirty individual boxes with a net weight of 690kg.

## Improved Heat Resistance

VMX5000 series pre-compounds offer significantly improved heat resistance over conventional carbon black filled AEM or HT-ACM. Figure 1 shows AEM temperature rating based on three industry-accepted criteria: less than 50% loss in tensile strength and elongation, and less than 15-point change in Shore A hardness.

A significant increase in temperature rating is achieved with VMX5000 compared to black filled AEM or HT-ACM.

| | | |
|---|---|---|
| at 6 weeks | from 167°C to 182°C rating | (+15°C) |
| at 3 weeks | from 175°C up to 190°C rating | (+15°C) |
| at 1 week | from 185°C up to 205°C rating | (+ 20°C) |

Likewise, when the temperature is held constant there is a significant increase in performance lifetime.

| | | |
|---|---|---|
| at 160°C | from 1800 hours up to 3600 hours | (2 x) |
| at 175°C | from 504 hours up to 1680 hours | (3.3 x) |
| at 185°C | from 168 hours up to 750 hours | (4.5 x) |



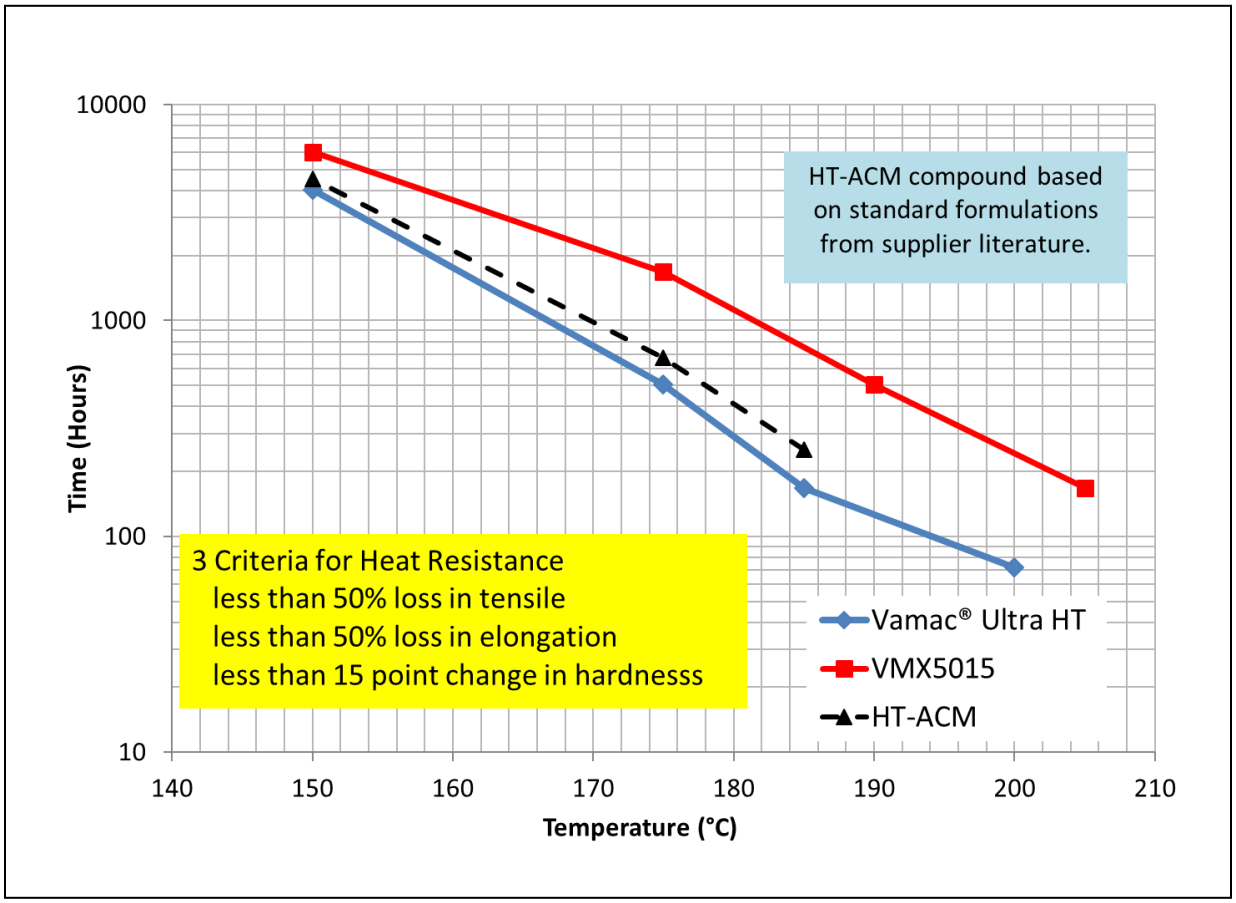


VME-A11215-00-C0321

# VMX5015 / VMX5020

Vamac® Ethylene Acrylic Elastomer Compound - Technical Data

Figure 1 – Temperature Rating

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# VMX5015 / VMX5020

Vamac® Ethylene Acrylic Elastomer Compound - Technical Data

## Improved Sealing Performance

Industry standard tests for sealing performance include compression set (CS) and compressive stress relaxation (CSR). Results of these tests for many elastomers, including AEM, can depend on sample geometry. When tested in air, a test specimen with a high surface area to volume ratio (like a D214 O-ring) experiences greater oxidation and therefore greater degradation of sealing properties than a larger specimen like an ASTM D395 type 1 button. Because many seals have small sealing beads, CS and CSR tests using large specimens can mask performance issues that may arise from in-service oxidation.

The improved heat ageing performance of VMX5000 pre-compounds therefore has significant benefit on long term compression set resistance, especially when tested using ISO buttons, or D214 O-rings. Figure 2 shows compression set results for 60 Shore A hardness compounds of VMX5020 / Vamac® Ultra IP blends with either carbon black (15phr) or red pigment (for colored compound), compared to a conventional carbon black filled Vamac® Ultra LS compound.

While all the compounds perform about equally when testing ISO buttons at 168 hours/170°C, the VMX5000 compound out performs the black-filled Ultra LS compound when the test time extends to 1008 hours, or when the specimen is switched to a D214 O-ring under conditions of 168 hours/180°C. Note the VMX5000 series compounds can tolerate small amounts of filler added for color or increasing hardness (typically by less than 10 points Shore A) without adversely affecting compression set or hot air ageing properties.



