



Performance of Vamac® and Viton® in Sealing Applications

DuPont Performance Polymers Conference

May 20th 2010

Albergo Cocca Hotel

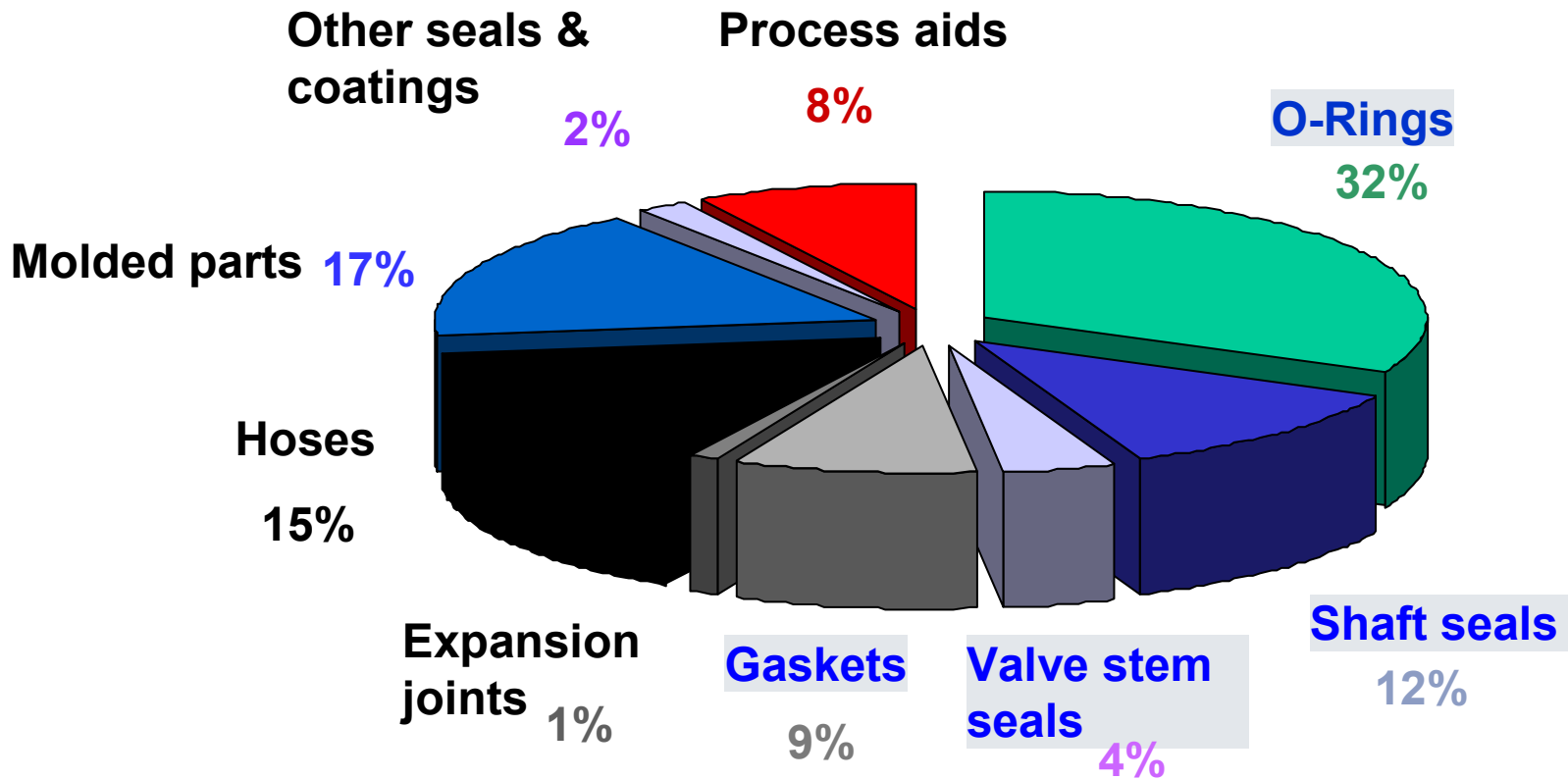
Sarnico (Bg)



The miracles of science™

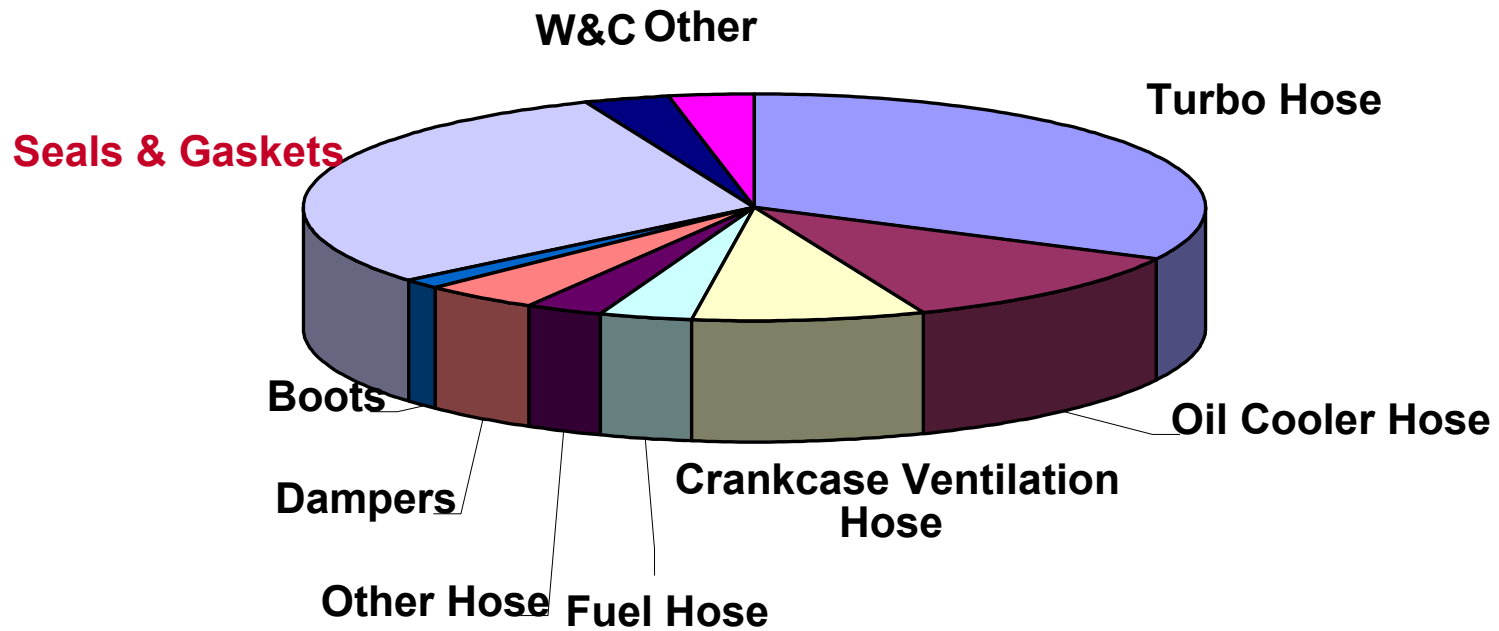
Pepa Mayor-Lopez

- ◆ Market outlook for Viton® and Vamac®
- ◆ Applications
- ◆ Sealing performance
 - ◆ Heat resistance
 - ◆ Chemical resistance
 - ◆ Compression Set and Compressive Stress Relaxation
 - ◆ Low Temperature Sealing
- ◆ 2K molding



All applications involve combinations of high and low temperature and/or aggressive fluids -> **60%+ automotive market**

*based on 2004 data



Major growth segments:

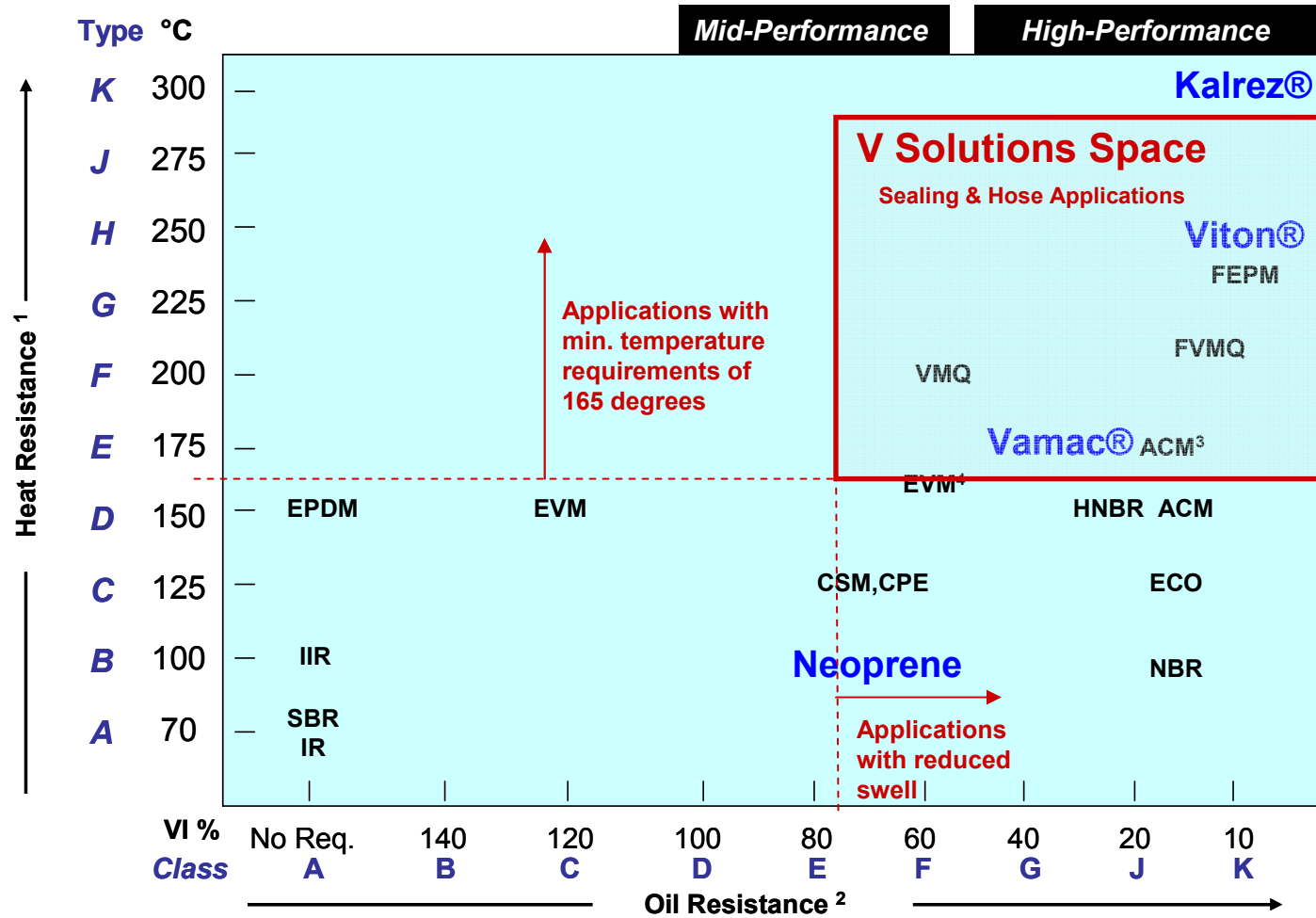
- Turbo hoses (volume wise)
- Crankcase venting and vacuum hoses (blow-by environment)
- Oil cooler Hoses
- Fuel hose covers
- Seals & gaskets

-> 90%+ automotive market

- ◆ **Bridge a gap between two substrates**
 - statically
 - dynamically

- ◆ **Provide this sealing function**
 - at high temperature
 - long term
 - in chemically harsh environments
 - without leakage at low temperature
 - at acceptable economy

Heat and Oil Resistance of Elastomers



1. Maximum temp. at which vulcanizates can be aged for 70 hrs with changes in tensile strength no greater than ± 30%, elongation no greater than -50%, and hardness no greater than ± 15 points

2. % volume increase in ASTM IRM 903 Oil, 70 hrs exposure
 3. New ACM grades
 4. High VA content grades



Fuel Systems

- Filler line and filler neck hose and covers – Viton®, Vamac®
- O-rings and gaskets – Viton®
- Injector O-rings – Viton®
- Fuel sender seals – Viton®
- Fuel cap seals – Viton®
- Fuel filter seals – Viton®



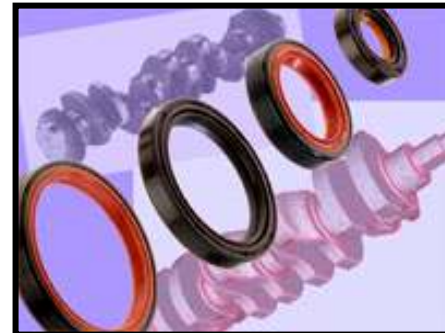
Air Mgmt, Engine, Exhaust

- Turbo charger and other hoses – Viton®, Vamac®
- AIM gaskets – Viton®, Vamac®
- Intercooler seals – Viton®, Vamac®
- Quick Connectors – Viton®, Vamac®
- Ventilation seals – Viton®, Vamac®
- Others – Viton®, Vamac®



Oil and Grease, Powertrain

- Shaft seals – Viton®, Vamac®
- Transmission seals – Viton®, Vamac®
- Ball bearing seals – Viton®, Vamac®
- Oil drain turbo hoses – Viton®, Vamac®
- EOC & TOC hoses – Viton®, Vamac®
- Boots, molded goods – Vamac®
- Dampers – Viton®, Vamac®
- MLS head cylinder gaskets – Viton®
- Oil pan gaskets – Viton®, Vamac®
- Cam cover gaskets – Viton®, Vamac®
- Oil filter seals – Viton®, Vamac®
- `Others – Viton®, Vamac®



Non-Auto Trans

- Hoses - Viton®, Vamac®
- O-rings, gaskets – Viton®, Vamac®
- Others - Viton®, Vamac®



Oil & Gas

- O-rings, V-rings and gaskets – Viton®
- Packers – Viton®



Chemical Processing, Utilities & Industries

- Bio fuel storage & handling - O-rings, gaskets, hoses, custom parts – Viton®
- Flue duct expansion joints – Viton®
- Hydraulic hoses -Vamac®



'Clean' Environment

- Vamac® for photovoltaic production membrane
- FDA-compliant parts made from select Viton® polymers



