DuPont™ Vamac® Ultra HT-OR

(formerly VMX-3121)

High viscosity & Low Swell for Extrusion Applications

Technical Information — Rev. 2, December 2013

Description

Standards grades of DuPont™ Vamac® G and Vamac® GXF ethylene acrylic elastomer (AEM) have been widely used for a number of years in turbo charger hose applications and current Vamac® Ultra grades are now extending the Vamac® offering for automotive hose applications. The Ultra grades deliver improved processing, heat and oil resistance required by the market.

Vamac® Ultra HT-OR (formerly VMX-3121) is an AEM grade that is part of the Ultra family displaying equivalent properties and processing as Vamac® Ultra HT with a clear improvement in oil resistance while maintaining a comparable resistance to acids. Vamac® Ultra HT-OR has equivalent physical, heat aging, dynamic and sealing performances as Vamac® Ultra HT for the temperature range of 170 – 180 ˚C and is extending the oil resistance of the current portfolio. For instance Vamac® Ultra HT-OR provides 50% improvement in volume swell in IRM 903.

Vamac® Ultra HT-OR is a terpolymer of ethylene and methyl acrylate (AEM) with an acidic cure site using a diamine-based vulcanization system delivering high mechanical properties and good low temperature flexibility. Inherently, it has a halogen free structure like other Vamac® grades, all providing superior acid resistance (acid presenting blow-by gas, and exhaust gas recirculation).

The Vamac® Ultra family which includes Vamac® Ultra HT-OR offers a specific polymer design with a higher viscosity improving process and properties versus standard Vamac® grades.

Vamac® Ultra HT-OR can be compounded as a DOTG free compound similar to other Vamac® terpolymer products.

For more information, please contact your DuPont technical representative.

Typical Product Properties

Property	Target Values	Method
Mooney Viscosity ML 1'+4' at 100 °C	31	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 light yellow translucent	Visual Inspection

Packaging

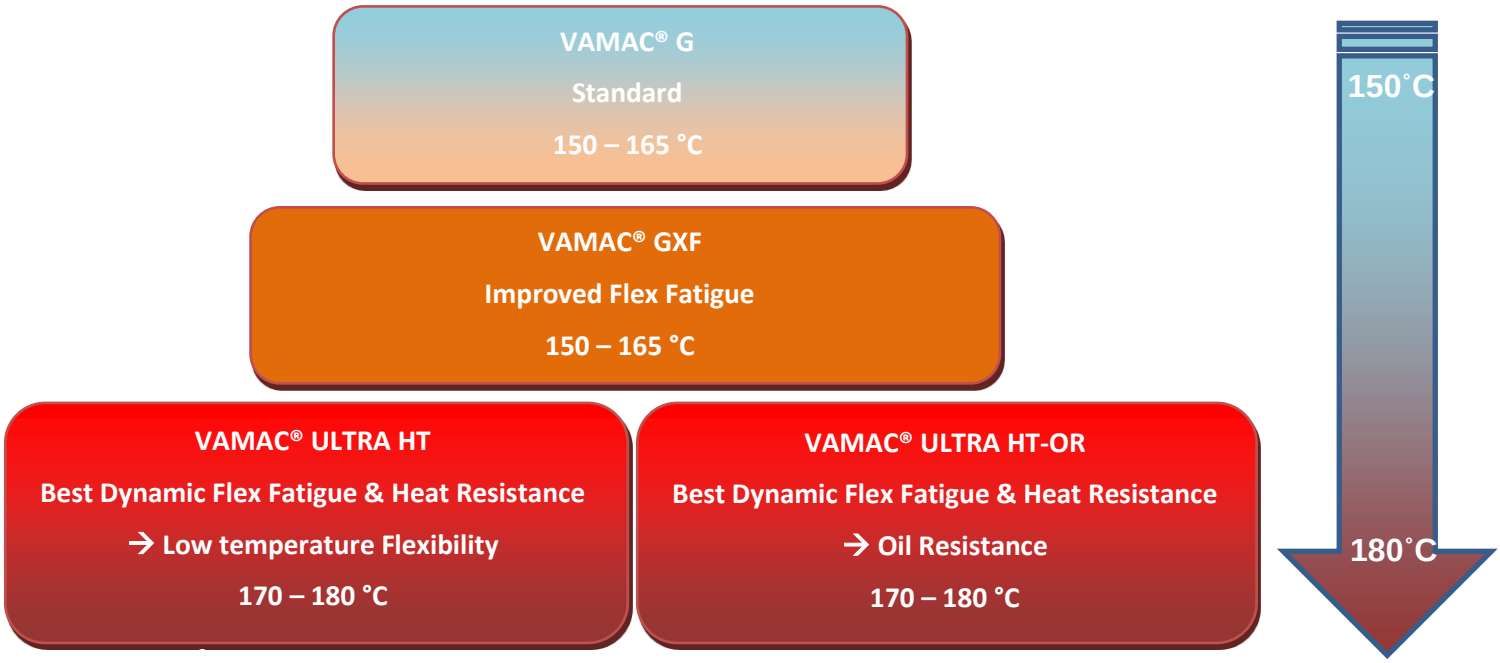
25 kg bales with blue strippable wrap in individual boxes that contain one bale or bulk boxes that contain thirty bales with flexible wrap. A full pallet will hold thirty individual boxes or one bulk box with a net weight of 750 kg.