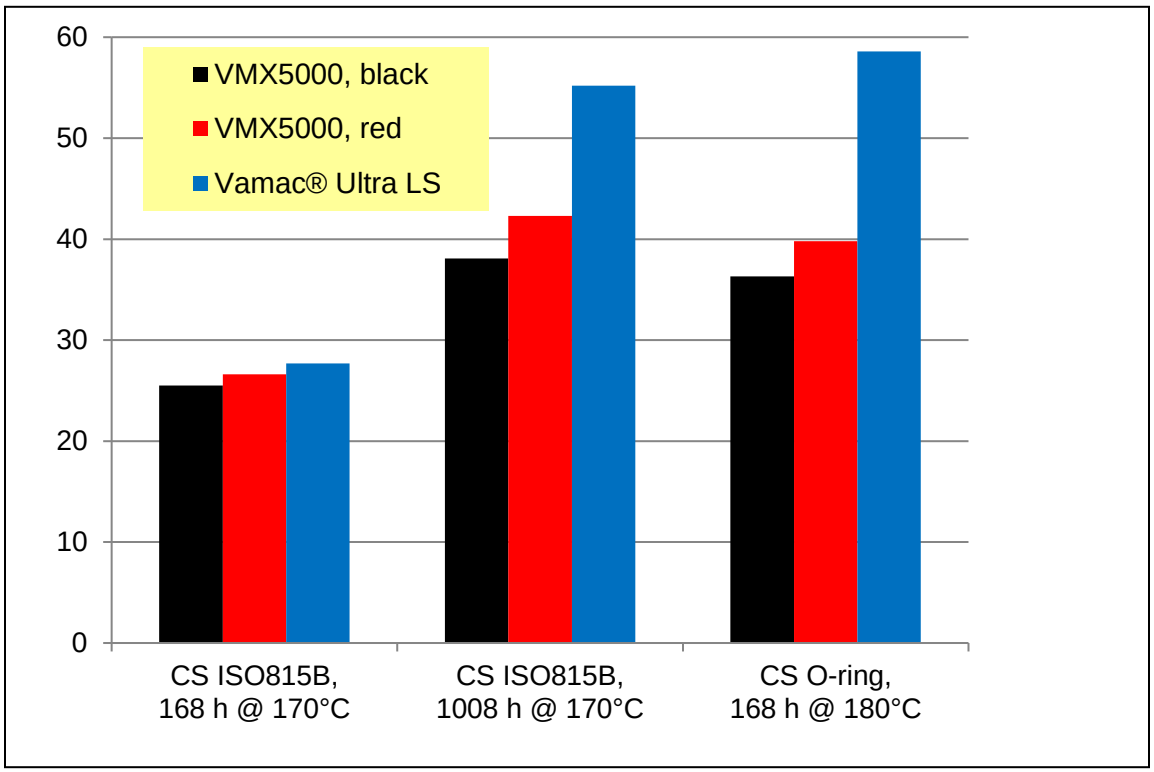


VME-A11215-00-C0321

# VMX5015 / VMX5020

Vamac® Ethylene Acrylic Elastomer Compound - Technical Data

Figure 2 – **Long Term Compression Set Resistance**

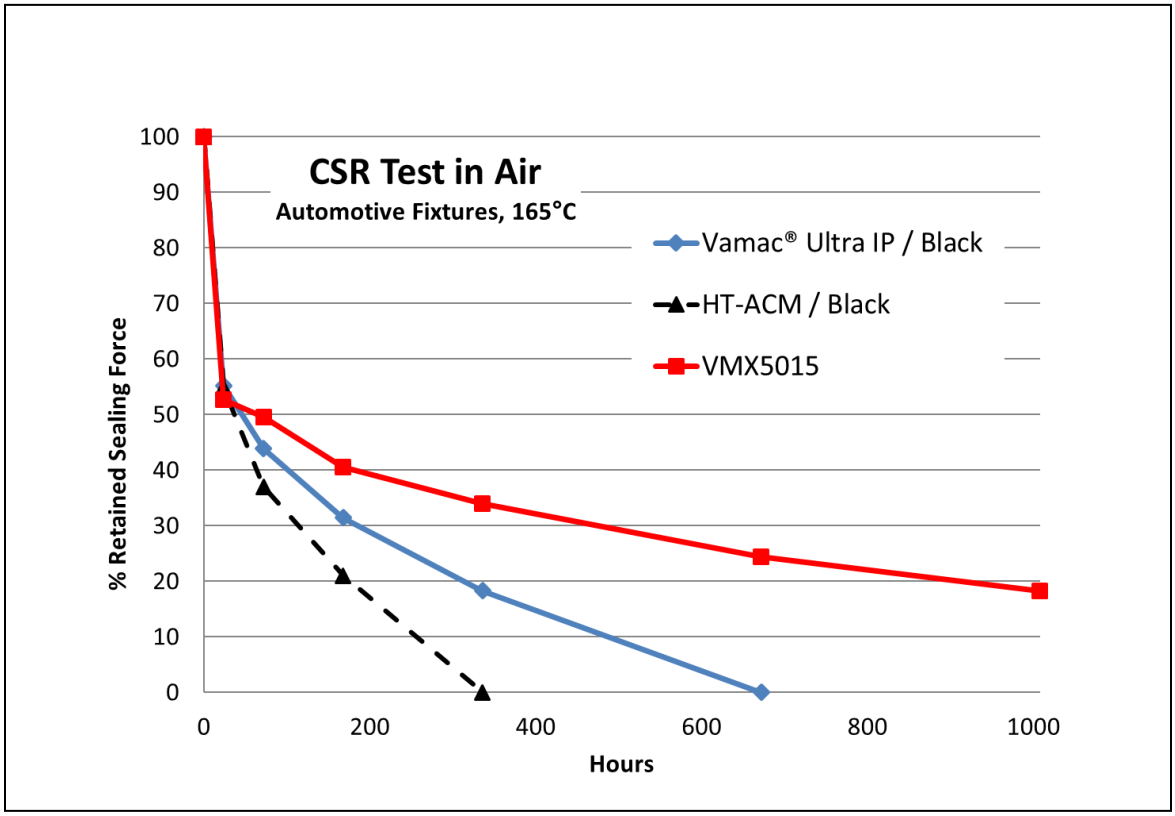


# VMX5015 / VMX5020

## Vamac® Ethylene Acrylic Elastomer Compound - Technical Data

Figure 3 shows compressive stress relaxation testing of ISO buttons in hot air for carbon black filled compounds of Vamac® Ultra IP, HT-ACM, and a VMX5015 compound containing 2phr N550 carbon black for color. The superior oxidative stability of the VMX5015 compound results in dramatically improved CSR performance.

Figure 3 – **CSR in Hot Air**



# VMX5015 / VMX5020

Vamac® Ethylene Acrylic Elastomer Compound - Technical Data

## Compounding VMX5000 Series Pre-Compounds

VMX5000 series compounds optimally contain about 20% lower Diak™1 levels than conventional AEM compounds, and use 4-aminodiphenylamine (ADPA) as the anti-oxidant. The preferred diarylamine anti-oxidants for carbon black or silica filled AEM compounds, like IPPD or Naugard® 445, do not perform as well in the VMX5000 series.

Table 2 shows starting point recipes where the amount of VMX5000 series pre-compound is set so that the compound comprise 100phr total AEM. As desired, additional AEM polymer may be added along with the VMX5000 pre-compound to adjust hardness or cure speed. Vamac® Ultra HT, Ultra IP, and GXF are suitable diluents. Vamac® Ultra IP provides faster curing.

Table 2 –**Starting Recipes for VMX5000**

| Ingredient (phr) | 75 ShA hose | 60 ShA gasket |
|---|---|---|
| VMX5000 Grade | 181.8 | 118 |
| AEM (additional) | | 36 |
| Diak™1 | 0.5 to 0.6 | 0.6 to 1.0 |
| Vulcofac® ACT-55 | 1 | 0 to 2 |
| Alcanpoudre® DBU-70 | | 0 to 2 |
| Armeen® 18D | 0.5 | 0 to 0.5 |
| Stearic Acid | 0 to 0.5 | 0 to 0.5 |
| ADPA* | 0.5 to 1.5 | 0.5 to 1.5 |
| Plasticizer** | 2 to 5 | 0 to 0.5 |
| Vanfre® VAM | 1 | 1 |
| Carbon Black | 2 | 2 |

* 4-aminodiphenyl amine, is available from ChemSpec or Safic Alcan as ADPA
** Alcanplast® PO80, TegMer® 812, or similar

# VMX5015 / VMX5020

Vamac® Ethylene Acrylic Elastomer Compound - Technical Data

- Fatigue resistance is optimized at 0.55phr or less of Diak™ 1, and ISO compression set is optimized at 0.8phr. VW compression set improves up to and beyond 1.0phr, although heat resistance worsens at Diak™1 levels greater than 1.0phr.

- Use at least 1phr accelerator, noting that Vulcofac® ACT-55 is a weaker accelerator than Alcanpoudre® DBU-70. Better release and faster cure may be achieved for molded compounds using 1.5 to 2phr DBU-70.

- ADPA is the preferred anti-oxidant for VMX5000 pre-compounds, and also provides added scorch protection along with Armeen® 18D.