Wire & Cable

- Halogen free, flame retardant - Vamac® compounds
- Jacketing - Viton®, Vamac®

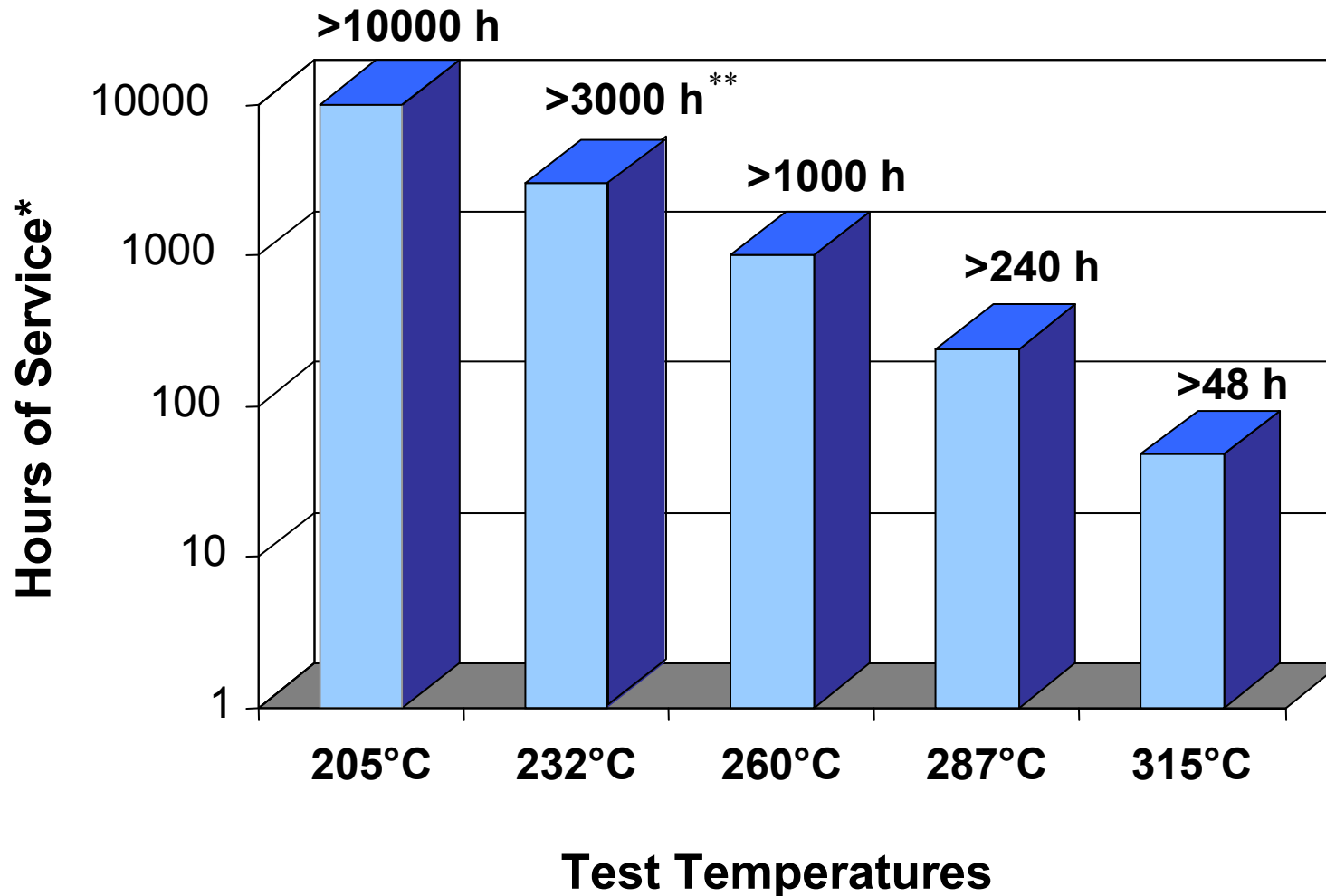


Viton® Fluoroelastomer



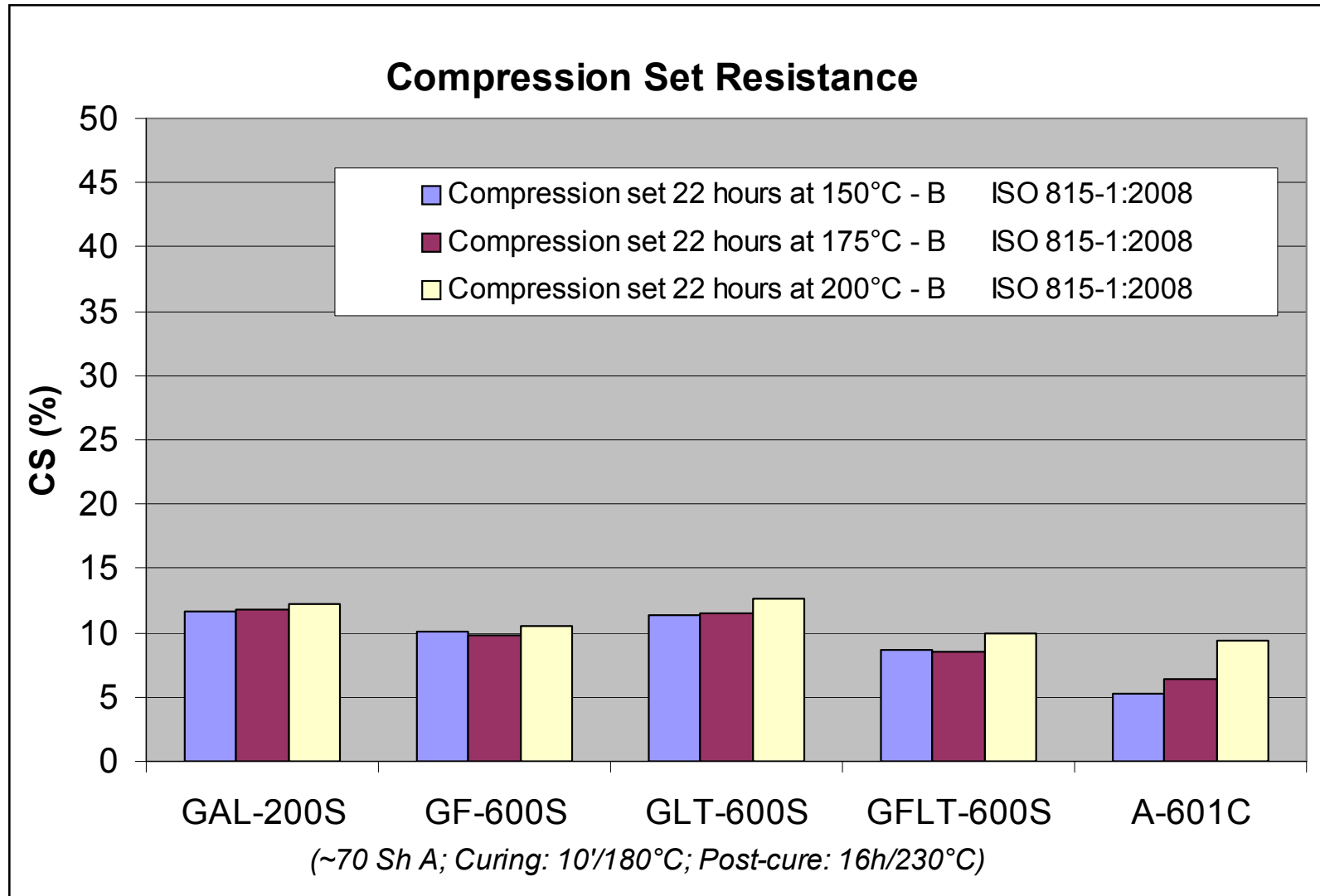
The miracles of science™

- **Continuous service temperature of 205°C**
- **Short term excursions to as high as 300°C**
- **Low swell in hot motor oil / ATF**
- **Very low swell in motor fuels**
 - gasoline, bioalcohols, diesel, biodiesel
- **Low temperature flexibility (-30°C to -40°C)**
- **Low compression set at 200°C**
- **Excellent sealing properties**
 - Compression set, compressive stress relaxation



* Approximate number of hours at which typical vulcanizate of Viton® will retain 50% of its original elongation at break. Data based on a standard 66% fluorine type (A family).

** car: 180'000 km at 60 km/hour. "normal car lifetime"

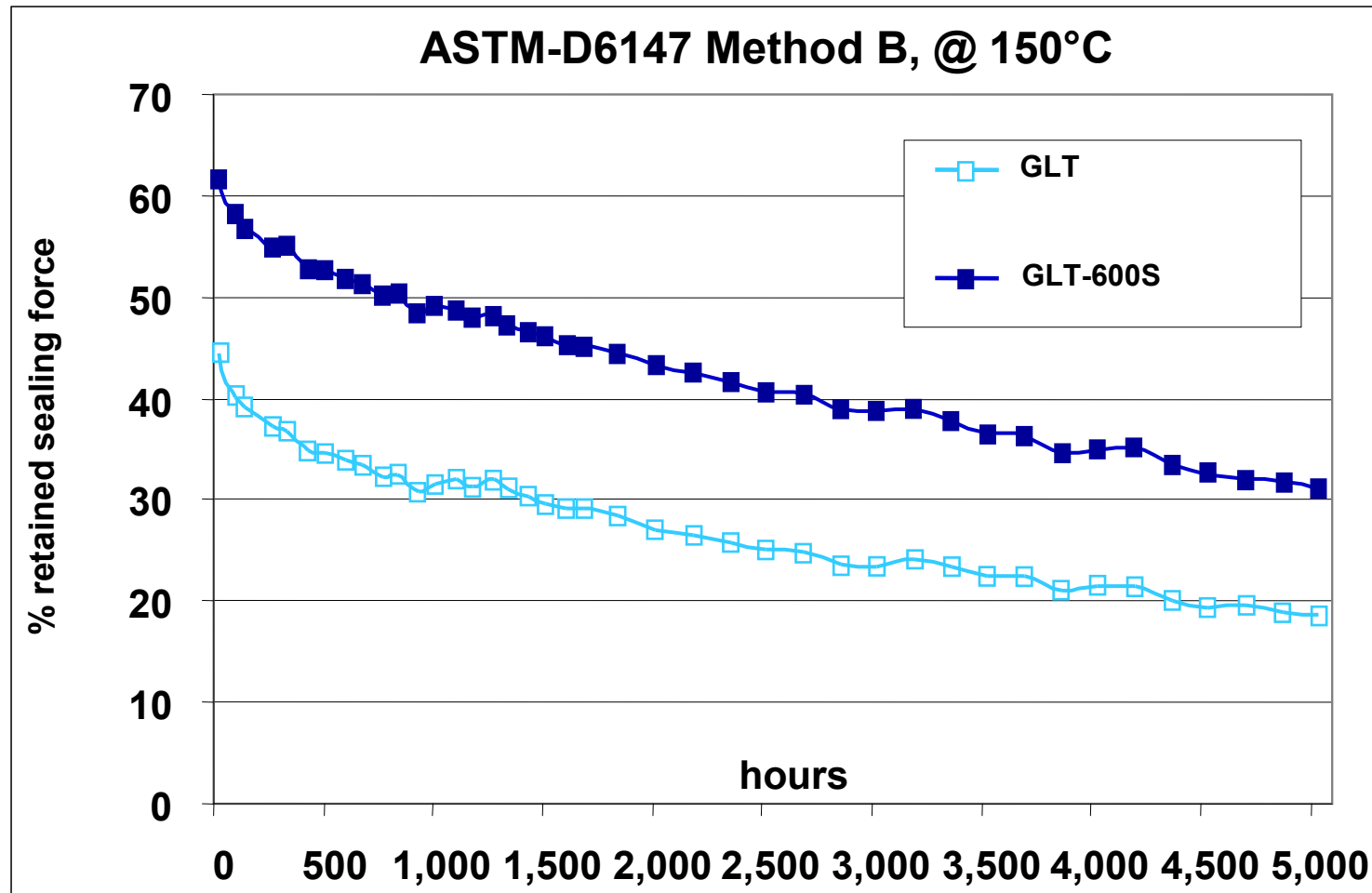


Sealing performance - Compressive Stress Relaxation

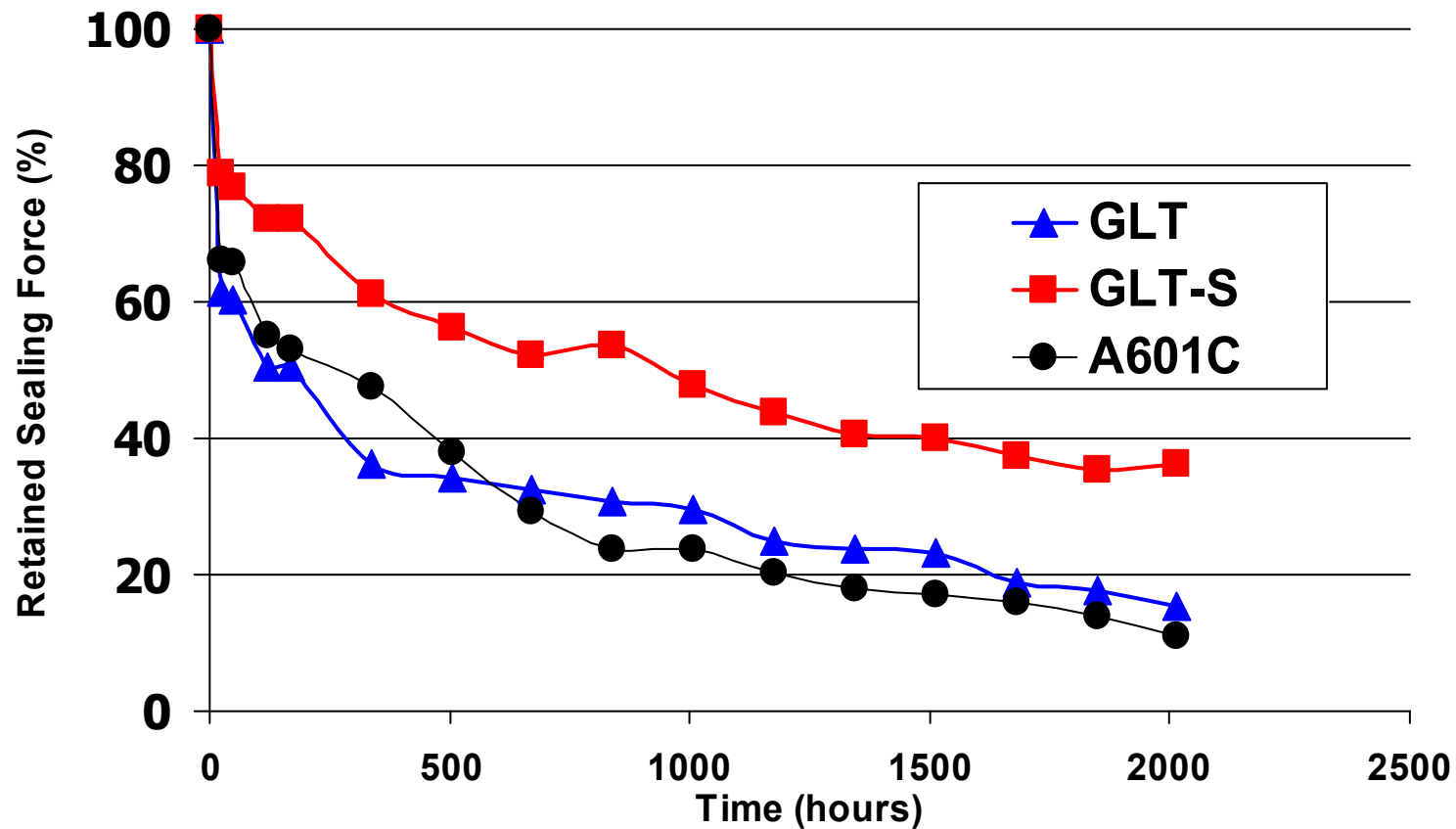
- CSR is a measure of the residual counter force against compression after exposure to heat and/or fluid under constant deformation
- It is a more realistic representation of **sealing capability and durability of elastomeric materials in use**
- Gaining attention as a screening tool



Compression set is the first indication,
but a more realistic picture is given by Compression Stress Relaxation



Stress Relaxation in Mobil Jet Oil 291 at 200°C



*Aerospace Gas Turbine HTS Oil (HTS, High Thermal Stability)



excellent

- hydrocarbons (solvents, fuels...)

