Vamac® GXF

Ethylene Acrylic Elastomer - Technical Data

Description

DuPont™ Vamac® GXF is a terpolymer of ethylene, methyl acrylate, and a cure site monomer cured using an amine-based vulcanization system. Compared with Vamac® G, Vamac® GXF has improved high temperature properties and better dynamic flex fatigue resistance. Vamac® GXF includes a small amount of processing aid and has a nominal specific gravity of 1.03. It has a mild acrylic odor. Use adequate ventilation during storage, mixing, and processing to prevent accumulation of residual vapors. Storage stability is excellent.

Product Properties

Property	Target Value	Method
Mooney Viscosity ML 1+4 at 100 °C	17.5	ASTM D1646
Volatiles	≤0.4 wt %	Internal DuPont Test
Form (25kg nominal bale size)	51.6 x 34.4 x 13.6 cm	Visual inspection
Color	Clear to light yellow translucent	Visual inspection

Major Performance Properties and Applications

Vamac® GXF is well suited for those applications which need improved high temperature properties or improved dynamic flex fatigue resistance over Vamac® G and can tolerate a slightly longer cure time. Typical applications that would benefit from the improved properties of Vamac® GXF are air ducts, hoses and torsional dampers.

Compounds of Vamac® GXF compared to Vamac® G have longer scorch time for improved processing and slightly higher compression sets. Elongation and properties at elevated temperature are improved resulting in significantly improved dynamic flex fatigue resistance. Heat and fluid ageing is similar.

Vamac® GXF is well suited for injection, transfer and compression molding, and is easily extruded.

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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 Vamac® product Safety Data Sheet (SDS), and DuPont™ bulletin, *Safe Handling and Processing of Vamac®*.

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 and vulcaniates of Vamac® are thus proprietary, and cannot be published by DuPont.

DuPont has independently formulated a wide variety of Vamac® compounds for its own short- and long-term properties testing programs. A comparison of the performance differences of typical compounds of Vamac® GXF and Vamac® G is reviewed below, followed by vulcanizate performance test data that can help end users evaluate the potential fitness of similar compounds for their own applications. Data is presented with the elimination of Armeen® 18D from the Vamac® GXF compound to improve the compound cure time t(50).

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Table 1 – Sample Compound: Vamac® G vs. GXF
Cure: 5 min. At 190 °C – Post Cure: 4 hr. at 175 °C

Ingredients	Parts	Parts
Vamac® G	100	
Vamac® GXF		100
Antioxidant: Naugard® 445	2	2
Release agent: Stearic acid	1.5	1.5
Release agent: Vanfre® VAM (alkylphosphate)	1	1
Release agent: Armeen® 18D (octadecylamine)	0.5	0.5
SRF black (N772)	45	45
Curative: Diak™ No. 1 (hexamethylene diamine carbamate)	1.5	1.5
Accelerator: DOTG (guanidine coagent)	4	4
Total Parts	155.5	155.5
Stock Properties		
Mooney Viscosity: ML1+4 at 100 °C, MU	31.9	30.6
Mooney Scorch: MS at 121 °C		
Time to 2-unit rise, min.	7.6	10.1
Time to 5-unit rise, min.	10.5	17.1
MDR, 12 min. at 180 °C		
ML, dNm	0.23	0.24
MH, dNm	10.6	9.39
t2, min	1.08	1.58
t(10), min.	0.8	1.0
t(35), min.	1.55	2.24
t(50), min.	2.09	3.15
t(90), min.	5.63	8.03
Original Properties at 23°C		
100% Modulus, MPa	2.7	2.7
Tensile Strength, MPa	17.1	19.5
Elongation at Break, %	367	440
Hardness, "A" Durometer, pts.	59	63
Tear Strength (ISO 34), N/mm	17.8	21.5
Compression Set, 70 hrs at 150 °C, %	18.4	27.3

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Table 2 – Sample Compounds: Vamac® G vs. GXF without Armeen® 18D
Cure: 5 min. At 190 °C – Post Cure: 4 hr. at 175 °C