- Low volatile plasticizers may be used up to 10phr, depending on the low temperature requirements.

- Low levels of carbon black (any type) may be used as a colorant without negatively impacting properties.

## Colored Compounds

There is a market demand for colored AEM compounds to help with product assembly. Conventional AEM compounds with mineral fillers have poor compression set properties. Since VMX5000 pre-compounds contain a non-black filler system, and exhibit excellent properties for heat ageing, and compression set, they are particularly suitable for colored AEM parts for differentiation, and optical control.
For colored compounds, staining diarylamine anti-oxidant like ADPA should be avoided, and less staining Naugard® 445, or non-staining AO like Irganox® 1010 and Ultranox® 626 may be used.

Figure 4 shows VMX5015 compounds with less staining Naugard® 445, 5phr $TiO_2$ and 2phr pigment to produce bright colors with good heat ageing.

Figure 4 – **Colored Compounds with VMX5015**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# VMX5015 / VMX5020

Vamac® Ethylene Acrylic Elastomer Compound - Technical Data

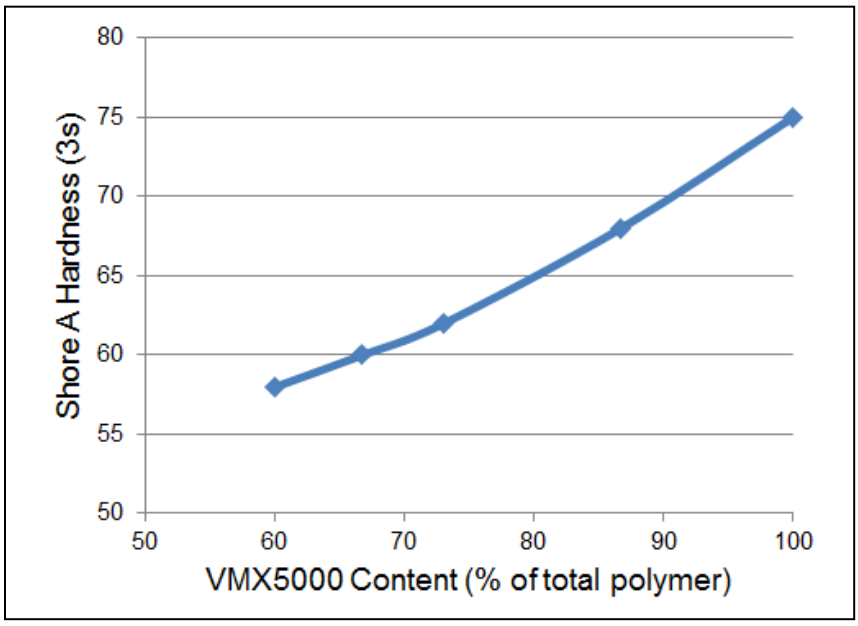
## Formulating for Different Hardness Level

VMX5000 series pre-compounds contain filler level for a hardness of approximately 75 Shore A after vulcanization. To achieve lower hardness levels, unfilled Vamac® AEM polymer must be added to dilute and reduce the overall filler level. Figure 4 exhibits a profile of hardness range between 55 to 75 Shore A (3 sec) for VMX5015 / Vamac® Ultra IP blends in a compound formulation and curative package typical for a sealing application. Further modification can be achieved by changing curative, supplemental filler, and plasticizer level. Dilution of VMX5000 pre-compounds may be extended to provide compounds of low hardness level (37 to 47 Shore A) with relatively good properties, and processing, which is difficult to achieve with conventional black filled compounds.

Example (%): VMX5015 = 73%, Vamac® Ultra IP = 27%, ADPA = 0.93%, Stearic Acid = 0.33%, Vanfre® VAM = 0.67%, Diak™ 1 = 0.67%, Alcanpoudre® DBU-70 =1.33% for a hardness (3s) of 62 Shore A.

Higher hardness compounds (>75 Sh A) may be achieve with addition of supplemental filler.

Figure 5 – **AEM Blends with VMX5000 Series for Lower Hardness**



# VMX5015 / VMX5020

Vamac® Ethylene Acrylic Elastomer Compound - Technical Data

## Compound Comparison of VMX5000 Grades (65-70 Shore A)

The following tables compares VMX5015 and VMX5020 versus a black filled Vamac® Ultra IP compound. Two variations of red colored compounds with VMX5020 are included. The later compound is a blend of VMX5020, and Vamac® Ultra LS with higher Diak™ 1 level.

Table 3 – **Comparison of VMX5000 Grades (65-70 Shore A)**

| Compound Formulation (phr) | Vamac® Ultra IP | VMX5015 | VMX5020 | VMX5020, red | VMX5020 / Ultra LS, red |
|---|---|---|---|---|---|
| Vamac® Ultra IP | 100 | 17.5 | 17.5 | 17.5 | |
| Vamac® Ultra LS | | | | | 17.5 |
| VMX5015 | | 150 | | | |
| VMX5020 | | | 150 | 150 | 150 |
| Alcanpoudre® ADPA 75 | | 1.5 | 1.5 | 1.5 | 1.5 |
| Naugard® 445 | 2 | | | | |
| Armeen® 18D PRILLS | 0.5 | | | | |
| Stearic Acid | 2 | 0.5 | 0.5 | 0.5 | 0.5 |
| Vanfre® VAM | 1 | 1 | 1 | 1 | 1 |
| Ultrasil® VN2 | | | | 10 | 10 |
| Alcanpoudre® A1100 70 | | | | 0.25 | 0.25 |
| Ferroxide 214 M | | | | 1.5 | 1.5 |
| Spheron™ SOA (N550) | 20 | | | | |
| Corax® N772 | 50 | | | | |
| MT Thermax® Floform N990 | | 20 | 20 | | |
| Alcanplast® PO 80 | 10 | 7 | 7 | 7 | 7 |
| Diak™ 1 | 1.4 | 0.9 | 0.9 | 0.8 | 0.9 |
| Vulcofac® ACT-55 | 2 | 2 | 2 | 2 | 2 |

# VMX5015 / VMX5020

Vamac® Ethylene Acrylic Elastomer Compound - Technical Data

Table 3 (continued) – **Comparison of VMX5000 Grades (65-70 Shore A)**

| Rheology | Vamac® Ultra IP | VMX5015 | VMX5020 | VMX5020, red | VMX5020 / Ultra LS, red |
|---|---|---|---|---|---|
| Mooney Viscosity ML 1+4 at 100°C (ISO 289-1:2005) | | | | | |
| Initial Mooney, MU | 70.8 | 87.0 | 70.7 | 89.7 | 89.8 |
| Final Mooney, MU | 49.2 | 56.2 | 45.6 | 47.5 | 49.8 |
| Slope, lg M/g s | -0.609 | -0.653 | -0.605 | -0.667 | -0.553 |
| Intercept Mooney, MU | 13.5 | 13.6 | 11.8 | 11.6 | 14.0 |
| MDR cure rate 15 minutes at 180°C, arc 0.5° (ISO 6502:1999) | | | | | |
| ML, dNm | 0.65 | 0.69 | 0.52 | 0.54 | 0.65 |
| MH, dNm | 16.45 | 15.03 | 12.40 | 13.28 | 12.19 |
| Ts1, min | 0.62 | 0.78 | 0.84 | 0.90 | 0.92 |
| Ts2, min | 0.86 | 1.03 | 1.14 | 1.24 | 1.30 |
| T10, min | 0.76 | 0.89 | 0.90 | 0.99 | 0.98 |
| T50, min | 2.46 | 2.58 | 2.56 | 3.00 | 3.10 |
| T90, min | 7.66 | 7.25 | 6.69 | 8.02 | 8.56 |
| T95, min | 9.99 | 9.18 | 8.53 | 10.02 | 10.63 |
| Tan delta at ML | 1.108 | 1.101 | 1.077 | 1.167 | 0.954 |
| Tan delta at MH | 0.009 | 0.045 | 0.047 | 0.047 | 0.049 |
| Peak rate, dNm/min | 6 | 6 | 5 | 5 | 4 |
| Mooney Scorch 45 min at 121°C (ISO 289-2:1994) | | | | | |
| Initial Mooney, MU | 27 | 41 | 30 | 29 | 32 |
| Minimum Mooney, MU | 17 | 20 | 17 | 17 | 19 |
| Ts1, min | 5.6 | 8.3 | 6.6 | 7.0 | 6.0 |
| Ts2, min | 7.0 | 9.9 | 7.8 | 8.2 | 6.9 |
| T5, min | 10.2 | 13.7 | 10.2 | 11.1 | 8.6 |
| T10, min | 13.7 | 17.4 | 12.6 | 14.0 | 10.6 |
| T35, min | 25.0 | 35.2 | 32.2 | 26.4 | 24.1 |
| Point rise at 30 min | | 31.5 | 33.9 | | |