very good

- chlorinated solvents
- mineral acids
- aromatic solvents
- oxidising fluids

fair to good

- hot aqueous fluids, e.g. acids and steam

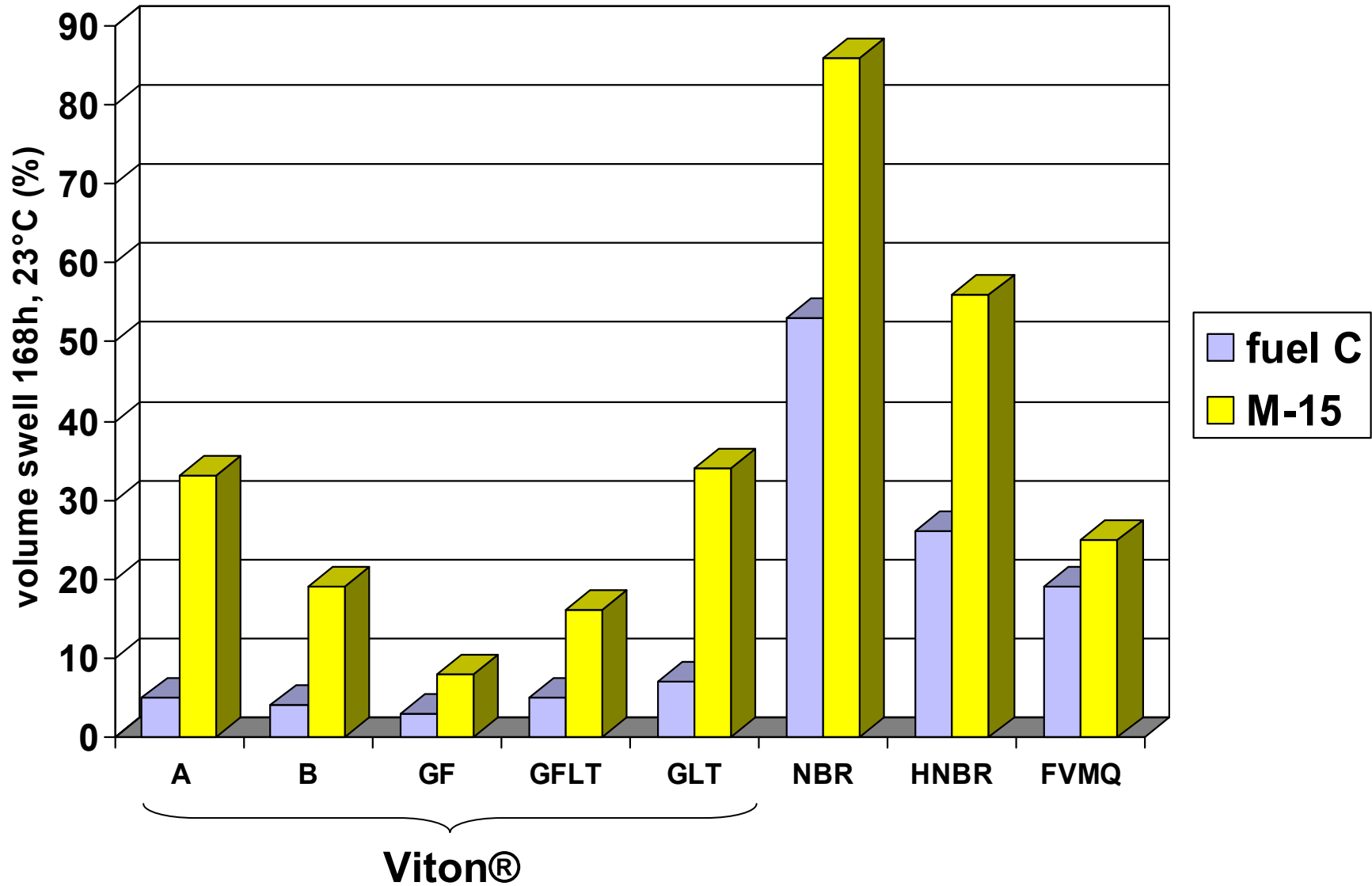


critical

- chemical attack
 - ◆ strong bases
 - ◆ strong organic acids, aldehydes
 - ◆ ammonia and amines
- high volume swell
 - ◆ low molecular weight ether,
 - ◆ ester and ketones



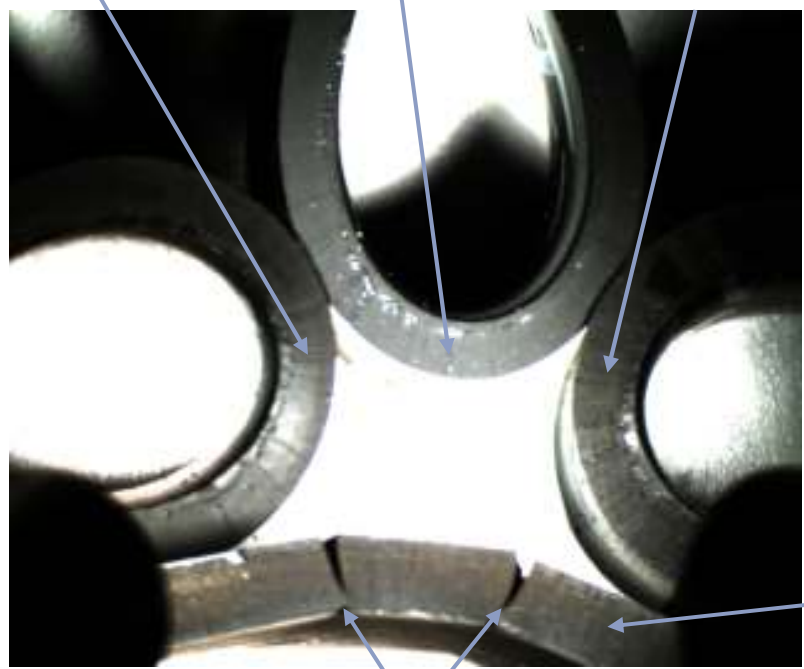
**Viton® Extreme™ Fluoroelastomers
or Kalrez® are preferred**



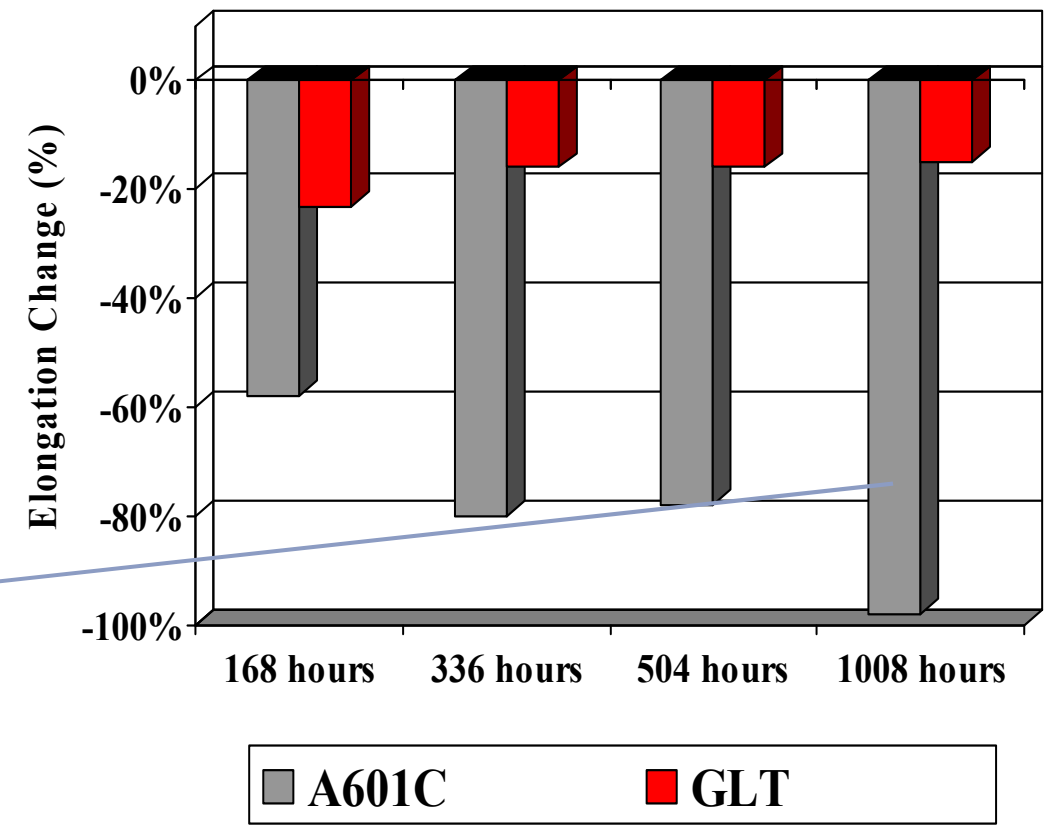
Fuel M-15 composition is 85% Fuel C and 15% methanol

Elongation change Aged in Ref. Oil 300* at 200°C (oil changed weekly)

**Original
GLT** **Original
A601C** **GLT after 1008
hours at 200°C**

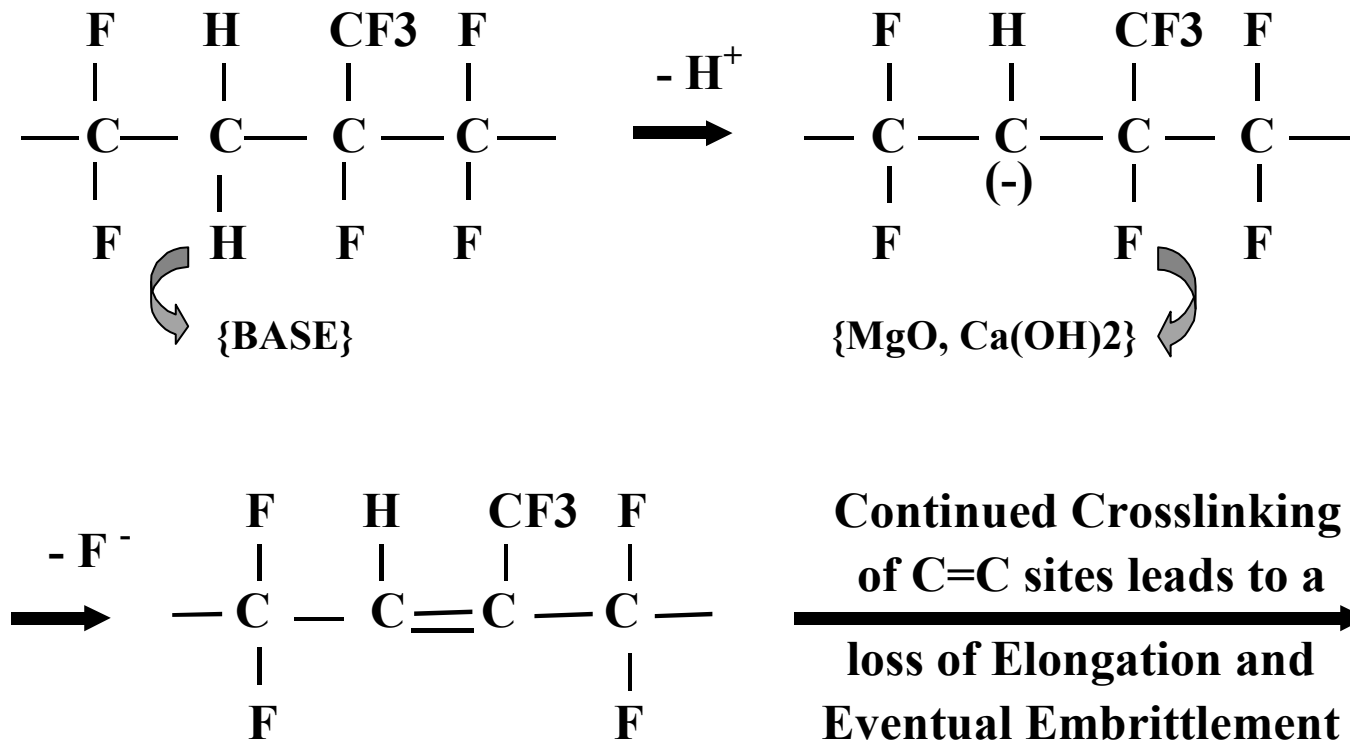


**Embrittlement of
A601C after 1008
hours at 200°C**



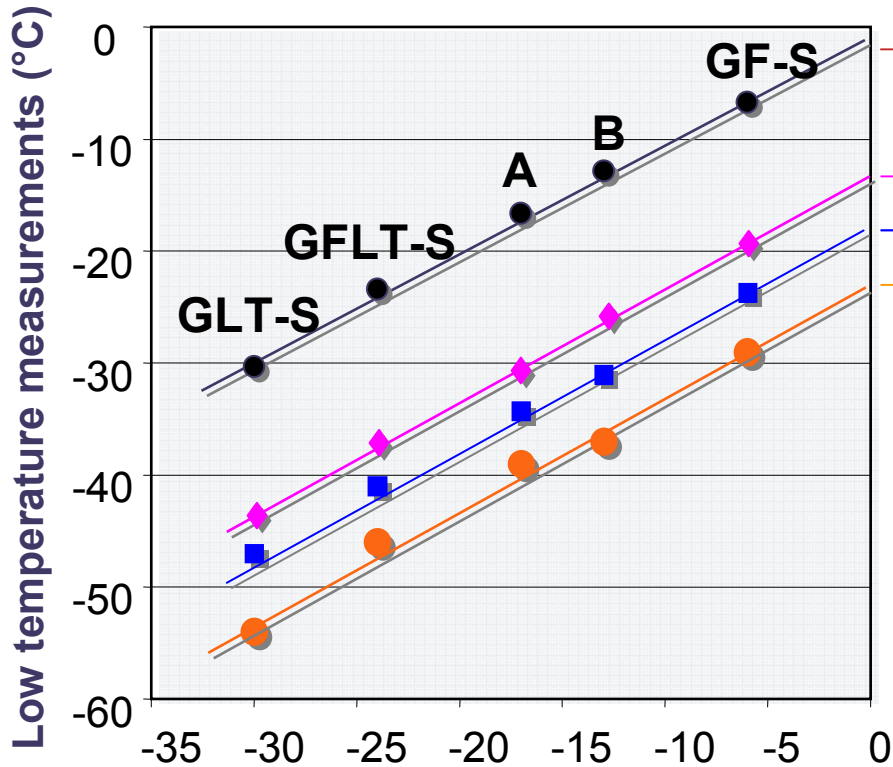
A proposed mechanism of chemical attack on standard fluoroelastomers

Base Attack on VF₂ / HFP FKM (VF₂ /HFP Sequences are the weak link in FKM)



Gasket requirements

-Low Temperature Flexibility



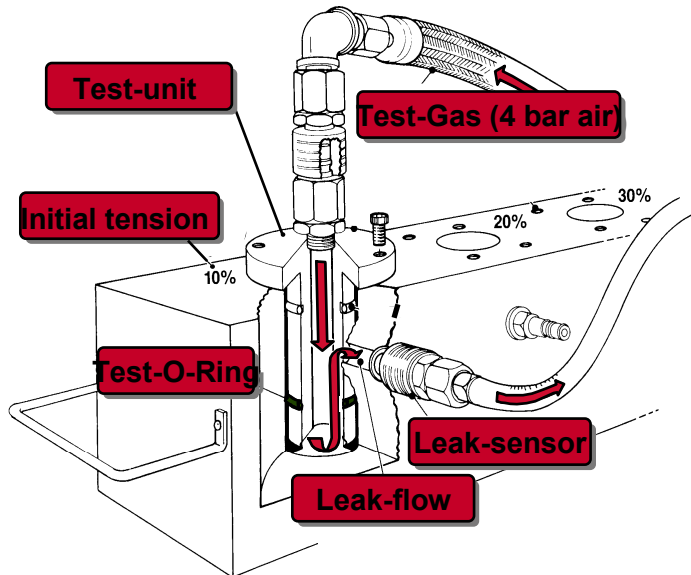
- Tg (DSC, inflection)
- Sealing — dry O-ring
- Sealing — soaked in unleaded fuel
- Sealing — soaked in fuel C