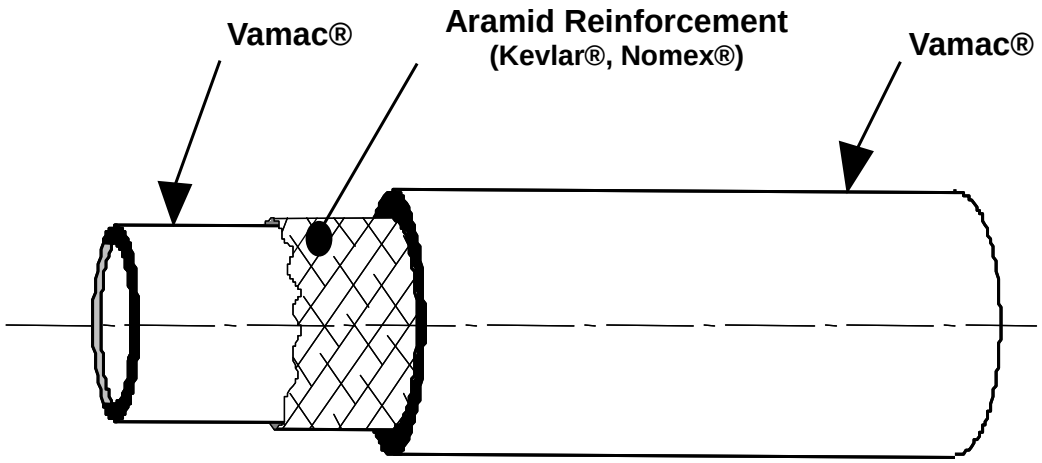
Note: Blue strippable wrap must be completely removed before using the product.

Handling and Precautions

Because Vamac® Ultra HT-OR contains small amounts of residual methylacrylate monomer, adequate ventilation should be provided during mixing and processing to prevent worker exposure to methylacrylate vapor. Additional information may be obtained in the 'Material Safety Data Sheet' (MSDS), and the 'Safe Handling and Processing guide of Vamac®' available from www.vamac.dupont.com.

Vamac® for Automotive Hoses





Performances & Applications

Engine downsizing and turbo charging are widely adopted by all OEMs for diesel and also gasoline engines to reduce both fuel consumption and CO_2 emission when compared to bigger engines naturally aspirated, and contribute to development of cleaner vehicles.

Vamac® Ultra HT-OR has been developed to meet severe fluid requirements in terms of volume swell and retention of properties after exposure in these fluids (for example IRM 903).