# VMX5015 / VMX5020

Vamac® Ethylene Acrylic Elastomer Compound - Technical Data

Table 3 (continued) – **Comparison of VMX5000 Grades (65-70 Shore A)**

| Original Properties | Vamac® Ultra IP | VMX5015 | VMX5020 | VMX5020, red | VMX5020 / Ultra LS, red |
|---|---|---|---|---|---|
| Compression molding 10 minutes at 180°C / Post-cure 4 hours at 175°C | | | | | |
| Hardness (ISO 7619-1:2004) | | | | | |
| Hardness Shore A (3s), pts | 71.9 | 65.7 | 64.4 | 66.0 | 65.2 |
| Hardness Shore A (1s), pts | 73.5 | 67.9 | 66.2 | 67.7 | 67.2 |
| Tensile Properties (type 2) at 23°C | | | | | |
| Tensile Strength, MPa | 19.0 | 17.4 | 13.4 | 11.5 | 10.6 |
| Elongation at Break, % | 270 | 240 | 238 | 184 | 201 |
| 10% Modulus, MPa | 0.67 | 0.58 | 0.52 | 0.56 | 0.55 |
| 25% Modulus, MPa | 1.29 | 1.05 | 1.00 | 1.05 | 1.00 |
| 50% Modulus, MPa | 2.4 | 2.1 | 1.9 | 1.9 | 1.8 |
| 100% Modulus, MPa | 6.1 | 5.8 | 4.9 | 5.0 | 4.6 |
| 200% Modulus, MPa | 14.8 | 15.1 | 12.0 | | 10.7 |
| Trouser Tear, Propagation Direction: Mill (ISO 34-1:2004) | | | | | |
| Tear Strength (type A), kN/m | 5.5 | 2.6 | 2.9 | 2.6 | 2.8 |
| Tg, °C | -36.0 | -35.0 | -34.4 | -33.8 | -33.9 |
| | | | | | |
| Tensile Properties T2 at 150°C (ISO 37:2005, Cor 1 2008) | | | | | |
| Tensile Strength, MPa | 6.3 | 6.0 | 5.3 | 3.9 | 3.8 |
| Elongation at Break, % | 110 | 179 | 146 | 112 | 114 |
| 10% Modulus, MPa | 0.57 | 0.40 | 0.36 | 0.38 | 0.36 |
| 25% Modulus, MPa | 1.17 | 0.82 | 0.74 | 0.77 | 0.73 |
| 50% Modulus, MPa | 2.25 | 1.58 | 1.41 | 1.45 | 1.35 |
| 100% Modulus, MPa | 5.7 | 3.7 | 3.3 | 3.5 | 3.2 |

# VMX5015 / VMX5020

## Vamac® Ethylene Acrylic Elastomer Compound - Technical Data

The conventional carbon black reference AEM compound exhibits more hardening, and greater loss of properties than the VMX5000 compounds.

Table 3 (continued) – **Comparison of VMX5000 Grades (65-70 Shore A)**

| Heat Ageing | Vamac® Ultra IP | VMX5015 | VMX5020 | VMX5020, red | VMX5020 / Ultra LS, red |
|---|---|---|---|---|---|
| Heat Ageing 1008 hours at 150°C | | | | | |
| Hardness Shore A (3s), pts | 74.0 | 66.3 | 65.0 | 65.1 | 64.7 |
| Delta Hardness, pts | 2.2 | 0.6 | 0.4 | -0.7 | -0.7 |
| Tensile Strength, MPa | 16.6 | 12.4 | 9.3 | 10.1 | 10.1 |
| Delta Tensile Strength, % | -12.6 | -28.9 | -30.8 | -12.3 | -5.2 |
| Elongation at Break, % | 230 | 216 | 222 | 217 | 226 |
| Delta Elongation at Break, % | -14.8 | -10.0 | -6.7 | 17.9 | 12.4 |
| 50% Modulus, MPa | 3.0 | 2.3 | 2.0 | 2.4 | 2.0 |
| Delta 50% Modulus, % | 23.4 | 11.2 | 4.7 | 25.0 | 8.3 |
| 100% Modulus, MPa | 6.8 | 5.5 | 4.8 | 4.9 | 4.9 |
| Delta 100% Modulus, % | 11.7 | -5.6 | -2.3 | -2.0 | 7.9 |
| 200% Modulus, MPa | 14.9 | 12.0 | 9.2 | 9.9 | 9.6 |
| Delta 200% Modulus, % | 0.9 | -20.2 | -22.8 | | -10.5 |
| | | | | | |
| Heat Ageing 1008 hours at 175°C | | | | | |
| Hardness Shore A (3s), pts | 93.3 | 61.8 | 62.6 | 62.5 | 63.5 |
| Delta Hardness, pts | 21.4 | -3.8 | -1.8 | -3.2 | -1.9 |
| Tensile Strength, MPa | 9.4 | 12.1 | 11.4 | 9.9 | 9.1 |
| Delta Tensile Strength, % | -50.5 | -30.2 | -15.0 | -14.3 | -13.9 |
| Elongation at Break, % | 37 | 175 | 158 | 140 | 127 |
| Delta Elongation at Break, % | -86.3 | -27.1 | -33.6 | -23.9 | -36.8 |
| 50% Modulus, MPa | | 1.6 | 1.7 | 1.4 | 1.6 |
| Delta 50% Modulus, % | | -24.8 | -13.1 | -26.0 | -11.1 |
| 100% Modulus, MPa | | 5.2 | 5.6 | 5.4 | 5.8 |
| Delta 100% Modulus, % | | -10.1 | 14.8 | 8.4 | 27.5 |

# VMX5015 / VMX5020

## Vamac® Ethylene Acrylic Elastomer Compound - Technical Data

Long term compression set at 160 to 170°C is lower for the VMX5000 compounds, and less impacted over time when cooled in the clamps compared to the black reference AEM compound. VW compression set can be made lower than what is shown for this study using higher Diak™ 1. VMX5015 is best among the VMX5000 series in VW compression set.

