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Vamac® VMX5020 65-70 Shore A (PRELIMINARY)

Ethylene Methylacrylate Elastomer

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 aging 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 aging resistance compared to mineral filled AEM compounds.

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.

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)

*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

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

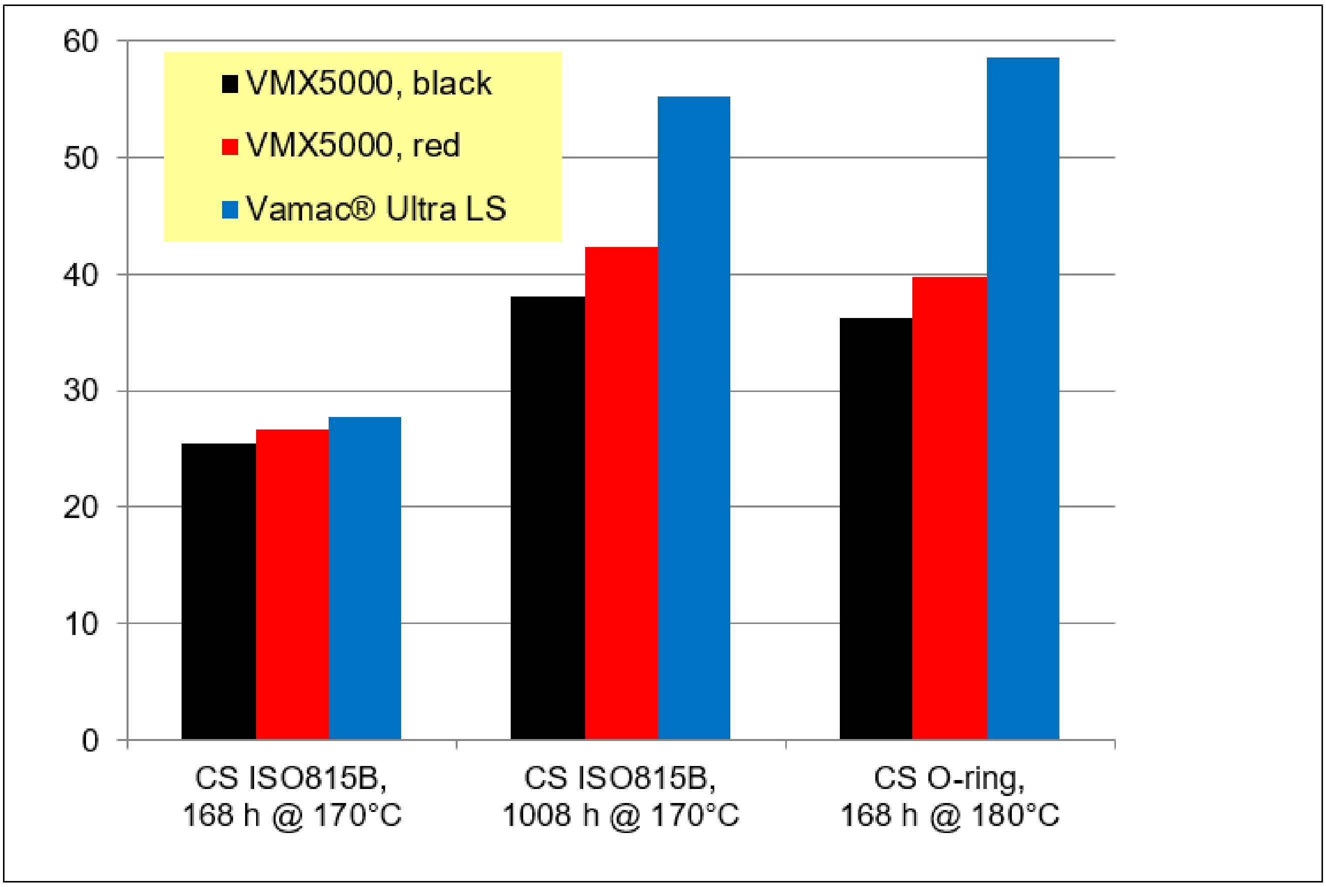
- at 160°C from 1800 hours up to 3600 hours (2 x)
- at 175°C from 504 hours up to 1680 hours (3.3 x)
- at 185°C from 168 hours up to 750 hours (4.5 x)

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 aging 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 aging properties.