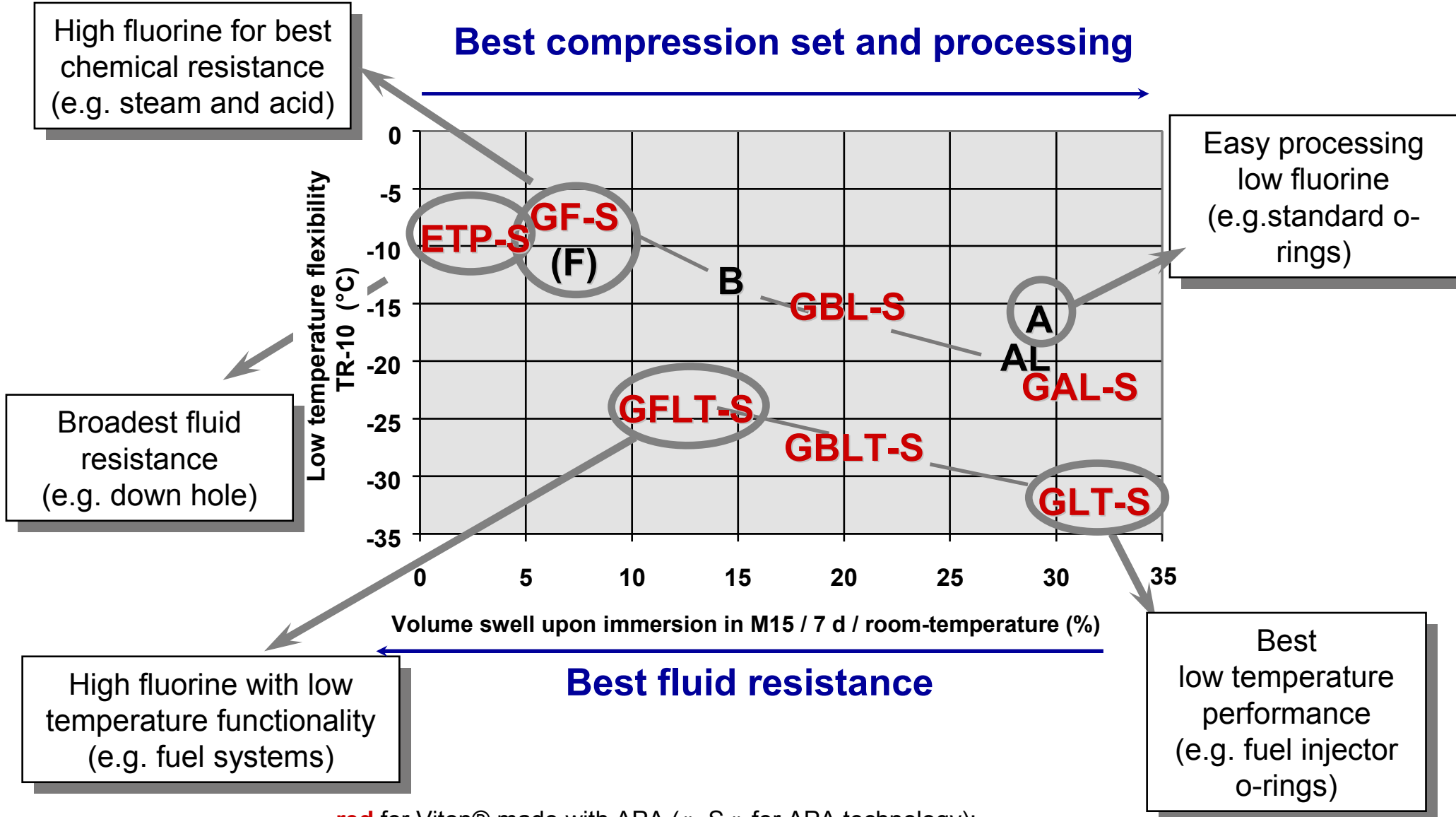
Static sealing possible at about 15°C below polymer Tg

Conditioning in fuel plasticizes the seal and lowers sealing temperature

e.g. GLT-S seals to :

- about -45°C (dry)
- about -48°C (conditioned in unleaded fuel)
- about -54°C (conditioned in Fuel C)





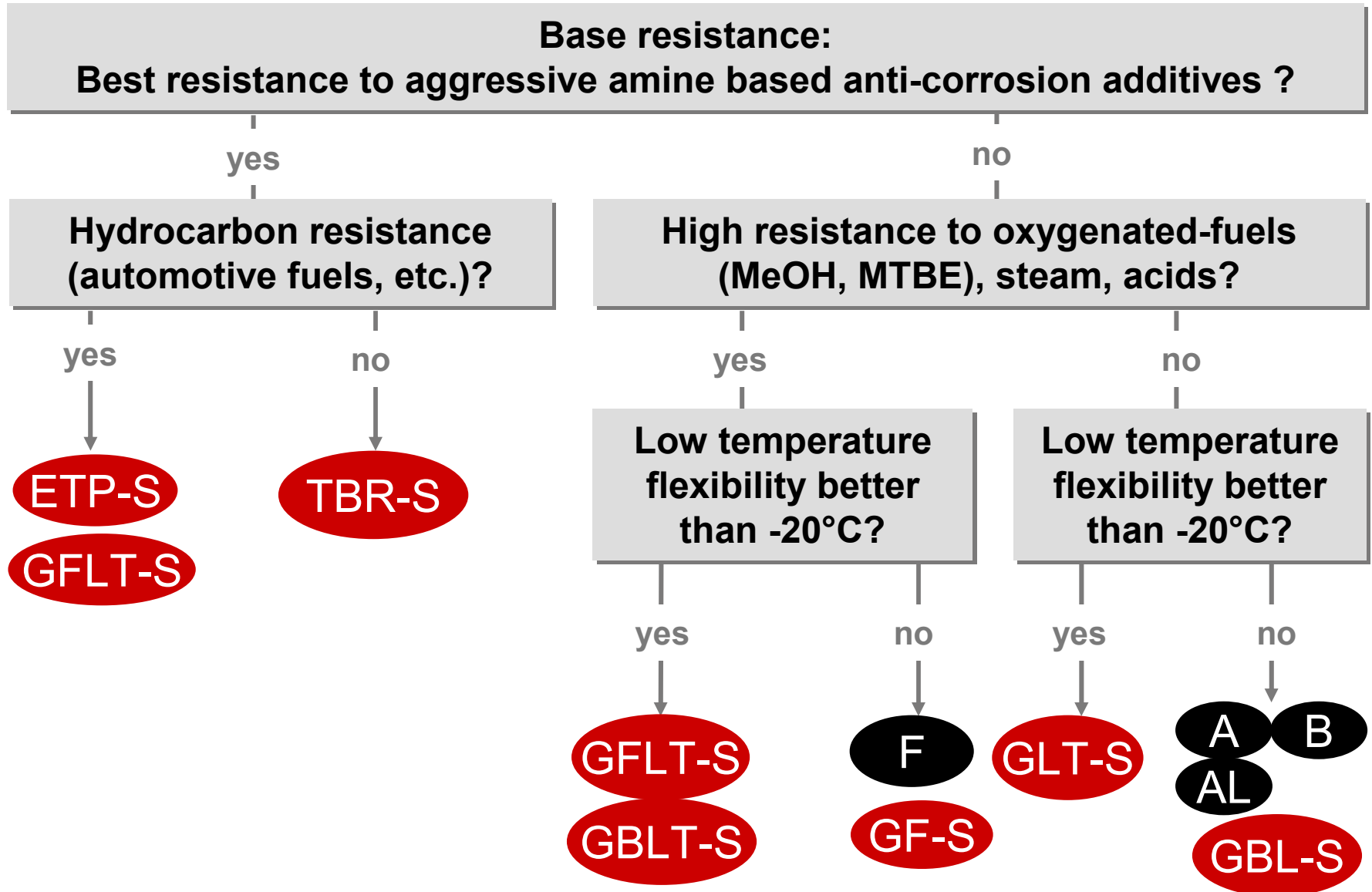
red for Viton® made with APA (« -S » for APA technology);
 « G » for peroxide curing vs. bisphenol curing, « LT » for low temperature

Viton® product	A	AL	B	F	GAL-S	GBL-S	GF-S	GLT-S	GBLT-S	GFLT-S	TBR-S	ETP-S
Curing system	bisphenol	bisphenol	bisphenol	bisphenol	peroxide	peroxide	peroxide	peroxide	peroxide	peroxide	bisphenol	peroxide
Fluorine content	66%	66%	68.5%	70%	65.5%	67.5%	70%	64.5%	66%	67%	60%	66%
Heat resistance	All Viton® products have outstanding thermal properties											
Chemical resistance* *	○	○	★	★★	★	★	★★	○	★	★★	○	BEST
Base resistance	✘	✘	✘	✘	○	○	○	★	★	★	BEST	BEST
Low temperature properties	★	★★	★	○	★★	★	○	BEST	★★	★★	✘	○
Compression set resistance	BEST	★★	★★	★	★★	★★	★★	★★	★★	★★	★	★
Relative cost of polymer	low	low	low	low	low	low	low	medium	medium	medium	low	high

BEST **Excellent** ★★ **Very good** ★ **Good** ○ **Fair** ✘ **Poor**

“S” indicates products made with Advanced Polymer Architecture

* Consult the Chemical Resistance Guide at www.dupontelastomers.com or contact your Viton® specialist.



DuPont Performance Elastomers When it Matters

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Products > Viton® > Technical Info > Selection Guide

Viton® Selection Guide

Viton®

- Technical Info
 - Selection Guide
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- Applications
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- Request Info

Search

Instructions

The choice of the most appropriate type of Viton® for any given application will be determined by the end-use service, and in particular, whether the finished part must provide:

- Resistance to amines or caustics
- Resistance to hydrocarbon fluids
- Flexibility at low temperatures.

To Determine Which Type of Viton® is Best Suited For An Application, Please Answer The Following Questions:

Does The Application Require Base Resistance? (Resistance To Strong Caustics, Primary Amines)

Details

Yes

No

How I Arrived Here

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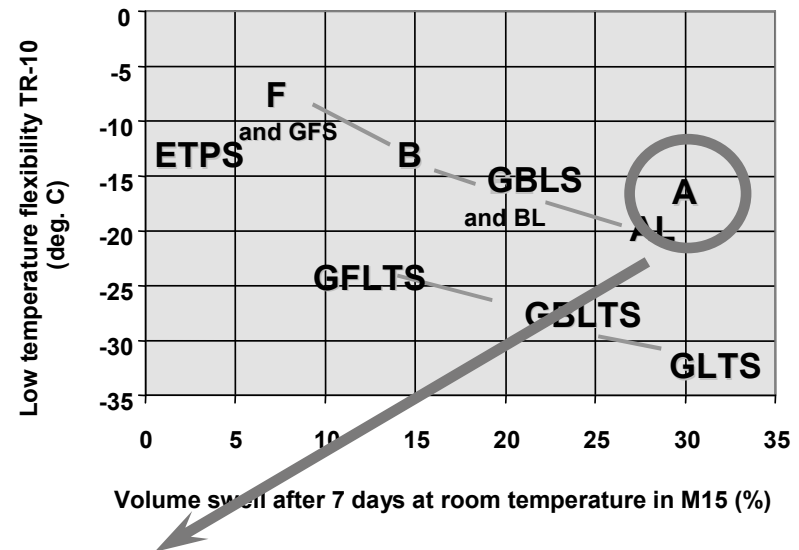
Viton® Fluoroelastomer Offering – Examples –



The miracles of science™

Important criteria

static seals
compression set
processing



A Type

A-201C, A-202C → VTR-9160 → NGDP

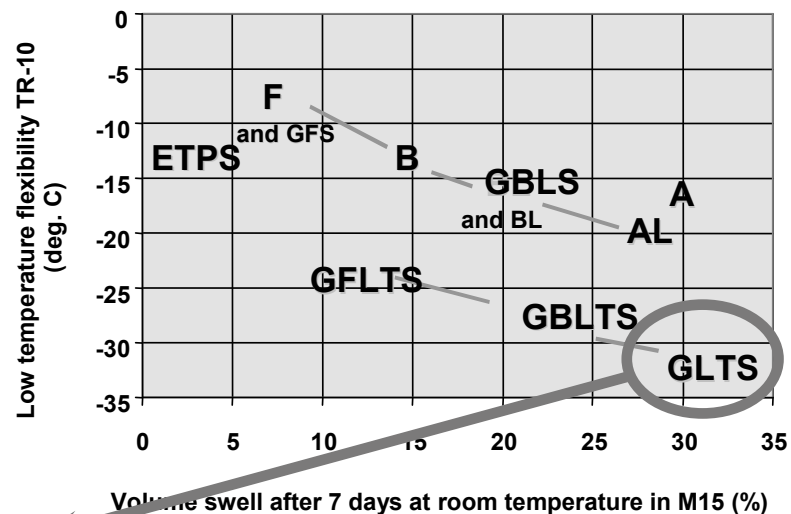
- **NGDP (Next Generation DiPolymer)**
- Broader operating window with better compression set
- **Triangle** strategy

Important criteria

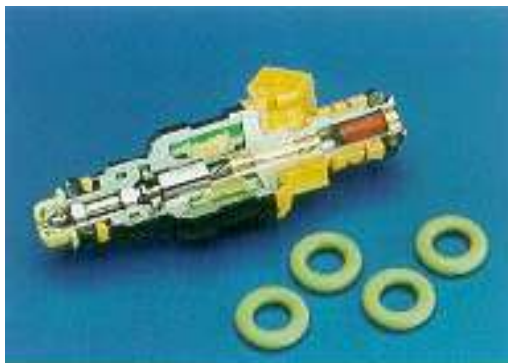
static seals

sealing at temperatures at or below -40°C

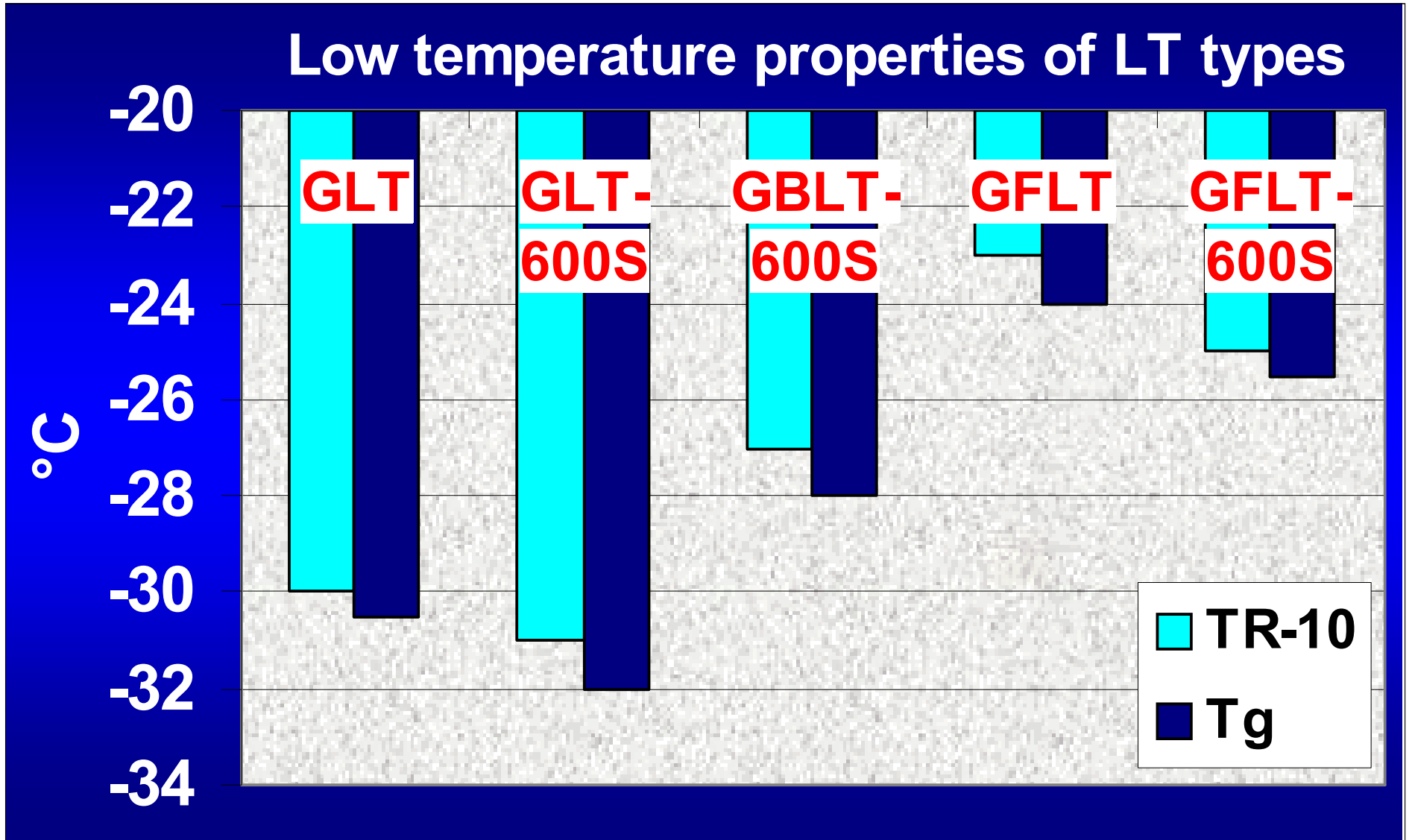
fuel resistance



GLT-S Types
GLT-200S/GLT-600S

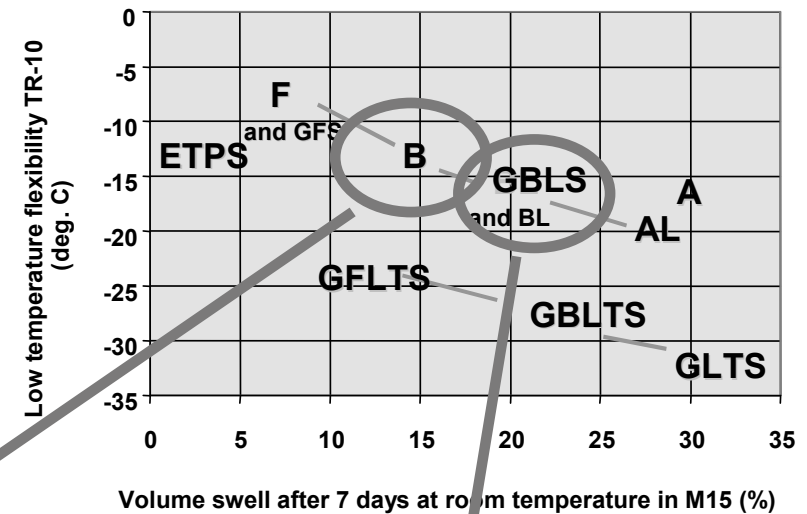


Biodiesels : Peroxide curable Viton® without metal oxide
Oxygenated fuels: High fluorine types