Ingredients	Parts	Parts
Vamac® G	100	
Vamac® GXF		100
Antioxidant: Naugard® 445	2	2
Release agent: stearic acid	1.5	1.5
Release agent: Vanfre® VAM (alkylphosphate)	1	1
Release agent: Armeen® 18D (octadecylamine)	0.5	
FEF black (N550)	50	50
Curative: Diak™ No. 1 (hexamethylene diamine carbamate)	1.5	1.5
Cure Accelerator: DOTG (guanidine coagent)	4	4
Total Parts	160.5	160.0
Stock Properties		
Mooney Viscosity: ML1+4 at 100 °C, MU	45.2	50.0
Mooney Scorch: MS at 121 °C		
Time to 5-unit rise, min.	8.3	11.17
MDR, 12 min. at 190 °C		
ML, dNm	0.34	0.42
MH, dNm	13.24	12.98
t2, min.	0.64	0.82
t(50), min.	1.29	1.92
t(90), min.	3.70	4.97
Original Properties at 23 °C		
100% Modulus, MPa	5.0	5.1
Tensile Strength, MPa	17.8	17.3
Elongation at Break, %	305	349
Hardness, “A” Durometer, pts.	67	71
Tear Strength (ISO 34), N/mm	25.0	30.6
Compression Set, 70 hrs at 150°C, %	21.2	26.8
Tg by DSC, °C	–26.5	–27.2

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Figure 1 – DeMattia Dynamic Fatigue (ASTM D430) – Vamac® G vs. GXF without Armeen® 18D

Relative cycles to failure, avg. from 3 slabs (not pierced), three different test temperatures, test at RT without any failure, stopped after 600,000 cycles