Compounding and Vulcanizate Properties

Mixing

Compounds made from Vamac® Ultra HT-OR can be mixed either in an internal mixer or an open mill, with a relatively short cycle time. For internal mixers, single pass, upside-down mixing is preferred to control overheating. It is recommended for Ultra grades to use a dump temperature lower than for standard grades and to do so the rotor speed of the internal mixer can be adjusted. For more information, please refer to the "Vamac® Compound Mixing Guide" available on line at **www.vamac.dupont.com.**

Formulation

General comments

Table 1 shows starting point formulation for Vamac® Ultra HT and Vamac® Ultra HT-OR with 1phr of Diak™ N.1 which is a diamine curing agent and accelerated with 2phr of a cyclo-aliphatic amine such as Vulcofac® ACT55. The compounding optimizations are equivalent for Vamac® Ultra HT and Vamac® Ultra HT-OR. For more information, refer to "Vamac® Ultra HT Technical Bulletin" which details all the general formulation recommendations in terms of curative, accelerator, scorch retarder and carbon black.

Vamac® Ultra HT-OR compounding filler study

Turbo charger hoses and automotive hoses for the class temperature 170 °C – 180 °C are the main target for this grade. The objective of this study is to demonstrate additional improvement in heat aging for Vamac® Ultra HT-OR.

The use of carbon black MT N990 has already proven some advantage for Vamac® Ultra HT for high temperature long term heat aging, maintaining hardness stability, while reducing the loss in elongation. Other advantages of MT carbon black are the reduction of Mooney viscosity of the Ultra grade compound and the improvement of the compression set.

Further compounding developments are under way in DuPont laboratories. Contact your DuPont technical service representative for more information.

The data are presented in tables 6 to 8 for the original properties and heat aging behavior.

Rheological Properties

Ultra HT-OR and Ultra HT have similar viscosity and rheological behavior as the same Ultra technology was used for the production of these polymers. The cure speed and scorch safety are equivalent and the compound viscosity displayed may be slightly higher.

Vulcanizate Properties

In general terms, Vamac® Ultra grades present high tensile strength and a broad set of properties required by automotive hose applications.

It can be seen in Tables 1 and 2 that both grades display an equivalent set of properties for sealing performance at 175 °C, tear strength and tensile strength both at room and elevated temperature.

The only difference is in the glass transition temperature where Vamac® Ultra HT-OR has a higher value. The difference in glass transition temperature is due to the higher Methyl Acrylate content in the Vamac® Ultra HT-OR backbone which is required to improve the chemical resistance in various fluids (engine oils and grease, diesel, IRM 903).

Dynamic properties

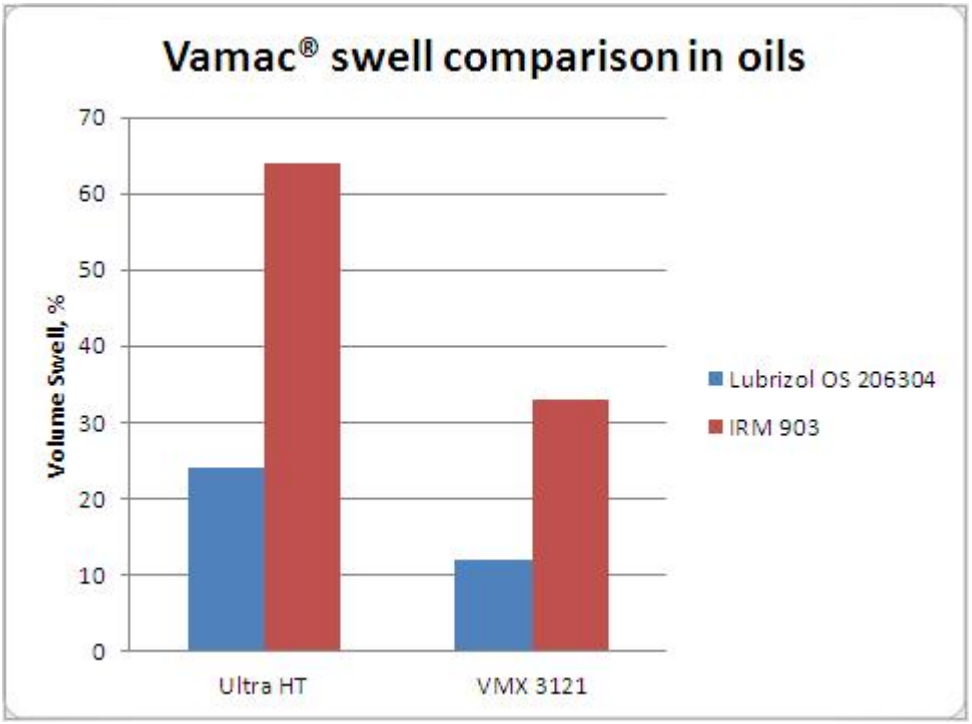
Vamac® Ultra HT-OR display equivalent or slightly improved flex-fatigue properties as shown in Table 2 based on De Mattia results.