Important criteria

dynamic seals
aggressive oils
metal adhesion



B Types

B-651C->B-435C, B-135C

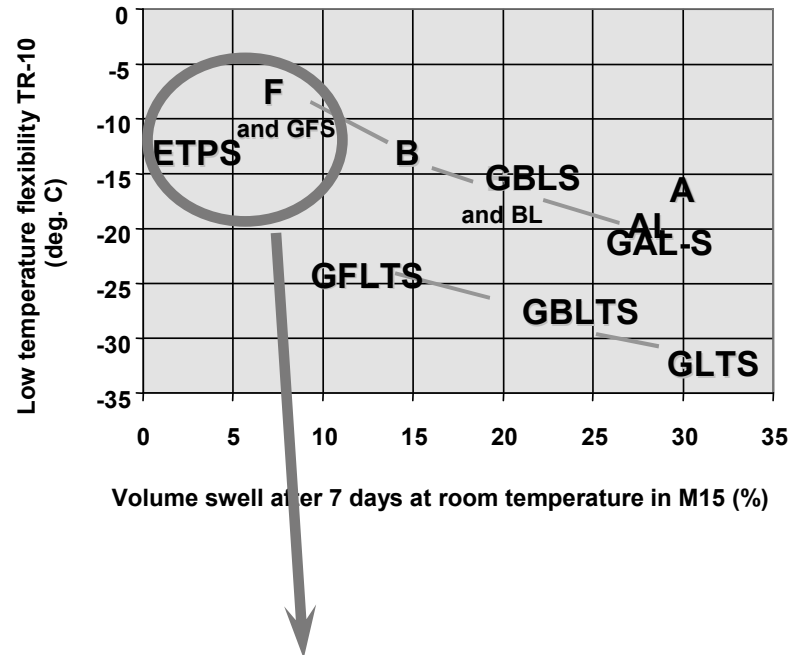
APA

GBL-S or GF-S

Chemical Resistance - e.g. PHEG, CPUI, oil & gas

Important criteria

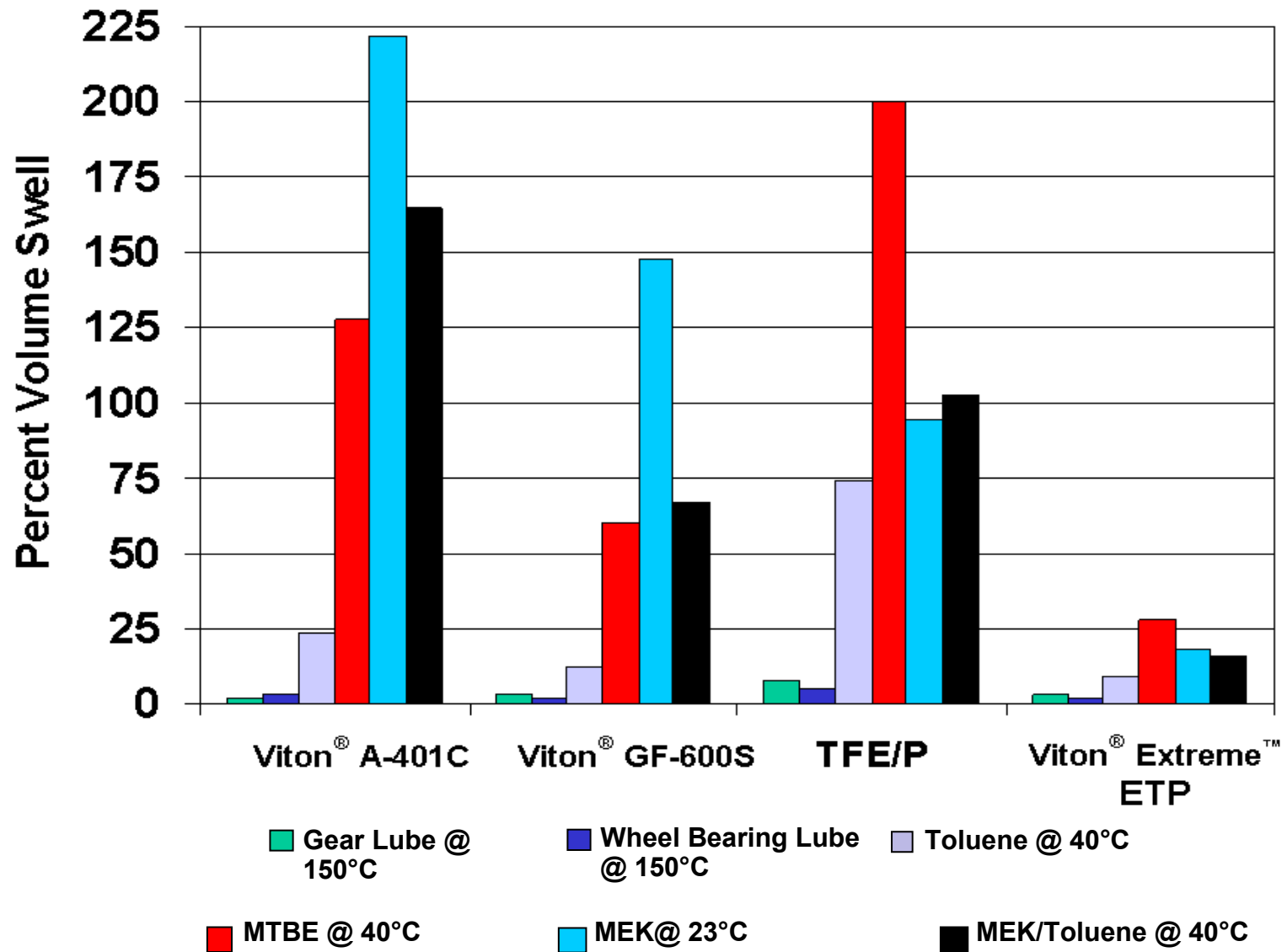
- broad chemical resistance
- processing



GF-S or ETP-S families

Viton® GF-200S / GF-600S

Viton® Extreme™ ETP-600S





Vamac® Ethylene Acrylic Elastomer



The miracles of science™

TEMPERATURE RESISTANCE:

High temperature durability

Good low temperature flexibility

FLUID RESISTANCE:

Good Oil and Blow-by Gas Resistance

Excellent Water Resistance up to 110-130 C

Outstanding Ozone/ Weather Resistance

New synthetic Engine Oils causing lower volume swell

Low gas & oil permeability

MECHANICAL PROPERTIES:

Good mechanical properties.

Good abrasion resistance

SEALING PERFORMANCE:

Excellent compression set resistance

Very good compressive stress force retention

ADHESION PROPERTIES:

Excellent adhesion to metals:
allow use of water-based bonding agents
to reduce output of VOCs (Volatile
Organic Components).

Good adhesion to polyamide

VIBRATION DAMPING PERFORMANCES:

High /Consistent vibration Damping
Capability

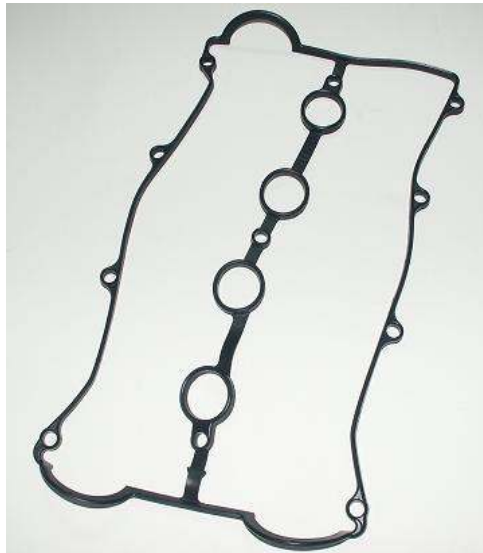
**Vamac® has
good resistance to**

- Lubricating oils and greases (mineral or synthetic based)
- Transmission / power steering fluids
- Diesel fuel
- Kerosene
- Water up to 110 °C (in continuous)
- Dry and wet sour gases
- Diluted acids and bases
- Blow-By & EGR

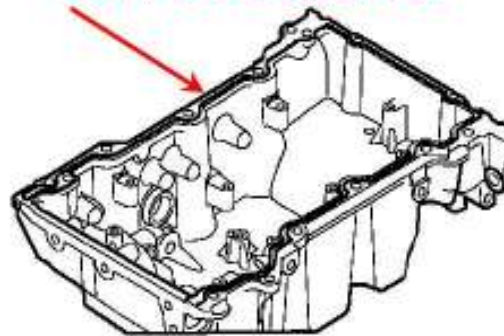
Fluids to avoid

AROMATIC HYDROCARBONS: gasoline, benzene, toluene
POLAR ORGANIC FLUIDS: esters, ketones, amines
HIGH and LOW ph-value WATER BASED SOLUTIONS: risks of hydrolysis

Rocker Cover Gasket



Oil Pan Gasket



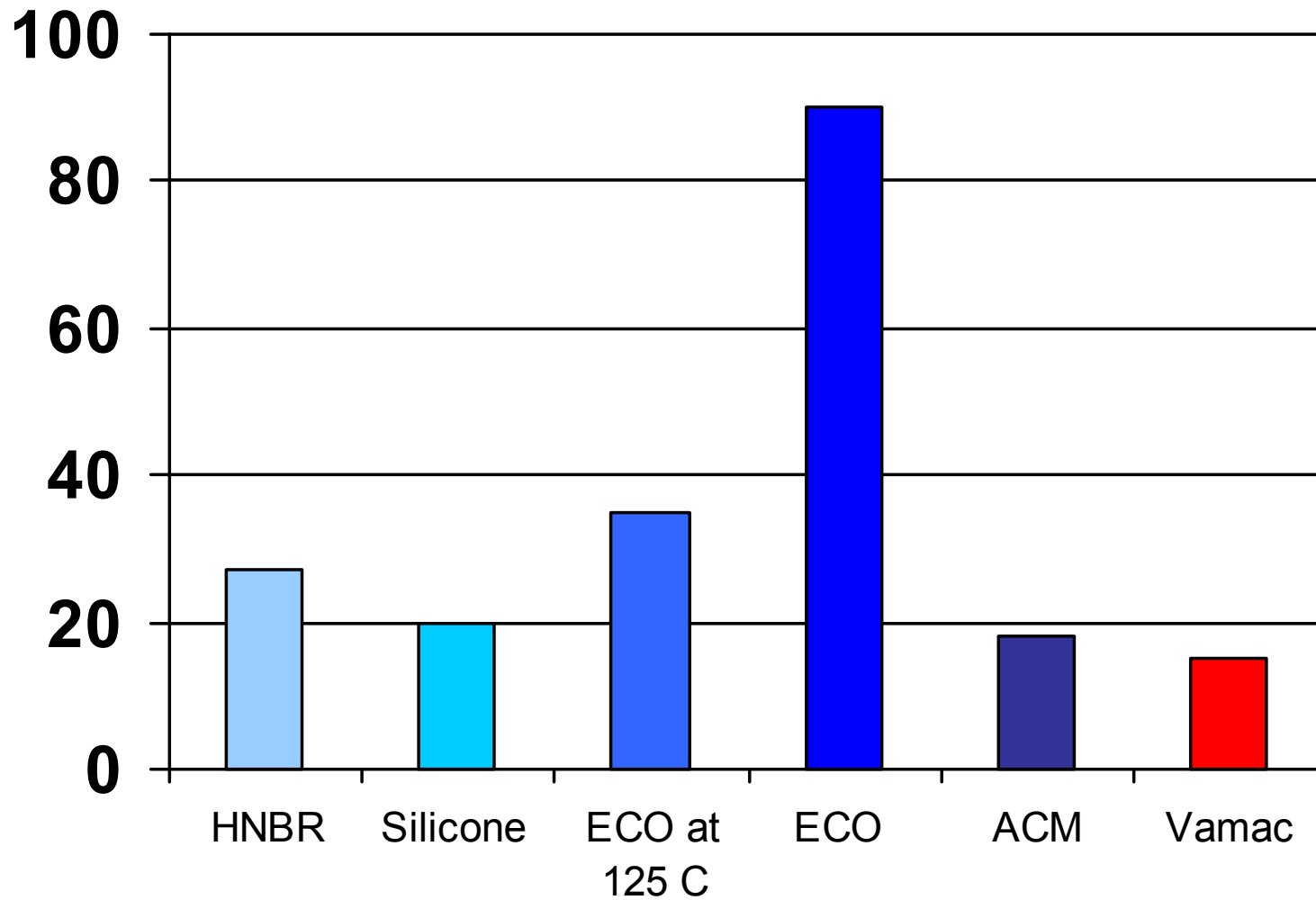
Transmission seals



- **Vamac® Ultra IP & VMX 3110** especially for low hardness applications
- 2K moulding Vamac®/Zytel®
- **Viton®** if continuous heat exposure > 180°C

