DuPont™ Vamac® Ultra LT

Technical Information — Rev. 3, July 2010

DuPont™ Vamac® Ultra LT polymer has improved low-temperature properties compared to DuPont™ Vamac® G. The Tg for Vamac® Ultra LT polymer is about 12 °C lower than the Tg for Vamac® G. A compound made from Vamac® Ultra LT with 20 phr of plasticizer has a Tg of –54 °C. A compound without any plasticizer has a Tg of –40 °C and that compound maintains that Tg after aging in air for six weeks at 150 °C or for one week at 175 °C.

The fluid resistance of Vamac® Ultra LT compounds is not as good as the G/GLS compounds, but resistance can be improved by blending with Vamac® G. The blends with G will have intermediate low-temperature performance and intermediate fluid resistance.

The polymer is typically cured with a diamine. It can also be cured with a peroxide. The gum elastomer has a low level of a processing aid and a nominal specific gravity of 1.03. The polymer has a mild acrylic odor and the storage stability of the polymer is excellent.

Vamac® Ultra LT (formerly, Vamac® VMX 4017) is an ethylene methyl acrylate-based polymer with an acidic cure site monomer. It has improved low-temperature properties compared to Vamac® G or Vamac® GLS. Compounds made from Vamac® Ultra LT have similar heat resistance, compression set, CSR and dynamic properties when compared to compounds made from Vamac® G or GLS.

Product Properties

Property	Target Value	Method
Mooney Viscosity, ML (1+4) at 100 °C (212 °F)	11	ASTM D1646
Volatiles, wt%	0.6	Internal DuPont Test
Form, mm (in)	Bale Size is nominally: 560 x 370 x 165 (22 x 15 x 7)	Visual inspection
Color	Clear to opaque with slight variations in color	Visual inspection

Major Performance Properties and Applications

Cured compounds made from Vamac® Ultra LT have a good combination of properties including a wide operating window for end use temperatures. A compound with no plasticizer has a temperature window of –40 °C up to 165 °C and the compound can withstand short term temperature spikes up to 200°C. The low temperature properties can be improved by the addition of a plasticizer, and with 20 phr of plasticizer the initial Tg is about –54 °C. The cured compounds are typically rated as class E for heat resistance using the ASTM D2000 system and this means that they will pass a heat rating test of **70 hours** at 175 °C (347 °F). They will also pass a **six week** air aging requirement at temperatures as high as 165 °C (329 °F).

The fluid resistance of a cured compound depends on the carbon black and plasticizer level. A typical value for volume swell in IRM 903 fluid after aging for 168 hr at 150 °C (302 °F) is about 90%.

The compounds made from DuPont™ Vamac® Ultra LT have much lower volume swell in transmission fluid and in engine oils. The volume swell in Service Fluid 105 (1 week/150 °C) is about 50% and the volume swell in ASTM #1 (1 week/150 °C) is about 7%.

Most of the newer engine oils, transmission fluids, and high temperature greases are more synthetic and have higher aliphatic content than conventional test oils. The newer fluids also have much lower or no aromatic content. The volume swell in IRM903 may not be a good predictor for performance in the newer fluids.

The compression set values for compounds based on Vamac® Ultra LT were measured after one week at 150 °C and the range in values is from 20 to 40%. The results depend on the curative package, the level of carbon black and the level of plasticizer.

CSR (Compressive Stress Relaxation) tests run on Vamac® Ultra LT compounds exhibit very good properties for six weeks at 150 °C in engine oils. The percent retained sealing force is a relatively high value and this is probably due to the relatively high volume swell. The Vamac® Ultra LT compounds have higher values compared to the Vamac® G compounds which in turn have higher retained sealing forces compared to Vamac® GLS compounds.

The properties of Vamac® Ultra LT compounds make them well suited for a wide range of automotive applications, including, molded boots, powertrain seals and gaskets, rocker cover seals, transmission oil coolant hoses, power steering hoses, turbocharger hoses, crankcase ventilating tubes, coverings for fuel and coolant hoses, O-rings, grommets and crankshaft dampers.

Vamac® Ultra LT is a halogen free polymer and does not decompose to give off corrosive gases when exposed to flame. It can be used for flame retardant, low-smoke, non-halogen wire and cable jackets and in non-halogen, low smoke flooring.

Vamac® Ultra LT compounds are well suited for injection, transfer or compression molding. They also can be extruded.

Handling Precautions

Vamac® Ultra LT contains small amounts of residual methyl acrylate monomer and residual n-butyl acrylate monomer so adequate ventilation should be provided during mixing and processing to prevent worker exposure to the acrylate monomers. Additional information may be obtained in the Vamac® Ultra LT Material Safety Data Sheet (MSDS) and the bulletin “Safe Handling and Processing of Vamac® and Vamac® Compounds”. Both are available at **vamac.dupont.com**.