Heat aging

Tables 3 and 4 show heat aging values at 175 ˚C, 190 ˚C and 200 ˚C which relates to the peak and continuous service temperature for turbo charger hoses, automotive hoses and air ducts application.

Fluid aging comments

The fluid aging data presented in Table 5 clearly show the improved oil resistance of Vamac® Ultra HT-OR over Vamac® Ultra HT. Vamac® Ultra HT-OR shows a 50% improvement in volume swell compared to Vamac® Ultra HT.



Vamac® Ultra HT-OR is the best Vamac® grade for turbo charger hoses application to pass severe oil and fluid aging requirements.

Processing

Compounds of Vamac® can be extruded using equipment commonly used to extrude thermoset elastomers. Short or moderate L/D extruders are suitable (10/1 up to 15/1). Extruded surface of Vamac® compounds are smooth and extrusion speed up to 20m/min can be achieved.

General temperature profile can be found in the chart below:

For a cold-feed extrusion, a typical starting point temperature profile is shown below

DIE	HEAD	ZONE 2	ZONE 1
80-90 ˚C	70-75 ˚C	60-65 ˚C	55-60 ˚C

The curing of extruded article must be completed in an autoclave system because Vamac® will "sponge" if cured without pressure. For more information on temperature and pressure range, please refer to the "Vamac® Compounds Extrusion Guide".

The mandrel phase assembly and disassembly are two key points in hose manufacturing phase requiring release agents in the market. Various mandrel release agent can be found and one them is the SaficRelease RPM-V which is a poly(ethylene glycol adipate).

Conclusion

Vamac® Ultra HT-OR provides the following properties:

- High tensile strength and elongation
- Best heat aging and flex fatigue
- Best chemical resistance to automotive lubricant

Introducing Vamac® Ultra HT-OR to the Vamac® Ultra family addresses the needs of newer demanding automotive applications. The advised starting point formulation for turbo charger hoses is using 1phr of Diak® N.1, 2phr of Vulcofac® ACT55, 2phr of Naugard® 445, 2 to 7phr of plasticizer, 1phr of Vanfre® Vam and stearic acid and with 45 to 50phr of FEF N550. To improve static heat ageing MT N990 carbon black fillers can be used pure or in blends with FEF N550.

Table 1. Vamac® Ultra HT and Vamac® Ultra HT-OR- Formulations & Original Properties

	Ultra HT 1phr Diak™ N.1	Ultra HT-OR 1phr Diak™ N.1
Vamac® Ultra HT	100	
Vamac® Ultra HT-OR		100
Naugard® 445	2	2
Stearic acid	1	1
Vanfre® VAM	1	1
Spheron™ SOA (N 550)	45	45
TegMeR® 812	2	2
Rubber chem Diak™ No 1	1	1
Vulcofac® ACT 55	2	2
Vamac® Internal mixing	Dump temperature from 90 to 95 ˚C	
Vamac® mill sheet-off		
MDR cure rate 15 minutes at 180°C, arc 0.5°		
ML [dNm]	0.8	0.9
MH [dNm]	13.2	12.7
Ts1 [min]	0.7	0.7
Ts2 [min]	1.0	0.9
T50 [min]	2.4	2.2
T90 [min]	7.1	7.7
Mooney Scorch 45 minutes at 121 °C		
Ts1 [min]	5.8	5.9
Ts2 [min]	7.1	7
T5 [min]	9.8	9.6
Mooney Viscosity ML 1+4 at 100 °C		
Final Mooney [MU]	66	73
Compression moulding 10 minutes at 180 °C		
Post-cure 4 hours at 175 °C		
Hardness Shore A (1 second)		
Shore A	69	71
Tensile properties (type 2) at 23 °C		
Tensile Strength [MPa]	20.1	20.1
Elongation at break [%]	430	420
Modulus at 50 % [MPa]	1.9	2.0
Modulus at 100 % [MPa]	4.1	4.0
Tensile properties (type 2) at 175 °C		
Tensile Strength [MPa]	5.7	6.7
Elongation at break [%]	130	150
Modulus at 50 % [MPa]	1.7	1.7
Modulus at 100 % [MPa]	3.9	3.9