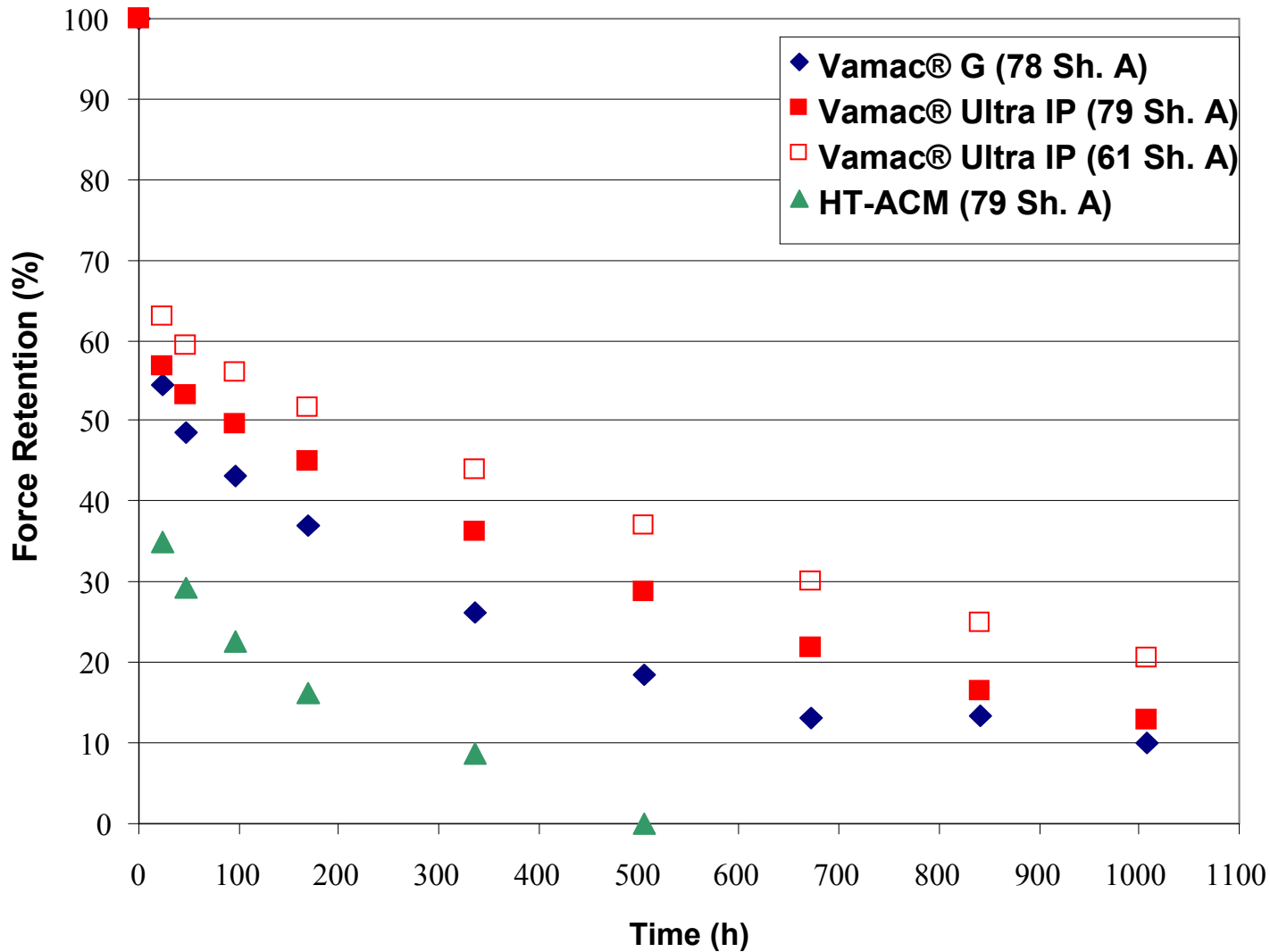
70 Shore A, 70 h @ 150°C, ASTM D 395 (Method B, 13 mm plied)

CS (%)



Sealing Performance of Vamac® vs HT-ACM in Hot air @ 150°C

Compressive Stress Relaxation in Air @ 150°C



Acc. To ISO 3384
Method B

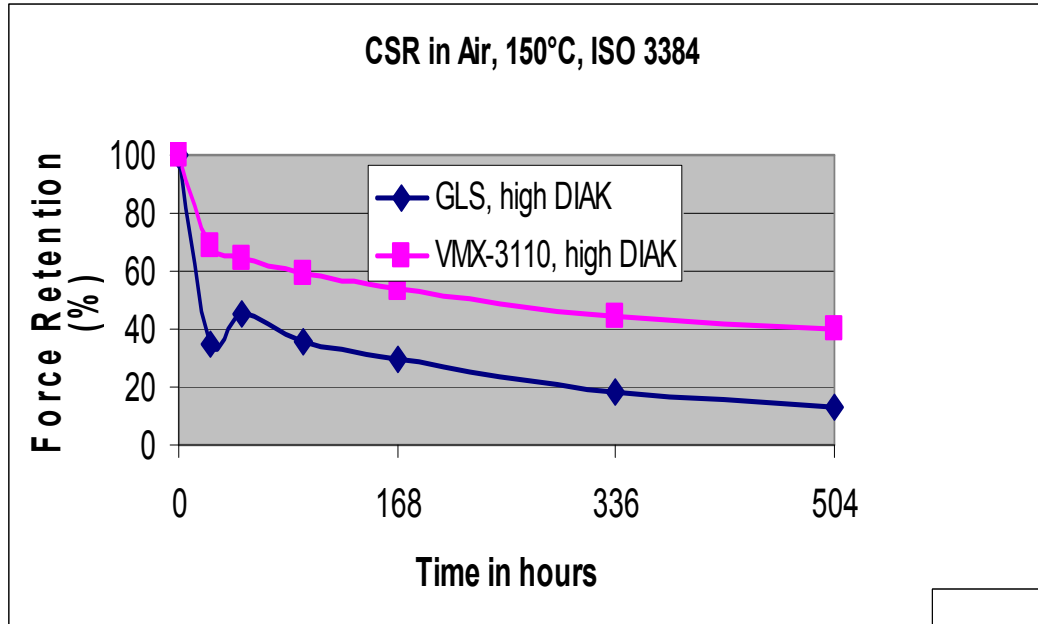
Shawbury Wallace
Test Equipment

Cylindrical Specimen,
6 mm high & 13 mm
diameter

**Higher force
retention stands for
better sealing
performance**

Force Retention Ranking: Vamac® Ultra IP > Vamac® G >> HT ACM

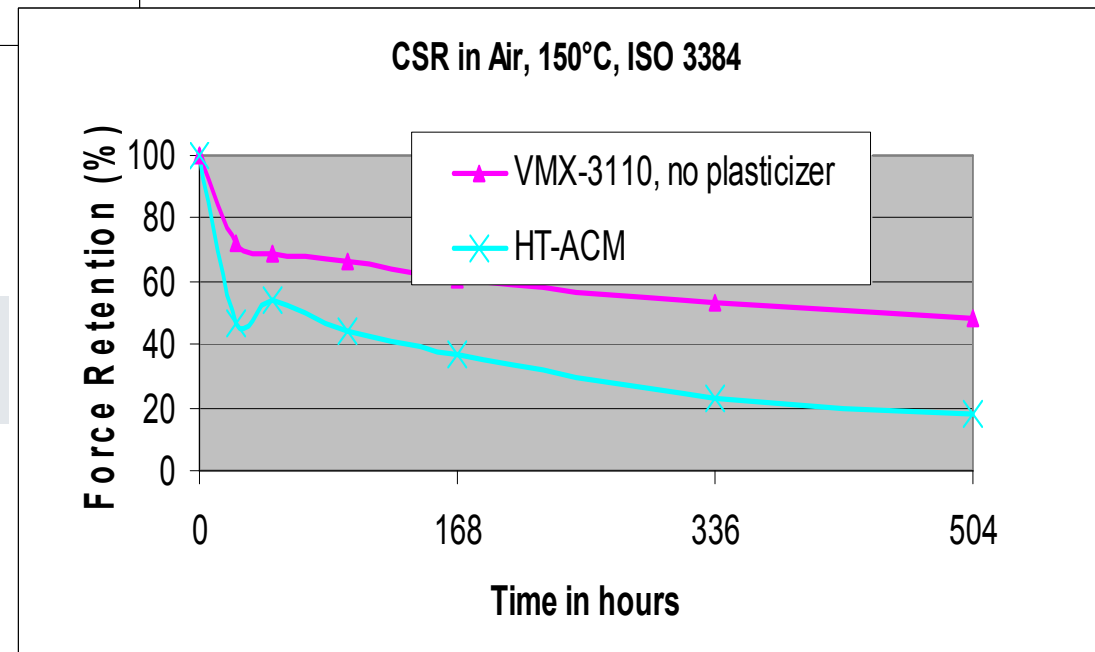
VMX-3110 Compressive Stress Relaxation in Air (60 Sh.A)



Vamac GLS and VMX-3110 with identical formulations (1.75 phr DIAK No1 & 20 phr of plasticiser)

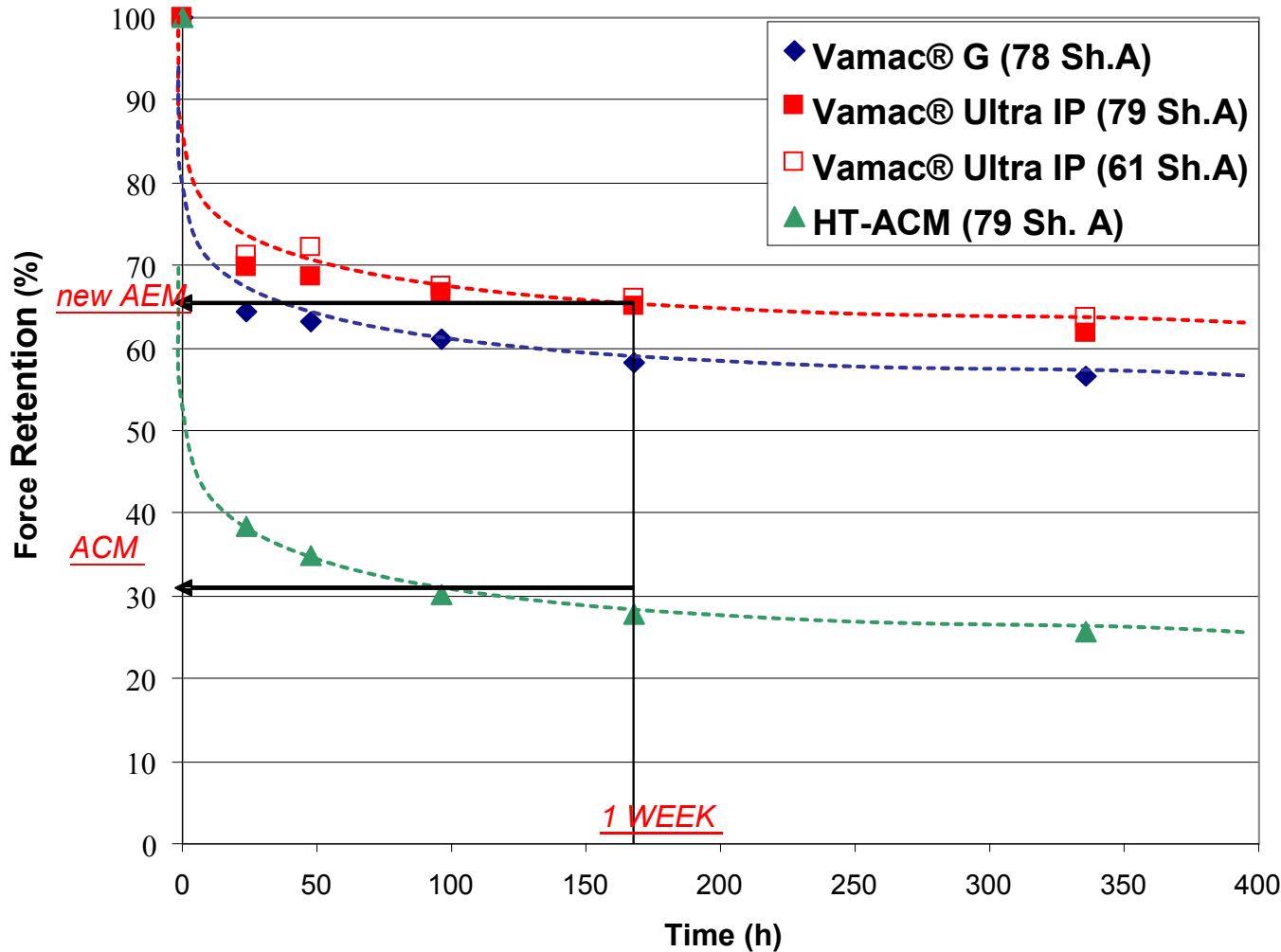
→ VMX-3110 provides significant improvement

Both formulations without plasticiser
→ VMX-3110 significantly better than HT-ACM



Sealing performance of Vamac® vs HT-ACM in New Synthetic Engine Oil

Compressive Stress Relaxation in oil (Castrol SLX LL III, 5W30 / 150°C)



According to ISO 3384 - Method B

Shawbury Wallace Test Equipment used

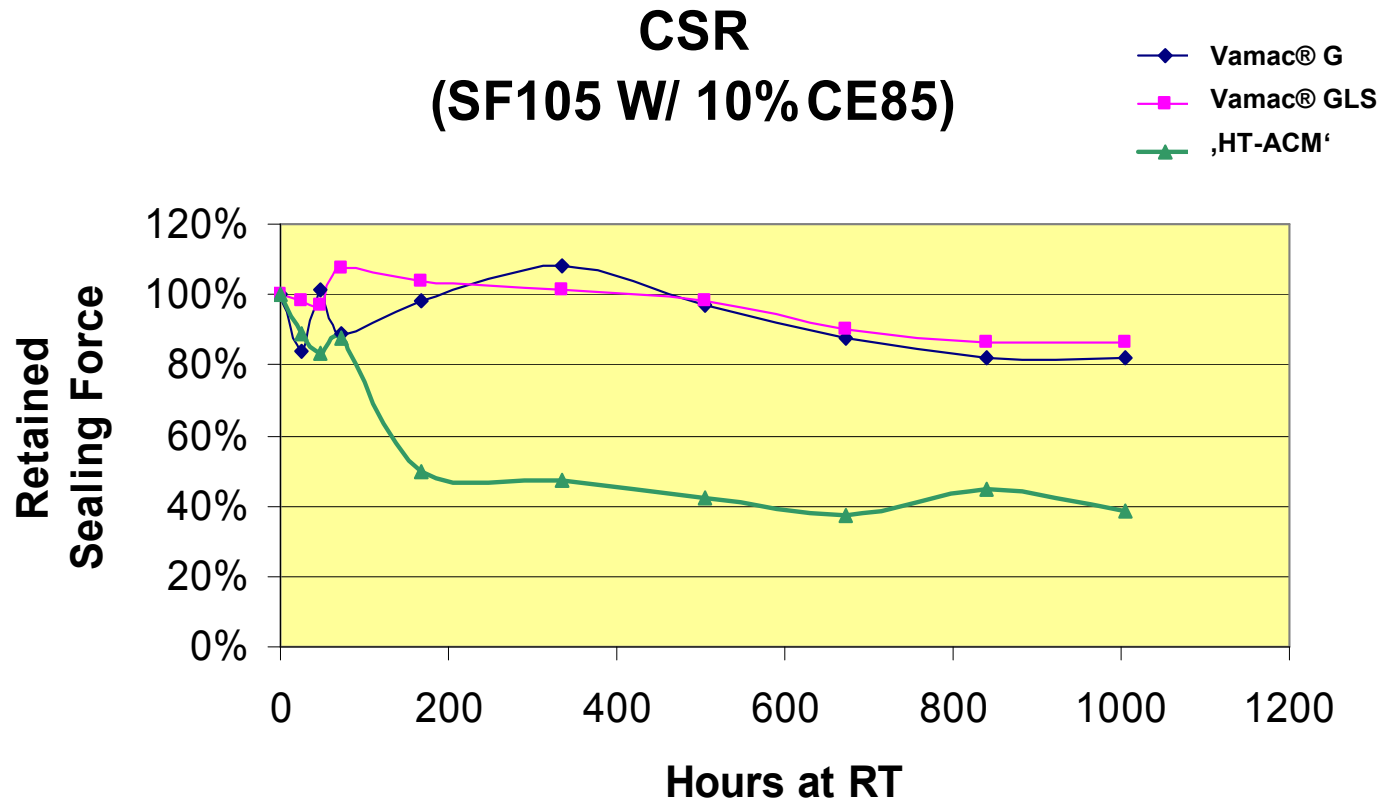
Molded pips, 6 mm high & 13 mm diameter

Higher force retention stands for better sealing performance

After one week, Vamac® Ultra IP shows more than double force retention level vs. HT ACM at same hardness level.



New test specifications include elastomer testing in Oil / Fuel blends, very often in a 90% / 10% blending ratio.