Table 3 (continued) – **Comparison of VMX5000 Grades (65-70 Shore A)**

| **Compression Set** | Vamac® Ultra IP | VMX5015 | VMX5020 | VMX5020, red | VMX5020 / Ultra LS, red |
|---|---|---|---|---|---|
| Compression Set – type B (ISO 815-1:2008) | | | | | |
| 70 hours / 150°C, % | 21.5 | 22.6 | 25.1 | 28.0 | 30.5 |
| 504 hours / 160°C, % | 49.1 | 41.1 | 40.6 | 45.3 | 48.0 |
| 1008 hours / 160°C, % | 58.0 | 45.0 | 44.8 | 49.3 | 52.9 |
| 504 hours / 170°C, % | 52.3 | 47.9 | 47.1 | 51.3 | 53.9 |
| 504 hours / 180°C, % | 56.3 | 54.2 | 54.0 | 56.0 | 60.5 |
| Compression Set – type B (ISO 815-1:2008), cooled in clamps for 2h | | | | | |
| 24h / 150°C, % | 22.7 | 30.6 | 32.8 | 36.4 | 37.3 |
| 1008h / 150°C, % | 58.7 | 53.6 | 53.5 | 59.0 | 61.5 |
| | | | | | |
| Compression Set VW (PV 3307:2004-08), 72 hours at 23°C | | | | | |
| at 5 seconds, % | 24.8 | 35.6 | 45.0 | 47.0 | 48.1 |
| at 30 minutes, % | 8.4 | 7.5 | 9.4 | 10.5 | 10.3 |
| Compression Set VW (PV 3307:2004-08), 22 hours at 150°C | | | | | |
| at 5 seconds, % | 46.2 | 60.5 | 69.7 | 73.8 | 71.8 |
| at 30 minutes, % | 30.1 | 32.8 | 40.3 | 46.8 | 45.7 |
| Deflection, % | 51 | 50 | 49 | 50 | 49 |

# VMX5015 / VMX5020

Vamac® Ethylene Acrylic Elastomer Compound - Technical Data

Table 3 (continued) – **Comparison of VMX5000 Grades (65-70 Shore A)**

| **Fluid Ageing: Engine Oil** | Vamac® Ultra IP | VMX5015 | VMX5020 | VMX5020, red | VMX5020 / Ultra LS, red |
|---|---|---|---|---|---|
| Ageing 1008 hours at 150°C, Aeroshell Oil Diesel Ultra, 5W-30 | | | | | |
| Compression Set – type B (ISO 815-1:2008), cooled in clamps for 2h | | | | | |
| CSet, (1008h / 150°C), % | 46.6 | 48.0 | 51.3 | 52.8 | 58.8 |
| | | | | | |
| Hardness Shore A (3s), pts | 72.5 | 62.0 | 60.2 | 63.2 | 63.1 |
| Delta Hardness, pts | 0.8 | -3.8 | -4.1 | -2.7 | -2.1 |
| Tensile Strength, MPa | 13.5 | 15.3 | 12.2 | 11.8 | 12.5 |
| Delta Tensile Strength, % | -28.9 | -12.2 | -9.1 | 2.5 | 17.6 |
| Elongation at Break, % | 139 | 174 | 173 | 154 | 154 |
| Delta Elongation at Break, % | -48.5 | -27.5 | -27.3 | -16.3 | -23.4 |
| 25% Modulus, MPa | 1.8 | 1.1 | 1.0 | 1.1 | 1.1 |
| Delta 25% Modulus, % | 37.2 | 1.0 | 3.0 | 1.0 | 13.0 |
| 50% Modulus, MPa | 3.5 | 2.5 | 2.2 | 2.2 | 2.4 |
| Delta 50% Modulus, % | 44.8 | 18.9 | 13.1 | 15.6 | 31.5 |
| 100% Modulus, MPa | 9.1 | 7.1 | 5.8 | 6.4 | 6.9 |
| Delta 100% Modulus, % | 49.8 | 22.9 | 19.8 | 26.9 | 49.6 |
| Weight Change, % | 3.8 | 5.4 | 4.4 | 5.6 | 3.8 |
| Volume Change, % | 6.7 | 7.4 | 6.1 | 7.7 | 5.5 |

# VMX5015 / VMX5020

Vamac® Ethylene Acrylic Elastomer Compound - Technical Data

Table 3 (continued) – **Comparison of VMX5000 Grades (65-70 Shore A)**

| **Fluid Ageing: Reference Oil** | Vamac® Ultra IP | VMX5015 | VMX5020 | VMX5020, red | VMX5020 / Ultra LS, red |
|---|---|---|---|---|---|
| Ageing 1008 h, 150°C, Lubrizol OS 206304 | | | | | |
| Compression Set – type B (ISO 815-1:2008), cooled in clamps for 2h | | | | | |
| CSet, (1008h / 150°C), % | 31.1 | 36.0 | 38.2 | 41.3 | 48.4 |
| | | | | | |
| Hardness Shore A (3s), pts | 67.9 | 58.6 | 57.8 | 59.2 | 59.3 |
| Delta Hardness, pts | -3.9 | -7.1 | -6.6 | -6.6 | -5.9 |
| Tensile Strength, MPa | 17.3 | 15.4 | 12.4 | 10.6 | 11.3 |
| Delta Tensile Strength, % | -8.8 | -11.2 | -7.1 | -7.6 | 6.6 |
| Elongation at Break, % | 173 | 181 | 188 | 147 | 151 |
| Delta Elongation at Break, % | -35.9 | -24.6 | -21.0 | -20.1 | -24.9 |
| 25% Modulus, MPa | 1.4 | 0.8 | 0.9 | 0.9 | 0.9 |
| Delta 25% Modulus, % | 10.1 | -20.0 | -13.0 | -10.5 | -10.0 |
| 50% Modulus, MPa | 3.1 | 2.0 | 1.9 | 2.1 | 2.0 |
| Delta 50% Modulus, % | 29.3 | -2.4 | 1.6 | 7.3 | 11.1 |
| 100% Modulus, MPa | 8.5 | 6.4 | 5.5 | 6.2 | 6.1 |
| Delta 100% Modulus, % | 40.0 | 11.3 | 12.8 | 22.9 | 33.0 |
| Weight Change, % | 9.3 | 11.7 | 11.2 | 11.7 | 9.5 |
| Volume Change, % | 13.9 | 14.7 | 14.0 | 14.9 | 12.5 |

# VMX5015 / VMX5020

Vamac® Ethylene Acrylic Elastomer Compound - Technical Data

Table 3 (continued) – **Comparison of VMX5000 Grades (65-70 Shore A)**

| **Fluid Ageing:** **Reference Oil + 10% FAM-B** | Vamac® Ultra IP | VMX5015 | VMX5020 | VMX5020, red | VMX5020 / Ultra LS, red |
|---|---|---|---|---|---|
| Fluid ageing 168 hours at 150°C in Lubrizol® OS 206304 +10% FAM-B (ISO 1817:2011) in Autoclave | | | | | |
| Hardness Shore A (3s), pts | 59.8 | 55.2 | 52.4 | 52.8 | 52.5 |
| Delta Hardness, pts | -12.1 | -10.6 | -12.2 | -12.9 | -12.4 |
| Tensile Strength, MPa | 13.2 | 14.0 | 10.5 | 8.6 | 8.0 |
| Delta Tensile Strength, % | -30.3 | -19.3 | -21.5 | -25.2 | -25.0 |
| Elongation at Break, % | 190 | 193 | 195 | 145 | 149 |
| Delta Elongation at Break, % | -29.6 | -19.6 | -18.1 | -21.2 | -25.9 |
| 10% Modulus, MPa | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| Delta 10% Modulus, % | -49.3 | -41.4 | -44.2 | -42.9 | -40.0 |
| 25% Modulus, MPa | 0.9 | 0.8 | 0.7 | 0.7 | 0.7 |
| Delta 25% Modulus, % | -32.6 | -28.6 | -35.0 | -33.3 | -30.0 |
| 50% Modulus, MPa | 2.1 | 1.7 | 1.4 | 1.6 | 1.5 |
| Delta 50% Modulus, % | -13.0 | -17.0 | -24.6 | -18.2 | -17.7 |
| 100% Modulus, MPa | 6.2 | 5.1 | 4.1 | 4.8 | 4.3 |
| Delta 100% Modulus, % | 2.3 | -12.0 | -16.1 | -5.0 | -6.6 |
| 200% Modulus, MPa | | | 10.9 | | |
| Delta 200% Modulus, % | | | -8.7 | | |
| Weight Change, % | 12.5 | 12.4 | 11.8 | 14.6 | 12.6 |
| Volume Change, % | 20.2 | 17.7 | 17.0 | 20.5 | 17.9 |