Table 2. Vamac® Ultra HT and Vamac® Ultra HT-OR- Original Properties

	Ultra HT 1phr Diak™ N.1	Ultra HT-OR 1phr Diak™ N.1
Tear strength type C - Crescent		
Tear Strength [kN/m]	29.3	27.6
Tear strength type C - Crescent at 175 °C		
Tear Strength [kN/m]	10.1	10.6
Compression set VW 22 hours at 175 °C		
Compression set at 5 seconds [%]	65	62
Compression set at 30 minutes [%]	43	45
Compression set 70 hours at 175 °C - plied		
Compression set [%]	30	30
Bending test - DuPont method: 24hrs conditionning		
Bending on mandrel at -35 ˚C	No cracks	No cracks
Differential Scanning Calorimetry (DSC)		
TG [°C]	-31	-24
De Mattia at 150˚C, after aging 94hrs@200 ˚C		
Median of 5 samples	155	635
Average of 5 samples	335	1499

Table 3. Vamac® Ultra HT and Vamac® Ultra HT-OR- Short term heat aging at 200 ˚C

	Ultra HT 1phr Diak™ N.1	Ultra HT-OR 1phr Diak™ N.1
Heat aging 94 hours at 200 °C		
Hardness Shore A (1 second)	71	76
Delta Hardness	2	5
Tensile properties (type 2) at 23 °C		
Tensile Strength [MPa]	12.6	12.3
Delta TS [%]	-37	-39
Elongation at break [%]	301	309
Delta Elong. [%]	-30	-26
Modulus at 50 % [MPa]	2.0	2.3
Delta 50% [%]	6	18
Modulus at 100 % [MPa]	3.8	4.1
Delta 100% [%]	-8	3

Table 4. Vamac® Ultra HT and ULTRA HT-OR- Heat aging at 190 ˚C & 175 ˚C

	Ultra HT 1phr Diak™ N.1	Ultra HT-OR 1phr Diak™ N.1
Heat aging 168 hours at 190 °C		
Hardness Shore A (1 second)	73	76
Delta Hardness	4	5
Tensile properties (type 2) at 23 °C		
Tensile Strength [MPa]	12.2	11.2
Delta TS [%]	-39	-44
Elongation at break [%]	292	294
Delta Elong. [%]	-32	-30
Modulus at 50 % [MPa]	2.3	2.4
Delta 50% [%]	17	23
Modulus at 100 % [MPa]	3.6	4.2
Delta 100% [%]	-12	5
Heat aging 168 hours at 175 °C		
Hardness Shore A (1 second)	69	73
Delta Hardness	0	2
Tensile properties (type 2) at 23 °C		
Tensile Strength [MPa]	16.4	16.4
Delta TS [%]	-18	-18
Elongation at break [%]	450	460
Delta Elong. [%]	5	9
Modulus at 50 % [MPa]	1.7	2.0
Delta 50% [%]	-12	1
Modulus at 100 % [MPa]	3.4	3.7
Delta 100% [%]	-16	-8
Heat aging 504 hours at 175 °C		
Hardness Shore A (1 second)	72	74
Delta Hardness	3	3
Tensile properties (type 2) at 23 °C		
Tensile Strength [MPa]	12.4	11.3
Delta TS [%]	-38	-44
Elongation at break [%]	311	292
Delta Elong. [%]	-28	-30
Modulus at 50 % [MPa]	2.0	2.3
Delta 50% [%]	4	18
Modulus at 100 % [MPa]	3.8	4.2
Delta 100% [%]	-8	5