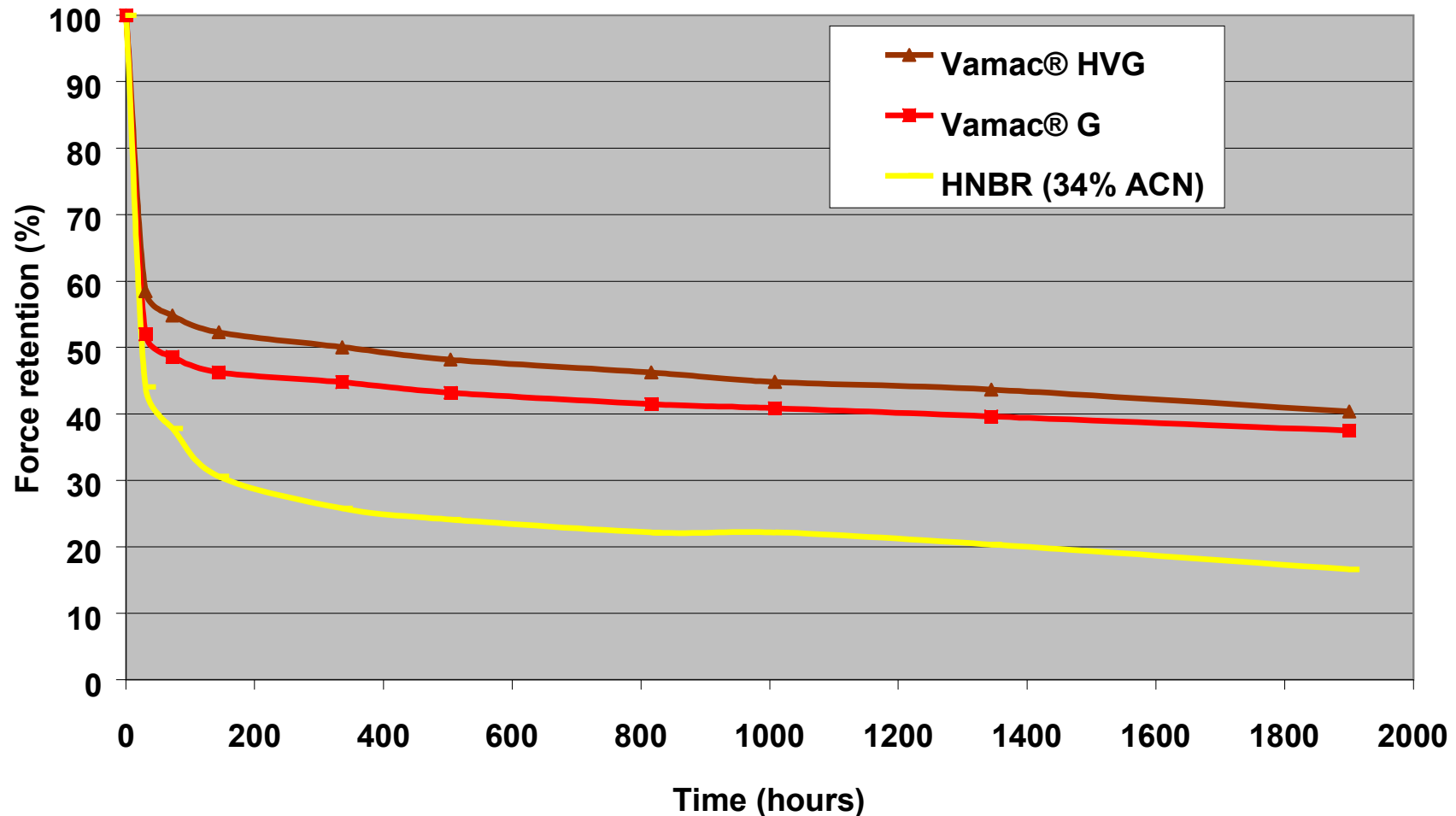


CE85 stands for Fuel C/Ethanol in a 15/85 blend

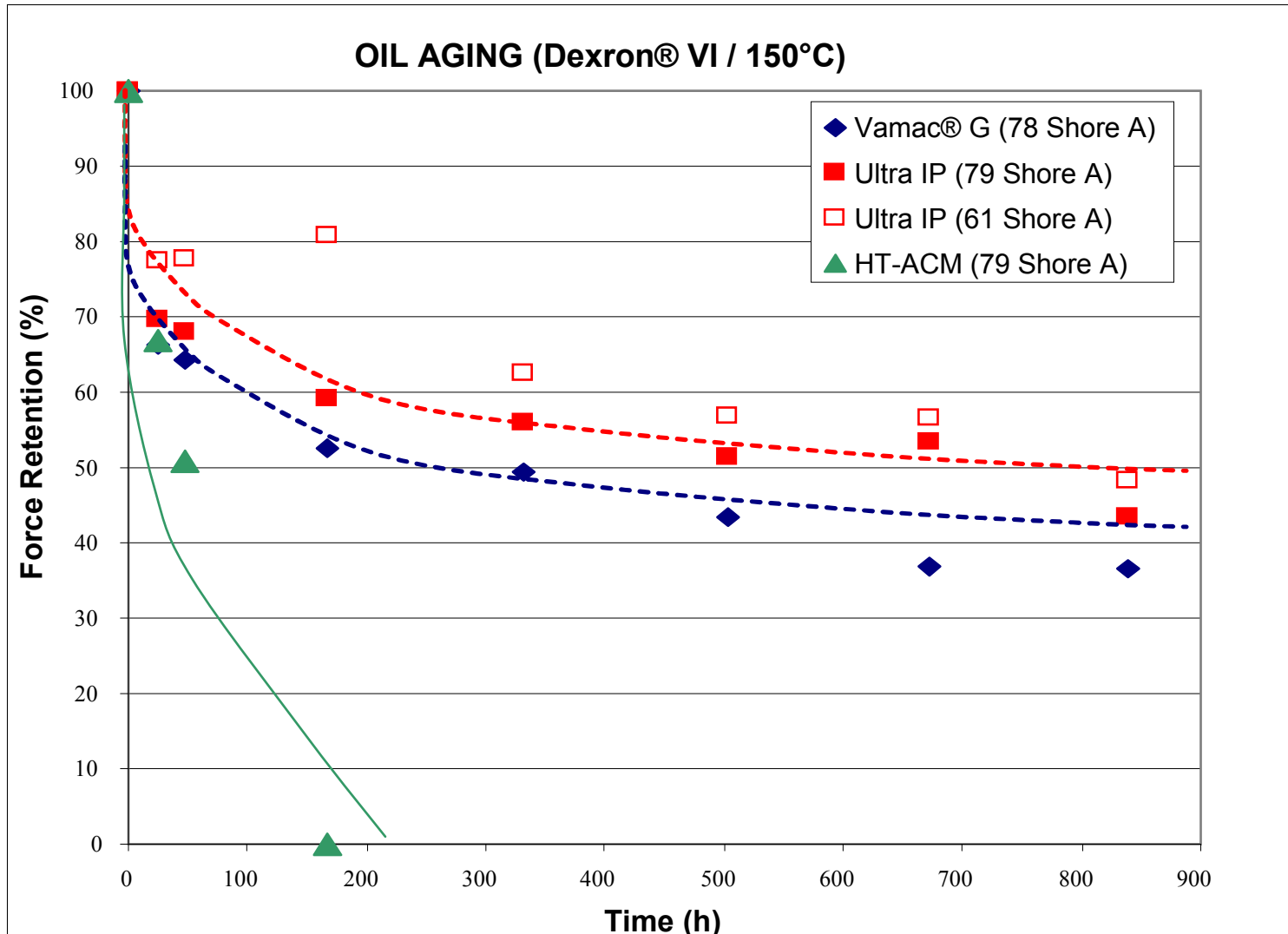
AEM shows advantages over ACM in Compressive Stress Relaxation Tests in Oil / Fuel blends

Sealing performance of Vamac® vs HNBR in Engine Oil

Compressive Stress Relaxation in oil (Castrol SLX 0W30 Super Longlife II, 150 °C)

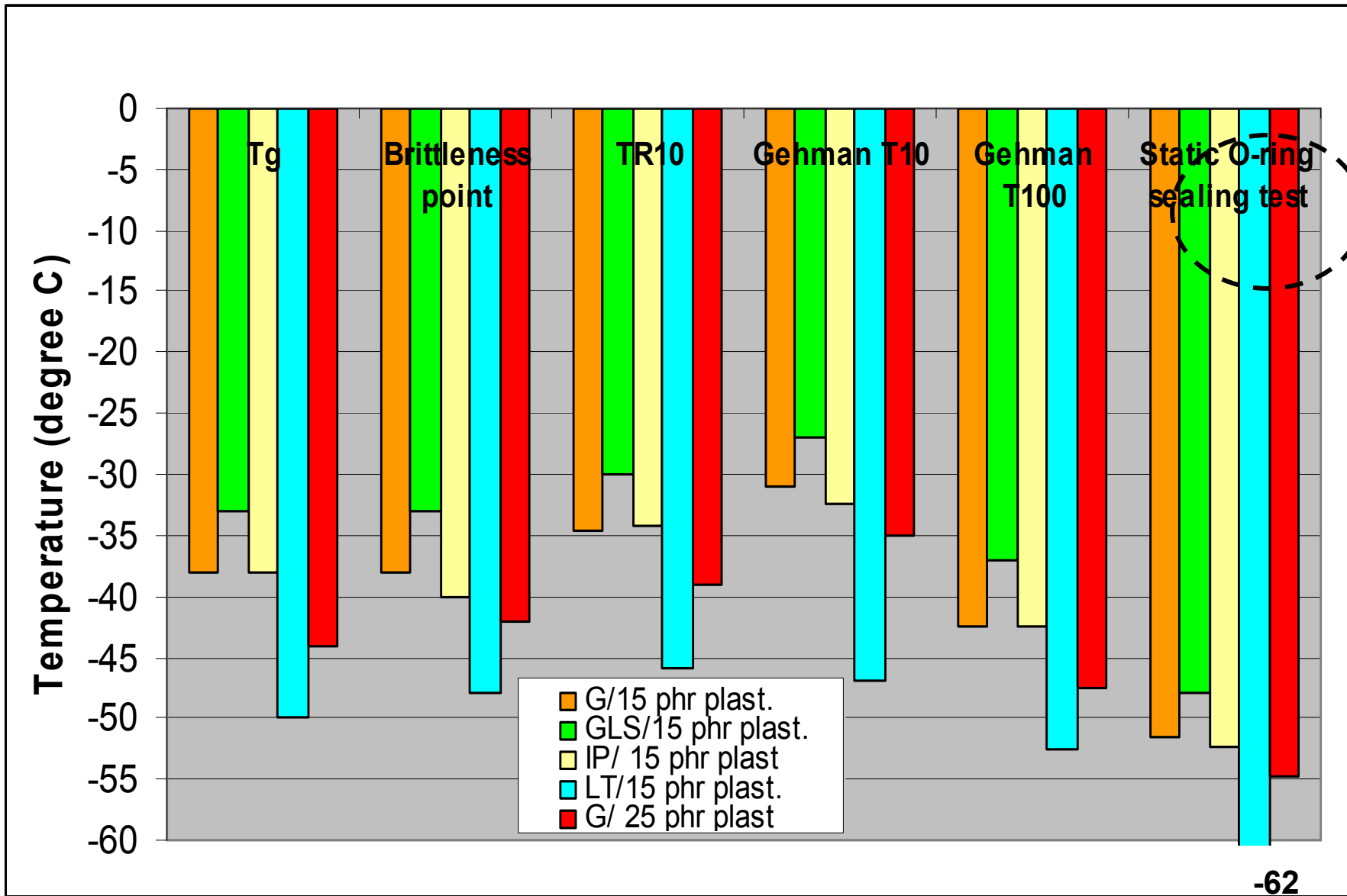


Higher force retention for Vamac®

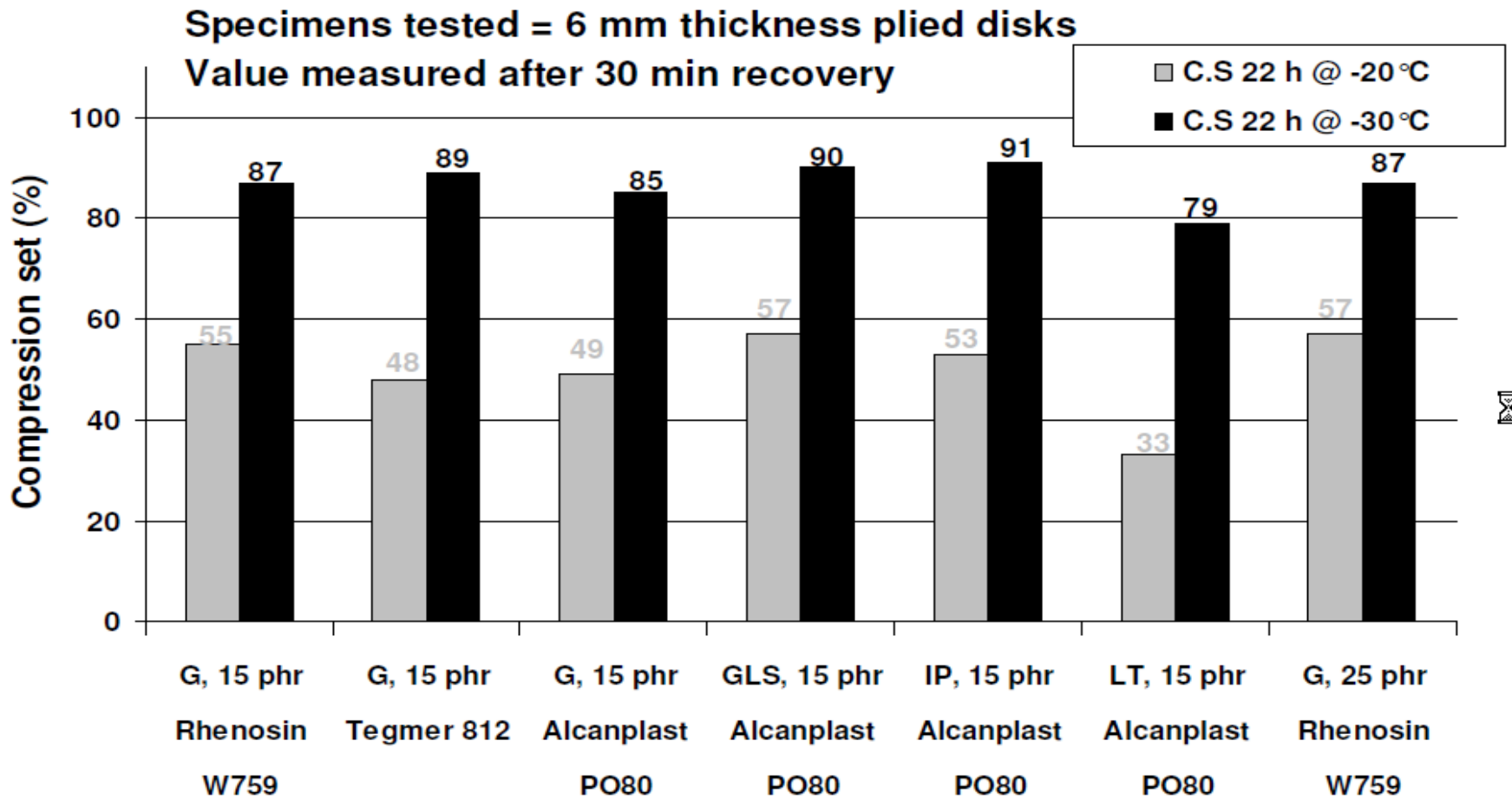


Acc. To ISO 3384
 Shawbury Wallace
 Test Equipment
 Cylindrical Specimen,
 6 mm high, 13 mm
 diameter

Ranking: Vamac® Ultra IP > Vamac® G >> HT ACM



Vamac® Ultra LT for improved low temperature properties



- Ultra LT >> G > Ultra IP > GLS
- Tegmer® 812 = Alcanplast® PO80 > Rhenosin® W759