# VMX5015 / VMX5020

Vamac® Ethylene Acrylic Elastomer Compound - Technical Data

Table 3 (continued) – **Comparison of VMX5000 Grades (65-70 Shore A)**

| **Fluid Ageing: Blow-By Condensate** | Vamac® Ultra IP | VMX5015 | VMX5020 | VMX5020, red | VMX5020 / Ultra LS, red |
|---|---|---|---|---|---|
| Fluid ageing 24 hours at 120°C in Blow-By Condensate (ISO 1817:2011), in Autoclave | | | | | |
| Hardness Shore A (3s), pts | 69.1 | 62.8 | 59.8 | 64.6 | 61.8 |
| Delta Hardness, pts | -2.6 | -2.9 | -4.3 | -1.4 | -3.4 |
| Tensile Strength, MPa | 14.5 | 12.9 | 11.6 | 10.8 | 9.5 |
| Elongation at Break, % | 253 | 239 | 238 | 208 | 194 |
| 50% Modulus, MPa | 2.3 | 1.6 | 1.5 | 1.5 | 1.4 |
| 100% Modulus, MPa | 5.8 | 3.7 | 3.5 | 3.7 | 3.6 |
| Weight Change, % | 0.6 | 5.2 | 5.8 | | |
| Volume Change, % | 0.7 | 6.1 | 6.9 | | |
| | | | | | |
| Drying - Blow-By Condensate, BMW - GS 97018 | | | | | |
| Hardness Shore A (3s), pts | 70.1 | 66.8 | 63.9 | 66.5 | 66.5 |
| Delta Hardness, pts | -1.8 | 1.2 | -0.5 | 0.7 | 1.3 |
| Tensile Strength, MPa | 18.5 | 16.6 | 13.9 | 11.5 | 12.4 |
| Elongation at Break, % | 259 | 238 | 235 | 199 | 196 |
| 50% Modulus, MPa | 2.6 | 2.0 | 1.7 | 1.9 | 2.0 |
| 100% Modulus, MPa | 6.9 | 4.9 | 4.3 | 4.7 | 5.2 |
| Weight Change, % | -0.2 | 0.1 | 0.1 | -0.5 | -0.6 |
| Volume Change, % | 0.0 | 0.0 | 0.2 | -0.8 | -0.9 |

# VMX5015 / VMX5020

Vamac® Ethylene Acrylic Elastomer Compound - Technical Data

Table 3 (continued) – **Comparison of VMX5000 Grades (65-70 Shore A)**

| **Fluid Ageing: AdBlue® (32% Urea Solution in Water)** | **Vamac® Ultra IP** | **VMX5015** | **VMX5020** |
|---|---|---|---|
| Fluid ageing 168 hours at 130°C in Adblue® (registered trademark of BASF) ISO 1817:2011, in Autoclave | | | |
| Hardness Shore A (3s), pts | 61.8 | 65.4 | 60.9 |
| Delta Hardness, pts | -10.1 | -0.3 | -3.5 |
| Tensile Strength, MPa | 18.3 | 12.7 | 11.8 |
| Delta Tensile Strength, % | -3.3 | -27.0 | -11.7 |
| Elongation at Break, % | 202 | 343 | 386 |
| Delta Elongation at Break, % | -25.2 | 42.9 | 62.2 |
| 50% Modulus, MPa | 2.9 | 2.4 | 2.0 |
| Delta 50% Modulus, % | 23.0 | 18.0 | 5.2 |
| 100% Modulus, MPa | 8.3 | 4.5 | 3.4 |
| Delta 100% Modulus, % | 36.7 | -22.9 | -29.6 |
| Weight Change, % | 33.1 | 25.0 | 29.1 |
| Volume Change, % | 35.8 | 24.9 | 29.3 |

# VMX5015 / VMX5020

Vamac® Ethylene Acrylic Elastomer Compound - Technical Data

## Higher Hardness Compounds – 70 to 80 Shore A

Formulating VMX5000 pre-compounds with additional filler allows for producing higher hardness compounds. The following study is made to further show the effect of carbon black filler type and level on VMX5015, and VMX5020 compounds, and compared with conventional black-filled AEM compounds for applications like bonded piston seals.

Table 4 – **Higher Hardness Compounds with Added Carbon Black**

| Compound Formulation | G | G / GLS | IP / GXF | IP / GLS | IP / LS | 5015, FEF | 5020, FEF | 5020, SRF | 5020, MT | 5020, low MT high Diak |
|---|---|---|---|---|---|---|---|---|---|---|
| Vamac® G | 100 | 50 | | | | | | | | |
| Vamac® GLS | | 50 | | 50 | | | | | | |
| Vamac® GXF | | | 50 | | | | | | | |
| Vamac® Ultra IP | | | 50 | 50 | 50 | | | | | |
| Vamac® Ultra LS | | | | | 50 | | | | | |
| VMX5015 | | | | | | 182 | | | | |
| VMX5020 | | | | | | | 182 | 182 | 182 | 182 |
| Alcanpoudre® ADPA 75 | | | | | | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| Naugard® 445 | 2 | 2 | 2 | 2 | 2 | | | | | |
| Armeen® 18D PRILLS | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | | | | | |
| Stearic Acid Reagent | 2 | 2 | 2 | 2 | 2 | | | | | |
| Vanfre® VAM | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Spheron™ SOA (N550) | 25 | 25 | 25 | 25 | 25 | 15 | 15 | | | |
| Corax® N772 | 60 | 60 | 60 | 60 | 60 | | | 20 | | |
| MT Thermax® N990 | | | | | | | | | 25 | 15 |
| Alcanplast® PO 80 | 10 | 10 | 10 | 10 | 10 | 7 | 7 | 7 | 7 | 7 |
| Diak™ no 1 | 1.5 | 1.5 | 1.5 | 1.5 | 1.3 | 0.9 | 0.9 | 0.9 | 0.9 | 1.2 |

# VMX5015 / VMX5020

## Vamac® Ethylene Acrylic Elastomer Compound - Technical Data

No scorch retarder was added to the VMX5000 compounds for this study. The addition of Armeen® 18D (stearyl amine) would reduce viscosity, lower scorch times, and slow cure speed.