Compound and Vulcanizate Properties

Compounds of Vamac® are formulated and processed by customers to meet their own specific performance requirements. Many of the highest-performing compounds are vulcanizates of Vamac® are proprietary, and cannot be published. We have

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independently formulated a wide variety of Vamac® compounds for its own short- and long-term properties testing programs.

A typical compound of Vamac® VMX5020 for low hardness is reviewed below. Vulcanizate performance test data are given to help endusers evaluate the potential fitness of similar compounds for their own applications.

Sample Compound, Vamac® VMX5020 lower hardness

Ingredients	Parts
Vamac® VMX5020	150
Vamac® Ultra IP	17.5
Vanfre® VAM	1
Stearic Acid Reagent	0.5
Alcanpoudre® ADPA 75	1.5
Diak™ 1	0.9
MT Thermax® Floform N990	20
Alcanplast® PO 80	7
Vulcofac® ACT-55	2

Product information

Colour	White[1]		
Viscosity, Mooney, ML 1'+4' at 100°C	43		ISO 289-1-2
Maximum Service Temperature	185	°C	

[1]: color may variate between white and pink

Rheological properties

Viscosity, Mooney, compound, ML 1'+4' at 100°C	46		ISO 289-1-2
Scorch, Mooney viscosity, MS at 121°C	≥30		ISO 289-1-2
Scorch, time to 10 unit rise, MS at 121°C	13	min	ISO 289-1-2
Moving Die Rheometer at 180°C, torque	52 - 1200	Nmm	ISO 6502
Moving Die Rheometer at 180°C, t(50)	2.6	min	ISO 6502
Moving Die Rheometer at 180°C, t(90)	6.7	min	ISO 6502

Cure conditions

Cure time	10	min
Cure temperature	180	°C
Post cure time	4	h
Post cure temperature	175	°C

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Typical mechanical properties

Tensile stress at 100% strain	4.9	MPa	ISO 527-1/-2
Tensile stress at break	13	MPa	ISO 527-1/-2
Tensile strain at break	240	%	ISO 527-1/-2
Shore A hardness, 3s	64		ISO 48-4 / ISO 868
Compression set, 150°C, 70h	25	%	ISO 815
Tear strength, parallel	2.9	kN/m	ISO 34-1

Thermal properties

Glass transition temperature, 10°C/min	-34[2]	°C	ASTM D 3418

[2]: Tg of compounds with Vamac® may be extended typically 10°C lower with the addition of plasticizer.

Physical/Other properties

Density	1070	kg/m^3	ISO 1183

Characteristics

Processing	Injection Moulding
Delivery form	Bale
Special characteristics	Heat stabilised or stable to heat, Colourable

Additional information

Injection molding

Handling Precautions

Because VMX5020 contains 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 bulletin, Safe Handling and Processing of Vamac®.

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 1 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 1 –Starting Recipes for VMX5000

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Ethylene Methylacrylate Elastomer

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

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 aging, 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.

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 VMX5000 / 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.

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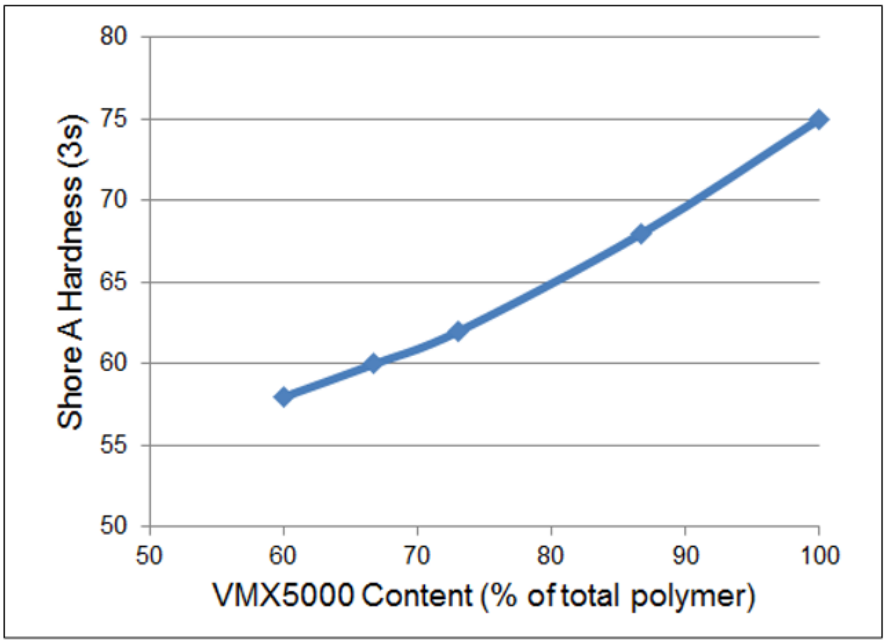