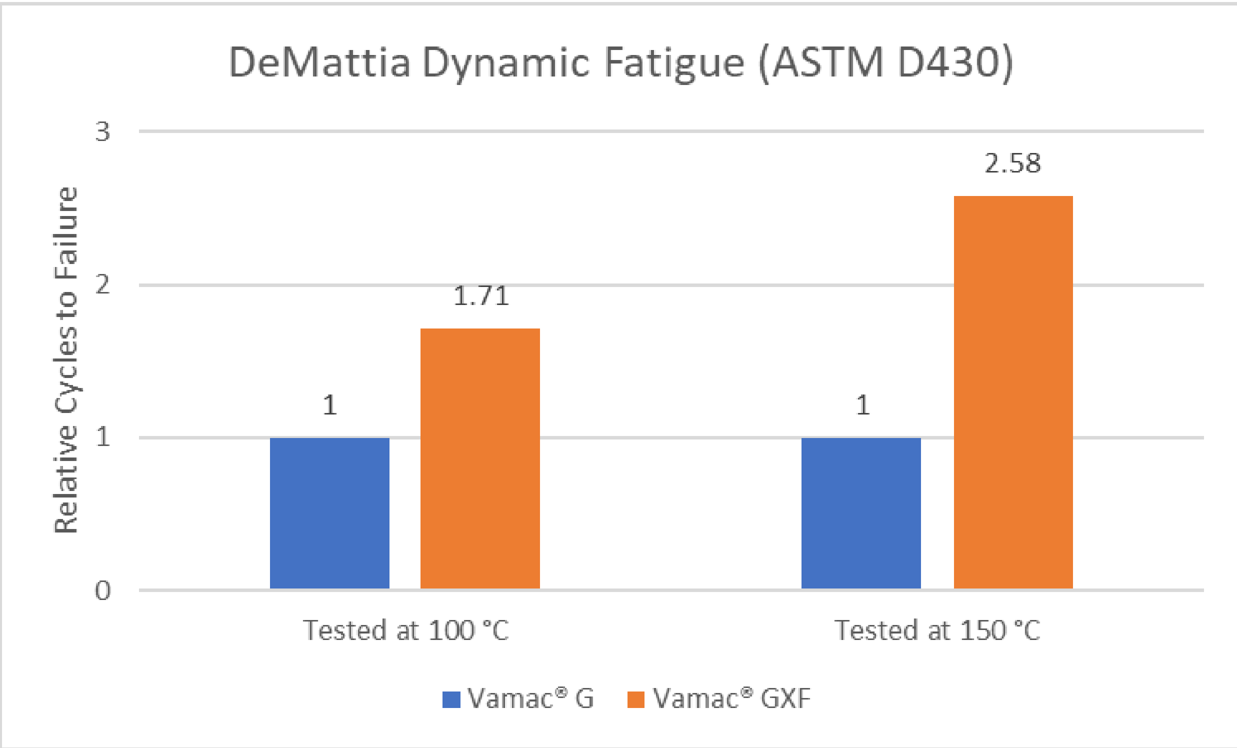

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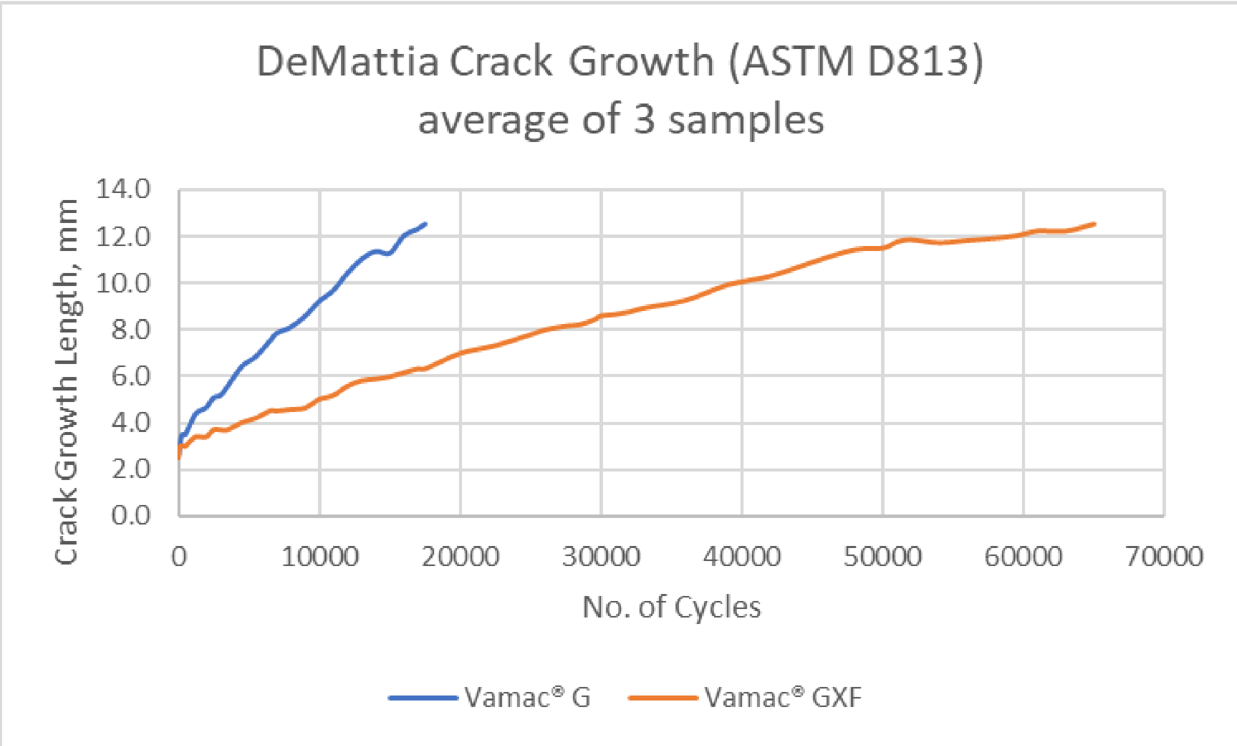
Figure 2 – DeMattia Crack Growth (ASTM D813) – Vamac® G vs. GXF without Armeen® 18D

(3 pierced slabs tested per compound at RT, test stopped at 12.5 mm crack length)



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DOTG Replacement

The compounds shown in Table 1 and 2 include DOTG as cure accelerator. Di-Ortho-Tolyl-Guanidine forms as decomposition product o-Toluidine (CAS 95-53-4) which is classified as carcinogen by IARC, NTP, OSHA and ACGIH.

DBU (1,8-Diazabicyclo[5.4.0] undec-7-ene, CAS 6674-22-2) based cure accelerators have been developed that can replace DOTG in Vamac® compounds. Typically, the exchange of DOTG by DBU causes slightly higher Modulus and Hardness, lower Elongation-at-Break, and higher Compression Set. Furthermore, DBU accelerated compounds usually have shorter Scorch and Cure times, which may lead to higher viscosity after mixing and thus reduced compound flow during injection molding processes.