Compound and Vulcanizate Properties — Vamac® Ultra LT compared to Vamac® G

Table 1 shows the formulation and rheological properties of four different compounds. Two are based on Vamac® Ultra LT where one compound has no plasticizer and the other has 20 phr of plasticizer. The other two compounds are based on Vamac® G and have 0 or 20 phr of plasticizer. The black level was adjusted to give a hardness of about 62 Shore A. The compounds were mixed on a small laboratory mixer and then press cured for five minutes at 175 °C followed by a four post cure at the same temperature. The rheology results are shown in *Table 1*.

The compound formulations are 100 phr of polymer, black level and plasticizer level as indicated, 1.5 phr Stearic acid, 1.0 phr Vanfre® VAM, 0.5 phr Armeen® 18D, 2 phr Naugard® 445, 1.25 phr Diak™ #1, 2.0 phr DOTG, 2.0 phr DPG.

Cured Properties

The cured properties of the four compounds are shown in *Table 2*. Included are several different test methods for determining low-temperature properties and each test method gives a different result. For example, the Vamac® Ultra LT compound with no plasticizer has a low-temperature value as high as –32 °C (Tan delta from DMA at 1 Hz) and as low as –55 °C (static O-Ring). It is very important to match up the low temperature test for a compound to the actual requirements of the end use.

The DuPont™ Vamac® Ultra LT compound with no plasticizer has about the same initial low temperature properties as the Vamac® G compound with 20 phr plasticizer. However, after aging in air or in a test fluid the Vamac® Ultra LT compound with no plasticizer is significantly better than the Vamac® G compound with 20 phr of plasticizer. A problem with any plasticized compound is the loss of plasticizer during heat aging. It is very difficult to find a plasticizer with good low-temperature properties and low volatility.

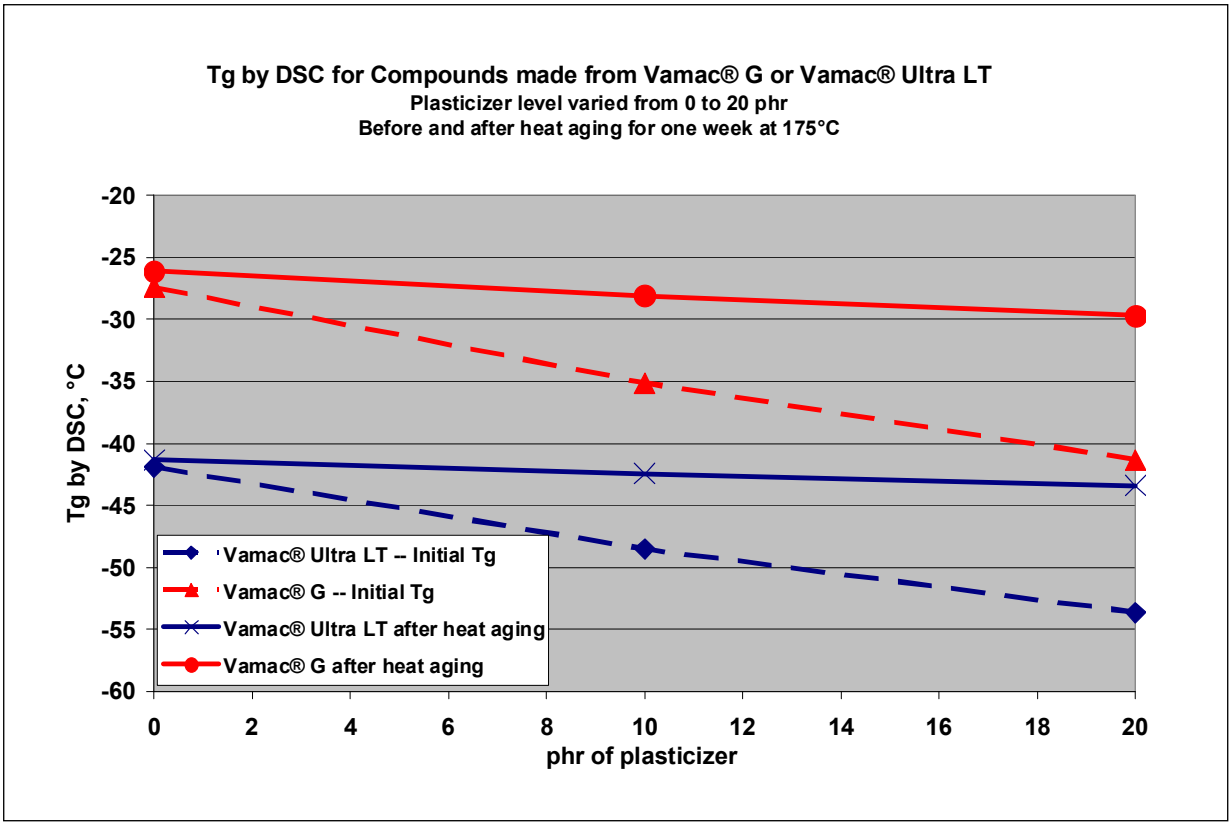
Table 1 – Compound and Vulcanizate Properties