Compression molding

Handling Precautions

Because VMX5015 contains 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 bulletin, Safe Handling and Processing of Vamac®.

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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

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Below picture shows VMX5015 compounds with less staining Naugard® 445, 5phr TiO_2 and 2phr pigment to produce bright colors with good heat aging.

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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.

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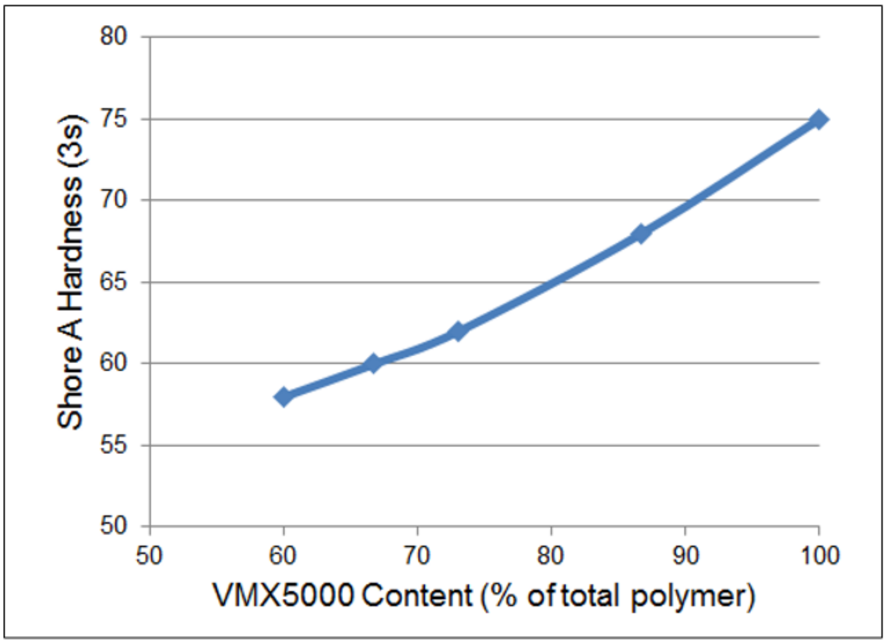