Table 4 (continued) – **Higher Hardness Compounds with Added Carbon Black**

| Rheology | G | G / GLS | IP / GXF | IP / GLS | IP / LS | 5015, FEF | 5020, FEF | 5020, SRF | 5020, MT | 5020, low MT high Diak |
|---|---|---|---|---|---|---|---|---|---|---|
| Mooney, ML 1+4 at 100°C | | | | | | | | | | |
| Initial Mooney, MU | 61.7 | 63.1 | 78.6 | 76.3 | 91.9 | 121.3 | 90.9 | 112.1 | 99.9 | 95.4 |
| Final Mooney, MU | 42.7 | 41.2 | 55.1 | 54.0 | 62.3 | 76.8 | 60.3 | 60.7 | 58.6 | 53.7 |
| MDR, 12 min, 180°C, arc 0.5° | | | | | | | | | | |
| ML, dNm | 0.63 | 0.65 | 0.82 | 0.84 | 0.97 | 1.02 | 0.74 | 0.79 | 0.74 | 0.59 |
| MH, dNm | 15.91 | 15.04 | 16.83 | 16.93 | 16.82 | 17.85 | 15.29 | 14.65 | 13.95 | 15.99 |
| Ts1, min | 0.58 | 0.56 | 0.64 | 0.55 | 0.58 | 0.76 | 0.80 | 0.82 | 0.81 | 0.90 |
| Ts2, min | 0.82 | 0.78 | 0.92 | 0.76 | 0.80 | 1.00 | 1.08 | 1.10 | 1.11 | 1.25 |
| T10, min | 0.70 | 0.66 | 0.81 | 0.68 | 0.71 | 0.94 | 0.94 | 0.92 | 0.91 | 1.09 |
| T50, min | 2.25 | 2.08 | 2.84 | 2.14 | 2.27 | 2.94 | 2.76 | 2.76 | 2.66 | 3.51 |
| T90, min | 6.67 | 6.85 | 8.06 | 6.93 | 7.17 | 8.20 | 6.86 | 7.03 | 6.69 | 8.86 |
| Tan delta at MH | 0.043 | 0.049 | 0.056 | 0.048 | 0.057 | 0.081 | 0.078 | 0.080 | 0.082 | 0.063 |
| Peak rate, dNm/min | 6 | 6 | 5 | 7 | 6 | 6 | 5 | 5 | 5 | 4 |
| Mooney Scorch 45 min at 121°C | | | | | | | | | | |
| Initial Mooney, MU | 23 | 21 | 29 | 26 | 32 | 47 | 35 | 39 | 38 | 37 |
| Minimum Mooney, MU | 16 | 15 | 19 | 19 | 22 | 27 | 22 | 23 | 22 | 20 |
| Ts1, min | 4.5 | 4.5 | 5.9 | 4.7 | 5.5 | 7.8 | 5.8 | 6.0 | 5.9 | 7.1 |
| Ts2, min | 5.6 | 5.4 | 7.3 | 5.7 | 6.8 | 9.4 | 6.7 | 6.8 | 6.7 | 8.2 |
| T5, min | 7.9 | 7.4 | 10.7 | 7.8 | 9.8 | 13.2 | 8.8 | 8.6 | 8.3 | 10.5 |
| T10, min | 10.5 | 9.7 | 14.9 | 10.4 | 13.3 | 17.7 | 11.0 | 10.6 | 10.2 | 13.2 |

# VMX5015 / VMX5020

Vamac® Ethylene Acrylic Elastomer Compound - Technical Data

Hardness of VMX5000 compounds may be adjusted by varying the addition of carbon black, and carbon black type. The VMX5000 series exhibit significantly lower IRHD hardness than conventional carbon black filled AEM compounds, especially VMX5020.

Table 4 (continued) – **Higher Hardness Compounds with Added Carbon Black**

| Original Properties | G | G / GLS | IP / GXF | IP / GLS | IP / LS | 5015, FEF | 5020, FEF | 5020, SRF | 5020, MT | 5020, low MT High Diak |
|---|---|---|---|---|---|---|---|---|---|---|
| Compression Molding 10 minutes at 180°C, Post-cure 4 hours at 175°C | | | | | | | | | | |
| Initial Specific Gravity, g/cm$^3$ | 1.27 | 1.28 | 1.27 | 1.28 | 1.28 | 1.12 | 1.12 | 1.13 | 1.14 | 1.12 |
| Hardness Sh A (1s), pts | 80.3 | 81.5 | 81.1 | 80.5 | 80.8 | 79.1 | 73.6 | 74.4 | 72.8 | 72.1 |
| Hardness Sh A (3s), pts | 79.3 | 80.4 | 80.1 | 79.8 | 79.7 | 77.7 | 72.0 | 72.8 | 71.1 | 70.6 |
| Hardness IRHD (Method N, ISO48:2007) | 79.5 | 79.5 | 80.7 | 80.0 | 79.8 | 74.9 | 68.2 | 68.9 | 67.0 | 67.5 |
| Tensile properties (type 2) at 23°C, ISO 37:2005 Cor 1 2008 | | | | | | | | | | |
| Tensile Strength, MPa | 16.4 | 16.4 | 17.3 | 16.7 | 17.7 | 18.6 | 14.7 | 14.8 | 15.0 | 18.3 |
| Elongation at Break, % | 179 | 174 | 203 | 184 | 230 | 190 | 199 | 194 | 231 | 207 |
| 10% Modulus, MPa | 1.2 | 1.1 | 1.0 | 1.2 | 1.1 | 0.9 | 0.8 | 0.8 | 0.7 | 0.7 |
| 25% Modulus, MPa | 2.2 | 2.1 | 1.9 | 2.3 | 2.1 | 1.9 | 1.5 | 1.6 | 1.5 | 1.6 |
| 50% Modulus, MPa | 4.2 | 4.0 | 3.4 | 4.4 | 3.7 | 4.0 | 3.1 | 3.1 | 2.9 | 3.1 |
| 100% Modulus, MPa | 9.3 | 9.3 | 8.3 | 9.8 | 8.4 | 9.5 | 7.4 | 7.4 | 6.6 | 7.6 |
| Tear Strength type A - Trouser test pieces (Tear propagation direction: mill), ISO 34-1:2004 | | | | | | | | | | |
| Tear Strength, kN/m | 5.4 | 4.2 | 4.8 | 5.6 | 5.2 | 5.7 | 4.0 | 3.5 | 4.2 | 4.4 |

# VMX5015 / VMX5020

Vamac® Ethylene Acrylic Elastomer Compound - Technical Data

Table 4 (continued) – **Higher Hardness Compounds with Added Carbon Black**

| Compression Set | G | G / GLS | IP / GXF | IP / GLS | IP / LS | 5015, FEF | 5020, FEF | 5020, SRF | 5020, MT | 5020, low MT high DIAK |
|---|---|---|---|---|---|---|---|---|---|---|
| Compression Set, ISO 815-1, type B | | | | | | | | | | |
| 70 h at 150°C, % | 26 | 31 | 24 | 27 | 25 | 25 | 27 | 27 | 33 | 25 |
| 504 h at 160°C, % | 49 | 52 | 49 | 49 | 50 | 43 | 44 | 42. | 42 | 37 |
| 504 h at 170°C, % | 56 | 55 | 52 | 50 | 50 | 51 | 52 | 51 | 50 | 46 |
| 504 h at 180°C, % | 66 | 69 | 62 | 62 | 61 | 61 | 61 | 60 | 57 | 57 |
| 504 h at 190°C, % | 86 | 88 | 81 | 79 | 78 | 70 | 70 | 71 | 70 | 67 |
| Compression Set, ISO 815-1:2008 (DBL 6038), plied – cooled in the clamps 2h | | | | | | | | | | |
| 1008 h at 150°C, % | 67 | 69 | 62 | 64 | 66 | 48 | 48 | 47 | 47 | 40 |
| | | | | | | | | | | |
| Compression Set VW (PV 3307:2004-08), 22h at 150°C | | | | | | | | | | |
| after 5 sec, % | 41 | 48 | 43 | 44 | 41 | 49 | 62 | 65 | 59 | 43 |
| after 30 min, % | 31 | 35 | 29 | 36 | 28 | 28 | 38 | 40 | 33 | 26 |
| Compression Set VW (PV 3307:2004-08), 72h at 23°C | | | | | | | | | | |
| after 5 sec, % | 28 | 32 | 25 | 28 | 31 | 36 | 43 | 45 | 42 | 26 |
| after 30 min, % | 10 | 11 | 9 | 10 | 11 | 8 | 10 | 10 | 4 | 7 |

# VMX5015 / VMX5020

## Vamac® Ethylene Acrylic Elastomer Compound - Technical Data

Six-week air oven ageing of VMX5000 compounds show significantly less change in hardness, and loss in elongation than carbon black filled AEM compounds.