	Ultra IP	Ultra IP/GLS	Engine Static Seals - Specifications	
			PSA S225106	VW TL 52293
Compression moulding 10 minutes at 180°C				
Post-cure 2 hours at 175°C				
Hardness Shore A (1 second)	61	61	55+/-5	55+/-5
Tensile properties (type 2) at 23°C				
Tensile Strength [MPa]	16	16	> 7	> 9
Elongation at break [%]	338	314	> 200	> 200
Modulus at 100 % [MPa]	3.3	3.7		> 2
Tear strength - Small (Delft), (N/mm)	17.2	17.4	> 10	
Tear strength type A - Trouser (N/mm)	11.7	8.7		> 5
Tg by DSC	-39	-38	< -30 (Gehman T10) < -35 (bending test)	
Compression set 22 hours at 150°C - VW PV3307				
Compression set after 5 sec recovery [%]	44	46		< 50
Compression set after 30 min recovery [%]	30	33		
<u>ISO 815-1:2008</u>				
Compression set 72 hours at 165°C - pips, 13x29mm				
Compression set after 30 min recovery [%]	14	17	< 25	
Compression set 1008 hours at 135°C - pips 13x29mm				
Compression set after 30 min recovery [%]	26	28	< 40	
Compression set 1008 hours at 150°C - pips 13x29mm ISO 815-1:2008				
Compression set after 30 min recovery [%]	31	34	< 40	

	Ultra IP	Ultra IP/GLS	Engine Static Seals - Specifications PSA S225106 VW TL 52293
Heat ageing 1008 hours at 150°C ISO 188:2007			
Hardness Shore A (1 second) ISO 7619-1:2004	60	61	
Hardness change (points)	0	0	0 to +15 max
Tensile properties (type 2) at 23°C ISO 37:2005 Cor 1 2008			
Tensile Strength [MPa]	15.7	14.6	
Tensile Change [%]	-4	-6	-40 max
Elongation at break [%]	336	320	> 100
Elongation Change [%]	-1	2	-50 max
Heat ageing 168 hours at 165°C			
Hardness Shore A (1 second)	62	61	
Hardness change (points)	1	0	0 to +10 max
Tensile properties (type 2) at 23°C			
Tensile Strength [MPa]	15.1	14.3	
Tensile Change [%]	-7	-8	-20 max
Elongation at break [%]	328	334	> 150
Elongation change [%]	-3	6	-30 max
Fluid ageing 1008 hours at 150°C in Total Quartz INEO ECS 5W30			
Hardness Shore A (1 second) ISO 7619-1:2004	58	60	PSA S225106
Hardness change (points)	-3	-1	-5 to +5
Tensile properties (type 2) at 23°C ISO 37:2005 Cor 1 2008			
Tensile Strength [MPa]	12.6	13.9	
Tensile Change [%]	-23	-11	-20 max
Elongation at break [%]	194	200	> 150
Elongation Change [%]	-43	-36	-40 max
Volume Change (%) ISO 1817:2005	13	9	-5 to +10
Weight change (%) ISO 1817:2005	8	5	

Ultra IP/GLS blend more suitable for fluid ageing requirement

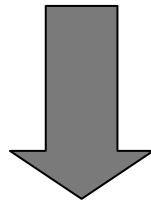
	Ultra IP	Ultra IP/GLS	
Engine Static Seals - Specifications			
			PSA S225106 VW TL 52293
Heat ageing 504 hours at 150°C ISO 188:2007			
Hardness Shore A (1 second) ISO 7619-1:2004	63	62	
Hardness change (points)	2	1	0 to +8
Tensile properties (type 2) at 23°C ISO 37:2005 Cor 1 2008			
Tensile Strength [MPa]	15.6	13.8	> 8
Tensile Change [%]	-5	-11	
Elongation at break [%]	343	322	> 150
Elongation Change [%]	1	3	
Fluid ageing 504 hours at 150°C in Lubrizol OS 206304 ISO 1817:2005			VW TL 52293
Hardness Shore A (1 second) ISO 7619-1:2004	59	61	
Hardness change (points)	-1	0	-3 to +10
Tensile properties (type 2) at 23°C ISO 37:2005 Cor 1 2008			
Tensile Strength [MPa]	14	13	> 6
Tensile Change [%]	-13	-14	
Elongation at break [%]	255	222	> 150
Elongation Change [%]	-25	-29	
Volume Change (%) ISO 1817:2005	15	7	
Weight change (%) ISO 1817:2005	9	3	0 to +10%
Fluid ageing 504 hours at 150°C in Castrol SLX Long Life III, 5W30			
Hardness Shore A (1 second)	62	65	
Hardness change (points)	2	4	-3 to +10
Tensile properties (type 2) at 23°C			
Tensile Strength [MPa]	16	15	> 6
Tensile Change [%]	-5	-3	
Elongation at break [%]	268	261	> 150
Elongation Change [%]	-21	-17	
Volume Change (%)	5	5	
Weight change (%)	2	2	0 to +10%

Ultra IP/GLS blend more suitable for fluid ageing requirement

Technology:

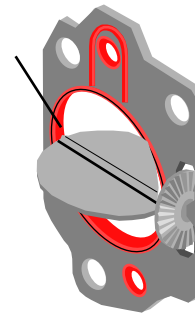
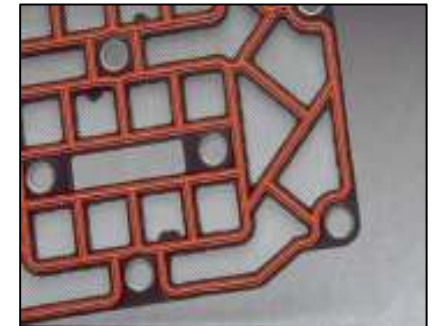
Direct overmoulding of thermoset gaskets onto thermoplastic parts

Technology objectives: Primerless adhesion
Easy moulding & process
Ensure part final function



Elastomer Target Performances:

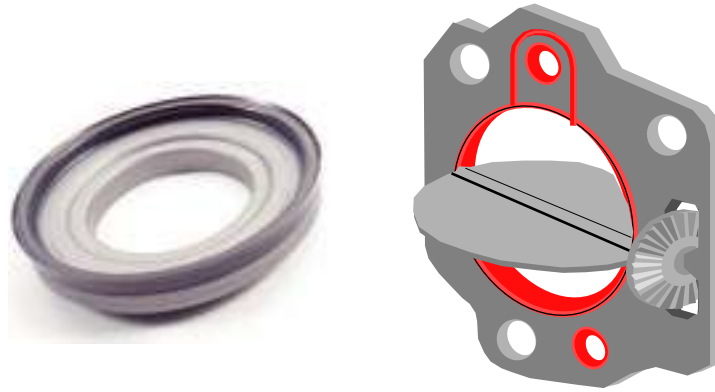
- Cohesion failure on peeling or bending test
- Sealing performance
- Hot air & fluid resistance
- Low permeation in fluids
- Fast curing
- Easy mould cleaning



Typical Applications Targeted

AIR MANAGEMENT

- AIM gasket
- Quick connectors



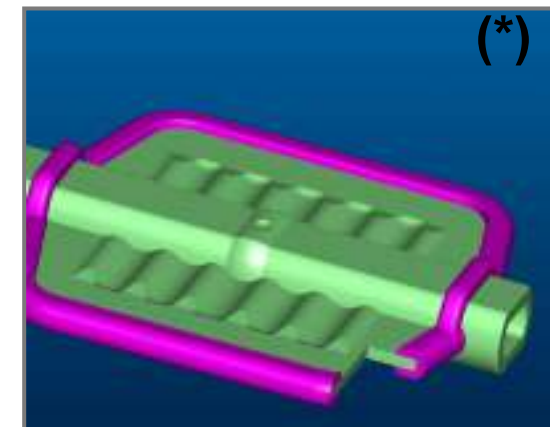
OIL & GREASE

- Rocker Cover gasket
- Oil pan gasket
- Oil filter seal
- Shaft seal



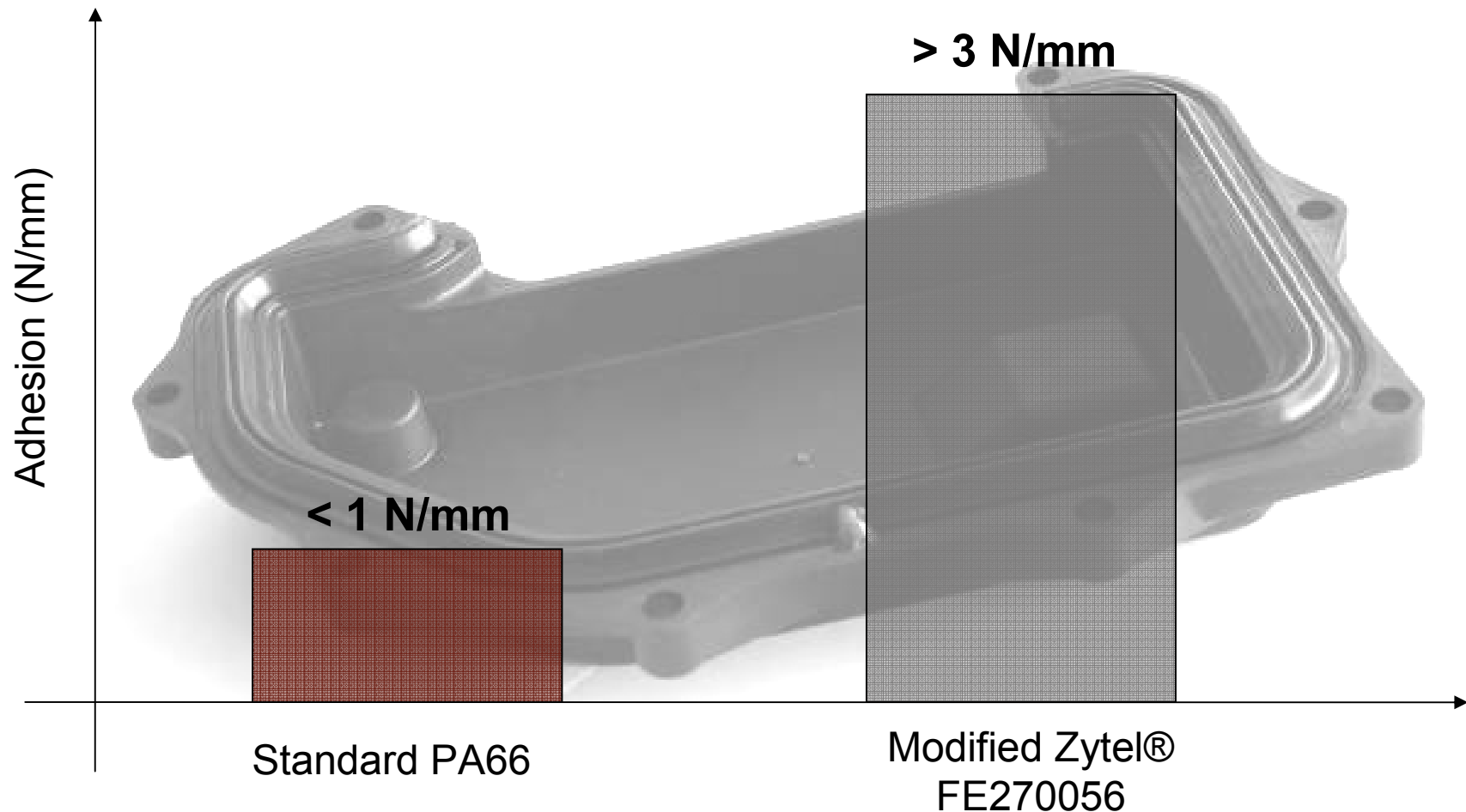
FUEL SYTEM

- Fuel filter seal
- Fuel sender seal



2K-Zytel® / Vamac®: ADHESION

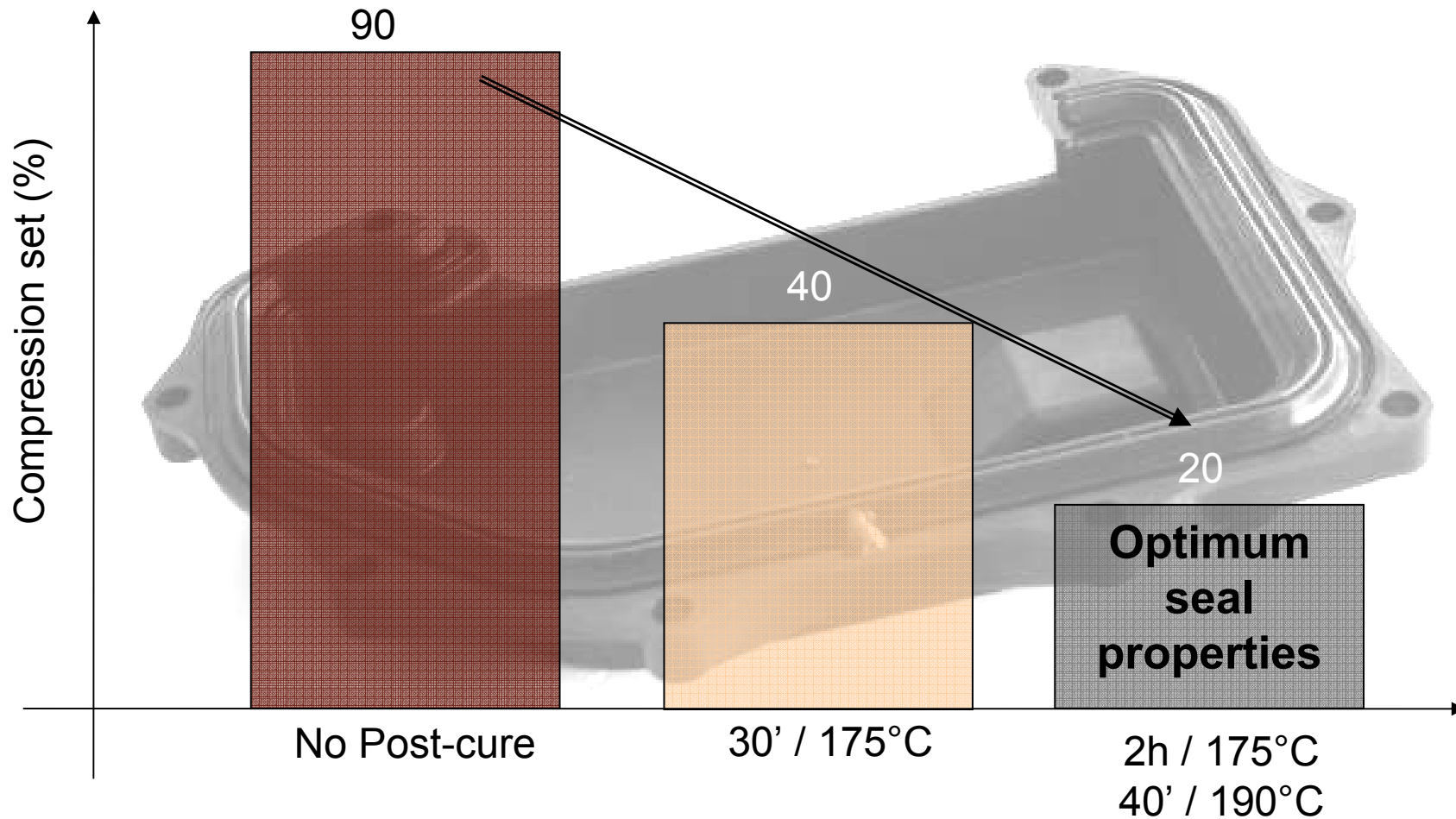
(measured on peel laboratory samples moulded with 2K)



- Vamac® Ultra IP combined with Zytel® FE270056 (= PA 6,6 modified) allows 2K moulding.
- Standard PA6,6 has no sufficient adhesion to keep the seal + cover together during the moulding ejection & handling process.

2K-Zytel® / Vamac®: COMPRESSION SET

(measured on peel laboratory samples moulded with 2k)





Billion, 150T



Vamac® Ultra IP: AEM

Zytel FE270056: PA66GF35 modified

- Direct adhesion
- Short cycle times
- Reduced Injection pressure

Process parameters:

Zytel® cavity: 80°C

Vamac® cavity: 190°C

Total cycle time: 41 sec

Cure time: 30 sec

Thank you for your attention

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