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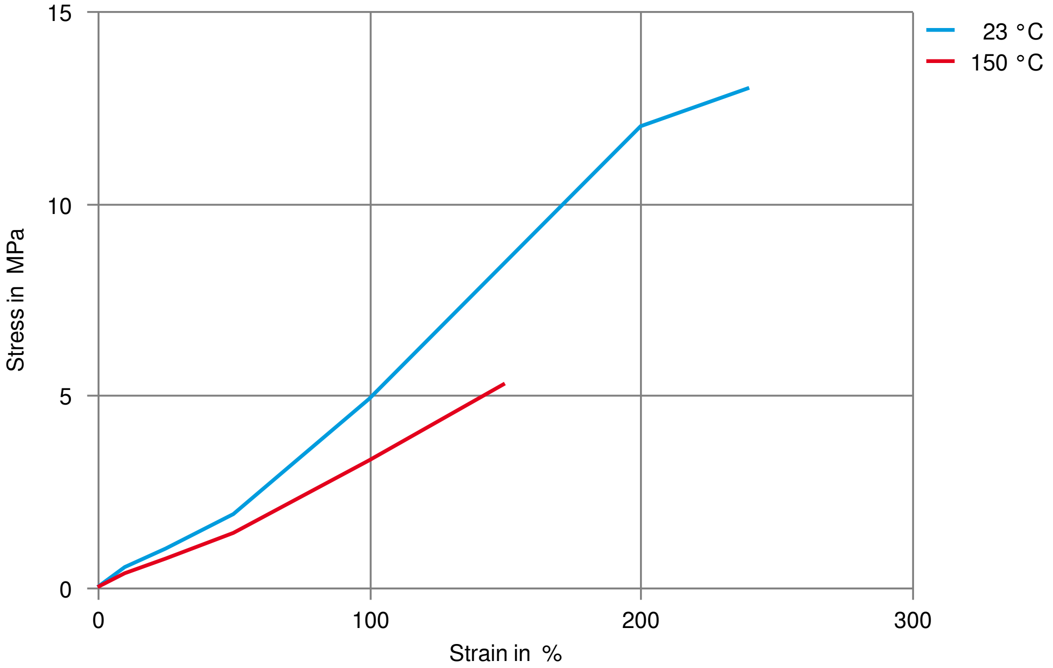
Stress-Strain (Flexible Materials)



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Chemical Media Resistance

Mineral oils

- ✔ SAE 10W40 multigrade motor oil, 23 °C
- ✔ SAE 10W40 multigrade motor oil, 130 °C
- ✔ SAE 80/90 hypoid-gear oil, 130 °C
- ✔ Insulating Oil, 23 °C
- ✔ Motor oil OS206 304 Ref.Eng.Oil, ISP, 135 °C
- ✔ Automatic hypoid-gear oil Shell Donax TX, 135 °C
- ✔ Hydraulic oil Pentosin CHF 202, 125 °C

Other

- ✔ Urea solution (32.5% by mass), 23 °C

Symbols used:

✔ possibly resistant
Defined as: Supplier has sufficient indication that contact with chemical can be potentially accepted under the intended use conditions and expected service life. Criteria for assessment have to be indicated (e.g. surface aspect, volume change, property change).

✖ not recommended - see explanation
Defined as: Not recommended for general use. However, short-term exposure under certain restricted conditions could be acceptable (e.g. fast cleaning with thorough rinsing, spills, wiping, vapor exposure).

The above data are preliminary and are subject to change as additional data are developed on subsequent lots.

NOTICE TO USERS: Values shown are based on testing of laboratory test specimens and represent data that fall within the standard range of properties for natural material. These values alone do not represent a sufficient basis for any part design and are not intended for use in establishing maximum, minimum, or ranges of values for specification purposes. Colourants or other additives may cause significant variations in data values. Properties of moulded parts can be influenced by a wide variety of factors including, but not limited to, material selection, additives, part design, processing conditions and environmental exposure. Other than those products expressly identified as medical grade (including by MT® product designation or otherwise), Celanese's products are not intended for use in medical or dental implants. Regardless of any such product designation, any determination of the suitability of a particular material and part design for any use contemplated by the users and the manner of such use is the sole responsibility of the users, who must assure themselves that the material as subsequently processed meets the needs of their particular product or use. To the best of our knowledge, the information contained in this publication is accurate; however, we do not assume any liability whatsoever for the accuracy and completeness of such information. The information contained in this publication should not be construed as a promise or guarantee of specific properties of our products. It is the sole responsibility of the users to investigate whether any existing patents are infringed by the use of the materials mentioned in this publication. Moreover, there is a need to reduce human exposure to many materials to the lowest practical limits in view of possible adverse effects. To the extent that any hazards may have been mentioned in this publication, we neither suggest nor guarantee that such hazards are the only ones that exist. We recommend that persons intending to rely on any recommendation or to use any equipment, processing technique or material mentioned in this publication should satisfy themselves that they can meet all applicable safety and health standards. We strongly recommend that users seek and adhere to the manufacturer's current instructions for handling each material they use, and entrust the handling of such material to adequately trained personnel only. Please call the telephone numbers listed for additional technical information. Call Customer Services for the appropriate Materials Safety Data Sheets (MSDS) before attempting to process our products.