Table 5. Vamac® Ultra HT and Vamac® Ultra HT-OR- Fluid aging in various automotive fluids

	Ultra HT 1phr Diak™ N.1	Ultra HT-OR 1phr Diak™ N.1
Fluid aging 168 hours at 160 °C in Lubrizol OS 206304		
Hardness Shore A (1 second)	57	66
Delta Hardness	-12	-5
Tensile properties (type 2) at 23 °C		
Tensile Strength [MPa]	17.0	18.3
Delta TS [%]	-16	-9
Elongation at break [%]	360	370
Delta Elong. [%]	-16	-11
Modulus at 50 % [MPa]	1.5	1.8
Delta 50% [%]	-23	-6
Modulus at 100 % [MPa]	3.7	4.1
Delta 100% [%]	-10	4
Volume change [%]	24	12
Fluid aging 70 hours at 150 °C in IRM 903		
Hardness Shore A (1 second)	50	56
Delta Hardness	-20	-15
Tensile properties (type 2) at 23 °C		
Tensile Strength [MPa]	14.3	17.9
Delta TS [%]	-29	-11
Elongation at break [%]	300	390
Delta Elong. [%]	-30	-8
Modulus at 50 % [MPa]	1.3	1.5
Delta 50% [%]	-30	-25
Modulus at 100 % [MPa]	4.1	3.8
Delta 100% [%]	-1	-5
Volume change [%]	64	33
Fluid aging 504 hours at 100°C in EGR Solution - Acetic acid (pH=2.5), liquid phase		
Hardness Shore A (1 second)	67	66
Delta Hardness	-2	-5
Tensile properties (type 2) at 23 °C		
Tensile Strength [MPa]	20.3	18.9
Delta TS [%]	1	-6
Elongation at break [%]	390	390
Delta Elong. [%]	-8	-7
Modulus at 50 % [MPa]	2.0	2.0
Delta 50% [%]	3	0
Modulus at 100 % [MPa]	4.4	4.4
Delta 100% [%]	7	10
Volume change [%]	9	13

Table 6. Filler study in Vamac® Ultra HT-OR compounds

	Ultra HT-OR T810T 50phr N550	Ultra HT-OR 1phr Diak™ N.1	Ultra HT-OR 90phr N990
Vamac® Ultra HT-OR	100	100	100
Naugard® 445	2	2	2
Stearic acid	1	1	1
Vanfre® VAM	0.5	1	1
Spheron™ SOA (N 550)	50	45	
MT Thermax® Floform N990			90
TegMeR® 812		2	2
Edenol® T810T stabilized	5		
Rubber chem Diak™ No. 1	1	1	1
Vulcofac® ACT 55	2	2	2
MDR cure rate 15 minutes at 180 °C, arc 0.5°			
ML [dNm]	0.9	0.9	0.7
MH [dNm]	13.4	12.7	13.2
Ts1 [min]	0.6	0.7	0.6
T50 [min]	2.1	2.2	2.2
T90 [min]	7.1	7.7	7.4
Mooney Scorch 45 minutes at 121 °C			
Ts1 [min]	5.3	5.9	5.6
Ts2 [min]	6.4	7	6.6
T5 [min]	8.9	9.6	8.9
Mooney Viscosity ML 1+4 at 100 °C			
Final Mooney [MU]	69	73	63
Compression moulding 10 minutes at 180 °C			
Post-cure 4 hours at 175°C			
Hardness Shore A (1 second)			
Shore A	73	71	69
Tensile properties (type 2) at 23 °C			
Tensile Strength [MPa]	19.7	20.1	15.2
Elongation at break [%]	390	420	360
Modulus at 50 % [MPa]	2.2	2.0	1.8
Modulus at 100 % [MPa]	4.6	4.0	3.8

Table 6. (Continued)