Table 4 (continued) – **Higher Hardness Compounds with Added Carbon Black**

| Heat Ageing | G | G / GLS | IP / GXF | IP / GLS | IP / LS | 5015, FEF | 5020, FEF | 5020, SRF | 5020, MT | 5020, low MT high Diak |
|---|---|---|---|---|---|---|---|---|---|---|
| Heat Ageing 1008 h at 150°C (ISO 188:2007) | | | | | | | | | | |
| Hardness Shore A (1s), pts | 85.4 | 88.6 | 85.5 | 87.0 | 85.9 | 77.5 | 74.0 | 73.8 | 72.5 | 72.9 |
| Delta Hardness, pts | 5.2 | 6.8 | 4.6 | 6.5 | 5.3 | -1.9 | 0.1 | -0.7 | -0.6 | 0.4 |
| Tensile Strength, MPa | 14.2 | 13.6 | 14.9 | 13.6 | 15.2 | 10.0 | 8.1 | 9.0 | 9.0 | 8.9 |
| Delta Tensile Strength, % | -13 | -17 | -14 | -19 | -14 | -47 | -45 | -41 | -38 | -52 |
| Elongation at Break, % | 145 | 134 | 163 | 140 | 178 | 174 | 213 | 189 | 192 | 206 |
| Delta Elongation at Break, % | -19 | -23 | -20 | -24 | -23 | -8 | 7 | -3 | -17 | 0 |
| 25% Modulus, MPa | 3.2 | 3.5 | 2.7 | 3.4 | 2.9 | 1.8 | 1.5 | 1.5 | 1.4 | 1.3 |
| Delta 25% Modulus, % | 43 | 65 | 45 | 47 | 38 | -6 | -5 | -9 | -7 | -17 |
| 100% Modulus, MPa | 10.5 | 11.0 | 9.9 | 10.6 | 9.9 | 7.9 | 6.6 | 6.8 | 6.1 | 5.8 |
| Delta 100% Modulus, % | 13 | 19 | 19 | 8 | 18 | -16 | -10 | -8 | -8 | -23 |
| Heat Ageing 1008 h at 175°C (ISO 188:2007) | | | | | | | | | | |
| Hardness Shore A (1s), pts | 97.0 | 96.5 | 97.2 | 97.0 | 95.4 | 74.3 | 71.2 | 70.1 | 69.2 | 69.3 |
| Delta Hardness, pts | 16.8 | 14.9 | 16.1 | 16.5 | 14.0 | -5.1 | -2.3 | -4.3 | -3.7 | -3.2 |
| Tensile Strength, MPa | 0.22 | 0.22 | 1.23 | 0.09 | 0.17 | 13.4 | 12.4 | 12.1 | 10.2 | 10.3 |
| Delta Tensile Strength, % | -99 | -99 | -93 | -100 | -99 | -28 | -16 | -18 | -32 | -44 |
| Elongation at Break, % | 0 | 0 | 0 | 0 | 0 | 144 | 137 | 128 | 123 | 129 |
| Delta Elongation at Break, % | -100 | -100 | -100 | -100 | -100 | -24 | -31 | -34 | -47 | -38 |
| 25% Modulus, MPa | | | | | | 1.0 | 0.94 | 1.04 | 0.84 | 0.85 |
| Delta 25% Modulus, % | | | | | | -48 | -39 | -36 | -43 | -45 |
| 100% Modulus, MPa | | | | | | 8.2 | 8.0 | 8.3 | 7.4 | 7.1 |
| Delta 100% Modulus, % | | | | | | -13 | 8 | 12 | 11 | -7 |

# VMX5015 / VMX5020

## Vamac® Ethylene Acrylic Elastomer Compound - Technical Data

Table 4 (continued) – **Higher Hardness Compounds with Added Carbon Black**

| Fluid Ageing | G | G / GLS | P / GXF | IP / GLS | IP / LS | 5015, FEF | 5020, FEF | 5020, SRF | 5020, MT | 5020, low MT high Diak |
|---|---|---|---|---|---|---|---|---|---|---|
| Fluid Ageing, 1008 h at 150°C in Petro Dexron® VI RDL 3434 | | | | | | | | | | |
| Hardness Shore A (1s), pts | 81.5 | 86.9 | 80.1 | 86.3 | 84.1 | 71.7 | 68.4 | 68.1 | 67.2 | 68.1 |
| Delta Hardness, pts | 1.3 | 5.4 | -1.0 | 6.3 | 3.3 | -7.4 | -5.1 | -6.3 | -5.5 | -4.4 |
| Tensile Strength, MPa | 15.3 | 14.3 | 15.8 | 15.1 | 17.5 | 14.1 | 11.8 | 11.8 | 11.8 | 11.0 |
| Delta Tensile Strength, % | -6.9 | -12.8 | -9.0 | -9.6 | -1.4 | -24.5 | -19.7 | -20.4 | -21.4 | -40.0 |
| Elongation at Break, % | 93 | 76 | 118 | 77 | 121 | 139 | 140 | 127 | 153 | 155 |
| Delta Elongation at Break, % | -48.0 | -56.3 | -41.9 | -58.2 | -47.4 | -26.8 | -29.7 | -34.5 | -33.8 | -25.1 |
| 10% Modulus, MPa | 1.3 | 2.0 | 1.2 | 2.0 | 1.7 | 0.6 | 0.5 | 0.5 | 0.5 | 0.5 |
| Delta 10% Modulus, % | 16.5 | 87.2 | 16.8 | 65.0 | 48.3 | -38.0 | -34.6 | -39.0 | -32.9 | -33.8 |
| 100% Modulus, MPa | | | 12.9 | | 14.3 | 10.4 | 8.4 | 8.9 | 7.4 | 7.1 |
| Delta 100% Modulus, % | | | 54.8 | | 71.3 | 9.7 | 14.8 | 20.6 | 10.8 | -6.1 |
| Weight Change, % | 7.8 | 5.0 | 8.5 | 5.0 | 5.2 | 9.2 | 9.3 | 8.6 | 8.5 | 8.9 |
| Volume Change, % | 11.4 | 7.4 | 12.5 | 7.6 | 7.9 | 11 | 11.5 | 10.7 | 10.8 | 10.2 |
| | | | | | | | | | | |
| Fluid Ageing, 1008 h at 150°C in Pentosin® FFL-5 LV | | | | | | | | | | |
| Hardness, Shore A (1s), pts | 85 | 87.6 | 85.8 | 88.7 | 88.6 | 76.6 | 73.5 | 72.8 | 72.8 | 73.6 |
| Delta Hardness, pts | 4.5 | 6.0 | 4.7 | 8.2 | 7.9 | -2.7 | 0 | -1.4 | -0.1 | 1.0 |
| Tensile Strength, MPa | 16.3 | 15.5 | 15.6 | 16.5 | 17.1 | 13.5 | 11.2 | 12.4 | 11.6 | 10.6 |
| Delta Tensile Strength, % | -0.7 | -5.5 | -9.7 | -0.8 | -3.8 | -27.5 | -24.0 | -16.2 | -22.7 | -42.0 |
| Elongation at Break, % | 83 | 84 | 102 | 83 | 108 | 167 | 184 | 137 | 178 | 193 |
| Delta Elongation at Break, % | -53.6 | -51.7 | -49.8 | -54.9 | -53.0 | -12.1 | -7.5 | -29.4 | -22.9 | -6.8 |
| 10% Modulus, MPa | 2.3 | 2.5 | 1.9 | 2.8 | 2.2 | 0.7 | 0.7 | 0.8 | 0.6 | 0.6 |
| Delta 10% Modulus, % | 99.1 | 127.5 | 91.1 | 129.2 | 93.0 | -19.6 | -9.0 | -8.5 | -12.3 | -16.2 |
| 100% Modulus, MPa | | | | 10.7 | 15.3 | 10.6 | 8.5 | 9.9 | 7.8 | 7.8 |
| Delta 100% Modulus, % | | | | 9.1 | 83.6 | 11.5 | 15.4 | 33.6 | 18.1 | 2.6 |
| Weight Change, % | 4.4 | 2.3 | 4.5 | 2.8 | 1.6 | 5.9 | 4.9 | 6.2 | 5.5 | 6.3 |
| Volume Change, % | 6.3 | 3.3 | 6.8 | 3.9 | 2.7 | 7.2 | 6.1 | 7.2 | 6.5 | 7.0 |