	Vamac® Ultra LT 20 phr plasticizer	**Vamac® Ultra LT no plasticizer**	**Vamac® G 20 phr plasticizer**	**Vamac® G no plasticizer**
Hardness, Shore A	**63**	**60**	**64**	**64**
Tg by DSC, °C	**–54**	**–42**	**–41**	**–27**
Vamac® Ultra LT	100	100	0	0
Vamac® G	0	0	100	100
Black, N550	**66**	**48**	**60**	**42**
Polyether/ester plasticizer	**20**	**0**	**20**	**0**
Mooney Viscosity, ML (1+4) at 100 °C	23	36.8	24.3	41.9
Mooney Scorch 121 °C, Minimum Viscosity, MU	7.9	12.1	8.2	14
t3 – minutes	10.1	9.21	8.27	8.26
t10 –minutes	17.4	14.8	15.1	13.1
MDR Summary at 177, 0.5° arc, 20 minutes				
ML, dNm	0.37	0.41	0.31	0.40
MH, dNm	7.83	9.63	7.35	9.41
ts2, minutes	1.37	1.21	1.39	1.17
t50, minutes	2.08	2.13	2.03	1.98
t90, minutes	8.92	9.41	10.1	9.76

Table 2 – Cured Properties

	Vamac® Ultra LT 20 phr plasticizer	**Vamac® Ultra LT no plasticizer**	**Vamac® G 20 phr plasticizer**	**Vamac® G no plasticizer**
Hardness, Shore A	63	60	64	64
Modulus at 100% Elongation, MPa	3.1	3.1	3.2	3.2
Tensile Strength, MPa	11.0	14.3	13.3	17.5
Elongation, %	355	360	411	443
Die C Tear, N/mm	27.7	28.2	31.5	31.9
Compression Set, 70 hr at 150 °C	25	22	25	18
Compression Set, 1 week at 150 °C	35	31	33	26
Tg by DSC, °C	–54	–42	–41	–27
Tg Results				
TR10, °C	–45	–39	–36	–26
TR30, °C	–33	–32	–271	–21
DMA Results, frequency = 1 Hz				
Tg, loss modulus, °C	–45	–37	–35	–26
Tg, dan delta, °C	–41	–32	–31	–20
Static O-Ring test, °C	–63	–55	–54	–41
Tg by DSC after heat/fluid aging				
Tg after 1 week in SF105, °C	**–52**	**–51**	**–35**	**–33**
Tg after 1 week in ASTM #1, °C	–46	–44	–32	–29
Tg after Air Aging, 1 week at 175 °C	**–43**	**–41**	**–30**	**–26**
Tg after Air Aging, 6 weeks at 150 °C	–47	–42	–32	–26

The graph below shows the change in Tg after heat aging for one week at 175 °C. As the plasticizer level increases there is a significant drop in Tg for the initial Tg. However, after heat aging for one week at 175 °C there is only a slight benefit for the high plasticizer levels. Heat aging for one week at 175 °C is approximately equal to six weeks at 150 °C.



Materials Used in Formulations and Test Fluids – General Composition and Supplier

Material	Chemical Composition	Supplier
Polymer		
Vamac® G	Ethylene Acrylic Elastomer	DuPont
Vamac® Ultra LT	Ethylene Acrylic Elastomer	
Release Aids		
Armeen® 18D	Octadecyl Amine	Akzo Nobel
Vanfre® VAM	Complex Organic phosphate ester	R. T. Vanderbilt
Stearic Acid		
Anti-Oxidant		
Naugard® 445	Diphenyl Amine	Uniroyal Chemical
Plasticizer		
TP-759	Mixed Ether/Ester Plasticizer	Rohm & Haas
Fillers		
N550	Carbon Black	
Curatives		
Diak™ #1	Hexamethylene Diamine Carbonate	DuPont
DOTG	Di-ortho-tolyl Guanidine	
DPG	Diphenyl Guanidine	
Test Fluids		
ASTM #1	Aliphatic Test Fluid	ASTM Test Monitoring Center
IRM 903	Test Fluid	ASTM Test Monitoring Center
Service Fluid 105	Service Fluid 105	

The test methods used in the work are shown below:

Rheology	
Mooney Viscosity	D 1646
Mooney Scorch	D 1646
MDR	D 5289
Physicals	
Hardness	D 2240
Tensile, Elongation, Mod	D 412
Tear, Die C	D 624
Fluid Aging	D 471
Compression Set	D 395
Tg by DSC	D 3418
Aging in Air	D 573
Temperature of Retraction	D 1329

The DMA test was run at 1 Hertz with a temperature sweep of –150 °C up to 150 °C using a dual cantilever fixture. The static O-ring test is described in “New, Improved Processing PMVE-Peroxide Cured Types of Viton®, “Paper number 30 at the Fall 2001 ACS Rubber Symposium, R. D. Stevens and D. F. Lyons.

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