	Ultra HT-OR T810T 50phr N550	Ultra HT-OR 1phr Diak™ N.1	Ultra HT-OR 90phr N990
Tensile properties (type 2) at 175 °C			
Tensile Strength [MPa]	5.9	6.7	3.9
Elongation at break [%]	130	150	130
Modulus at 50 % [MPa]	1.8	1.7	1.5
Modulus at 100 % [MPa]	4.2	3.9	3.0
Tear strength type C - Crescent			
Tear Strength [kN/m]	28.0	27.6	25.4
Tear strength type C - Crescent at 175 °C			
Tear Strength [kN/m]	10.7	10.6	8.3
Compression set VW 22 hours at 175 °C	**VW PV 3307:2004-08**		
Compression set at 5 seconds [%]	71	62	59
Compression set at 30 minutes [%]	46	45	37
Compression set 70 hours at 175 °C - plied			
Compression set [%]	28	30	27
Bending test - DuPont method: 24 hrs conditioning			
Bending on mandrel at, ˚C	-35	-35	-35
Note	pass	pass	pass
Differential Scanning Calorimetry (DSC)			
TG [°C]	-25	-24	-24

Table 7. Filler study in Vamac® Ultra HT-OR compounds: short & long term heat aging

	Ultra HT-OR T810T 50phr N550	Ultra HT-OR 1phr Diak™ N.1	Ultra HT-OR 90phr N990
Heat aging 168 hours at 190 °C			
Hardness Shore A (1 second)	76	76	67
Delta Hardness	4	5	-2
Tensile properties (type 2) at 23 °C			
Tensile Strength [MPa]	11.2	11.2	9.5
Delta TS [%]	-43	-44	-37
Elongation at break [%]	301	294	296
Delta Elong. [%]	-23	-30	-18
Modulus at 50 % [MPa]	2.5	2.4	1.5
Delta 50% [%]	16	23	-15
Modulus at 100 % [MPa]	4.5	3.6	2.9
Delta 100% [%]	-2	-10	-23

Table 7 (Continued)

	Ultra HT-OR T810T 50phr N550	Ultra HT-OR 1phr Diak™ N.1	Ultra HT-OR 90phr N990
Heat aging 94 hours at 200 °C			
Hardness Shore A (1 second)	78	76	67
Delta Hardness	6	5	-2
Tensile properties (type 2) at 23 °C			
Tensile Strength [MPa]	11.7	12.3	9.0
Delta TS [%]	-41	-39	-41
Elongation at break [%]	290	309	272
Delta Elong. [%]	-26	-26	-24
Modulus at 50 % [MPa]	2.6	2.3	1.6
Delta 50% [%]	21	18	-12
Modulus at 100 % [MPa]	4.4	4.1	3.0
Delta 100% [%]	-4	3	-20
Heat aging 504 hours at 175 °C			
Hardness Shore A (1 second)	75	74	66
Delta Hardness	3	3	-3
Tensile properties (type 2) at 23 °C			
Tensile Strength [MPa]	10.6	11.3	9.9
Delta TS [%]	-46	-44	-35
Elongation at break [%]	290	292	256
Delta Elong. [%]	-26	-30	-29
Modulus at 50 % [MPa]	2.4	2.3	1.8
Delta 50% [%]	12	18	-1
Modulus at 100 % [MPa]	4.2	4.2	3.5
Delta 100% [%]	-8	5	-7
Heat aging 504 hours at 180 °C			
Hardness Shore A (1 second)	83	84	71
Delta Hardness	11	13	2
Tensile properties (type 2) at 23 °C			
Tensile Strength [MPa]	7.3	6.2	6.3
Delta TS [%]	-63	-69	-59
Elongation at break [%]	122	92	146
Delta Elong. [%]	-69	-78	-59
Modulus at 50 % [MPa]	4.0	4.2	2.1
Delta 50% [%]	86	115	16
Modulus at 100 % [MPa]	6.8		4.2
Delta 100% [%]	49		12