Table 3 shows results when DOTG is replaced by a DBU based accelerator preparation like Vulcofac® ACT55 from Safic-Alcan in a standard 70 Shore A Vamac® G recipe. Partial replacement of Vamac® G by Vamac® GXF helps to increase Elongation at Break values and provide longer Scorch times to allow for better compound flow. Higher Compression Set values with Vamac® GXF can be optimized by other compounding techniques such as reduction of Armeen® 18D, use of plasticizers with lower volatility or use of Vamac® Ultra polymers.

Table 3 – Compounds, DuPont™ Vamac® G vs. GXF, DOTG Replacement
Cure: 5 min. At 180 °C – Post Cure: 4 hr. at 175 °C

Ingredients	Parts	Parts	Parts	Parts	Parts	Parts
Vamac® G	100	100	75	50	25	
Vamac® GXF			25	50	75	100
Antioxidant: Naugard® 445	2	2	2	2	2	2
Release Agent: Armeen® 18D	0.5	0.5	0.5	0.5	0.5	0.5
Release Agent: Vanfre® VAM	1	1	1	1	1	1
Release Agent: stearic acid	1.5	1.5	1.5	1.5	1.5	1.5
Filler: FEF N 550	60	60	60	60	60	60
Plasticizer: Rhenosin® W 759	10	10	10	10	10	10
Curative: Diak™ No 1	1.5	1.5	1.5	1.5	1.5	1.5
Cure Accelerator: Vulcofac® ACT 55		2	2	2	2	2
Cure Accelerator: Ekaland® DOTG C	4					

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Table 3 (continued) – Compounds, DuPont™ Vamac® G vs. GXF, DOTG Replacement

Ingredients	Parts	Parts	Parts	Parts	Parts	Parts
Vamac® G	100	100	75	50	25	
Vamac® GXF			25	50	75	100
Stock Properties						
Mooney Viscosity: ML(1+4) at 100 °C, MU	38	41	41	41	41	41
Mooney Scorch: MS at 121 °C						
Time to 5-unit rise, min.	8.6	7.2	8.5	9.3	10.8	12
MDR, 12 min. at 180 °C						
ML, dNm	0.39	0.47	0.47	0.46	0.45	0.47
MH, dNm	12.4	12.9	12.3	11.7	11.1	10.1
t2, min	0.94	0.87	0.97	1.1	1.2	1.4
t(50), min	2.0	2.0	2.2	2.5	2.8	3.1
t(90), min	6.0	6.3	6.7	7.2	7.7	8.2
Original Properties at 23 °C						
100% Modulus, MPa	5	6.8	6.2	5.9	5.6	5.0
Tensile Strength, MPa	14.5	17.1	20.7	16.2	16.8	16.2
Elongation at Break, %	306	230	243	255	273	305
Hardness, "A" Durometer, 1 s, pts.	71.1	73.9	73.7	74.2	73.8	72.2
Tear Die C at 23ºC	29.1	23.5	22.9	25.3	27.3	28.5
Comp. set, 70 h at 150ºC, ISO 815, %	23	28	29	29	28	29
Properties After Heat Ageing 168 h at 175 °C						
100% Modulus, MPa	6.6	6.7	6.8	6.4	6.3	5.8
Tensile Strength, MPa	14.0	15.0	14.8	14.4	15.3	15.0
Delta Tensile Strength, %	-3	-12	-29	-11	-9	-7
Elongation at Break, %	238	220	231	257	274	304
Delta Elongation at Break, %	-22	-4	-5	1	0	0
Hardness, "A" Durometer, 1 s, pts.	78.8	80.2	80.6	80.9	79.2	79.9
Delta Hardness, pts.	7,7	6,3	6,9	6,7	5,4	7,7

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The test methods used in the work are shown below:

Rheology	ASTM
Mooney Viscosity	D 1646
Mooney Scorch	D 1646
MDR	D 5289
Physicals	
Hardness	D 2240
Tensile, Elongation, Modulus	D 412
Tear, Die C	D 624
Compression Set	D 395
Tg by DSC	D 3418
Ageing in Air	D 573
DeMattia Flex Fatigue	D 430
DeMattia Crack Growth	D 813

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