Table 8. Filler study in Vamac® Ultra HT-OR compounds: Fluid aging

	Ultra HT-OR T810T 50phr N550	Ultra HT-OR 1phr Diak™ N.1	Ultra HT-OR 90phr N990
Fluid aging 168 hours at 160°C in Lubrizol OS 206304			
Hardness Shore A (1 second)			
Shore A	68	66	63
Delta Hardness	-5	-5	-6
Tensile properties (type 2) at 23 °C			
Tensile Strength [MPa]	17.9	18.3	15.2
Delta TS [%]	-9	-9	0
Elongation at break [%]	360	370	350
Delta Elong. [%]	-6	-11	-1
Modulus at 50 % [MPa]	2.0	1.8	1.6
Delta 50% [%]	-7	-6	-13
Modulus at 100 % [MPa]	4.5	4.1	3.3
Delta 100% [%]	-3	4	-12
Volume change [%]	10	12	10
Fluid aging 70 hours at 150 °C in IRM 903			
Hardness Shore A (1 second)	58	56	55
Delta Hardness	-14	-15	-14
Tensile properties (type 2) at 23 °C			
Tensile Strength [MPa]	17.0	17.9	13.9
Delta TS [%]	-14	-11	-8
Elongation at break [%]	350	390	340
Delta Elong. [%]	-11	-8	-6
Modulus at 50 % [MPa]	1.6	1.5	1.3
Delta 50% [%]	-27	-25	-30
Modulus at 100 % [MPa]	4.1	3.8	3.1
Delta 100% [%]	-11	-5	-18
Volume change [%]	30	33	29
Fluid aging 504 hours at 100°C in EGR Solution VW - Acetic acid (pH=2.5), liquid phase			
Hardness Shore A (1 second)	69	66	64
Delta Hardness	-4	-5	-5
Tensile properties (type 2) at 23 °C			
Tensile Strength [MPa]	19.4	18.9	13.6
Delta TS [%]	-2	-6	-11
Elongation at break [%]	350	390	390
Delta Elong. [%]	-9	-7	9
Modulus at 50 % [MPa]	2.1	2.0	1.5
Delta 50% [%]	-3	0	-16
Modulus at 100 % [MPa]	4.7	4.4	3.1
Delta 100% [%]	4	10	-18
Volume change [%]	10	13	12

Material used in formulations and test fluids – general composition and suppliers

Material	Chemical Composition	Supplier
Polymer		
Vamac® Ultra HT-OR (VMX 3121)	Ethylene Acrylic Elastomer	DuPont Performance Polymers
Vamac® Ultra HT (VMX 3038)	Ethylene Acrylic Elastomer	DuPont Performance Polymers
Release Aids		
Armeen® 18D	Octadecyl Amine	Akzo Nobel
Vanfre® Vam	Complex Organic phosphate ester	R.T Vanderbilt
Stearic Acid	Carboxylic acid	Sigma-Aldrich
SaficRelease RPM	Poly(Ethylene Glycol Adipate)	Safic Alcan
Anti-oxidant		
Naugard® 445	Diphenyl Amine	Chemtura
Plasticiser		
Rhenosin® W759	Mixed Ether/Ester Plasticizer	Rhein Chemie
Edenol® T810T	Tri-Alkyl-mellitate	Emery Oleochemical
TegMer® 812	Ester Plasticiser	HallStar
Filler		
Spheron® SO N550	Carbon Black	Cabot
MT Thermax® Floform N990	Carbon black	Cancarb Ltd
Curatives		
Diak® No. 1	Hexamethylene Diamine Carbamate	DuPont Performance Poymers
Accelerator		
Vulcofac® ACT 55	Amine derivative	Safic Alcan
Test Fluids		
IRM 903	Test Fluid	
Long life III 5W30	5W30 engine oil	Castrol Limited
Lubrizol OS 206304	5W40 engine oil	Lubrizol Ltd

ISO testing methods were used to produce this technical bulletin and the ASTM are shown in the below table only for comparison purpose.

Rheology	ISO / ASTM standard	
Mooney Viscosity	ISO 289-1:2005	D1246
Mooney Scorch	ISO 289-2:1994	D1246
MDR	ISO 6502:1999	D5289
Physicals		
Hardness	ISO 7619-1:2004	D2240
Tensile, elongation	ISO 37:2005	D412
Fluid aging	ISO 1817:2005	D471
Heat aging	ISO 188:2007	D573
Compression set	ISO 815-1:2008	D395
Compression set VW	VW PV 3307:2004-08	
Tg by DSC	ISO 22768:2006	D7426
Tear strength	ISO 34	D624
De Mattia	ISO 132:2005	D430

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