

Specialty Elastomers in EV Powertrain and Drivetrain

New challenges towards eFluids compatibility

ZEON

IOM3 Seminar | Elastomers in Energy Transition

March 28th 2025

Dr. Björn Nelson – Technical Manager Europe

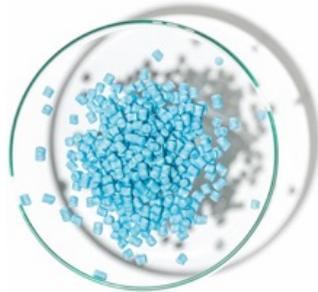
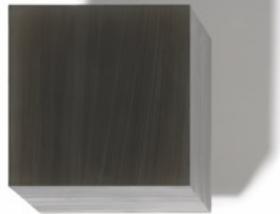
1. ZEON Introduction

2. ZEON Elastomers in Powertrain and Drivetrain

3. Elastomer Compatibility in New Generation Fluids for EV Powertrain and Drivetrain

- Drivetrain Lubrication
- Thermal Management

ZEON Overview | Dedicated to Rubbers & Elastomers since 1950

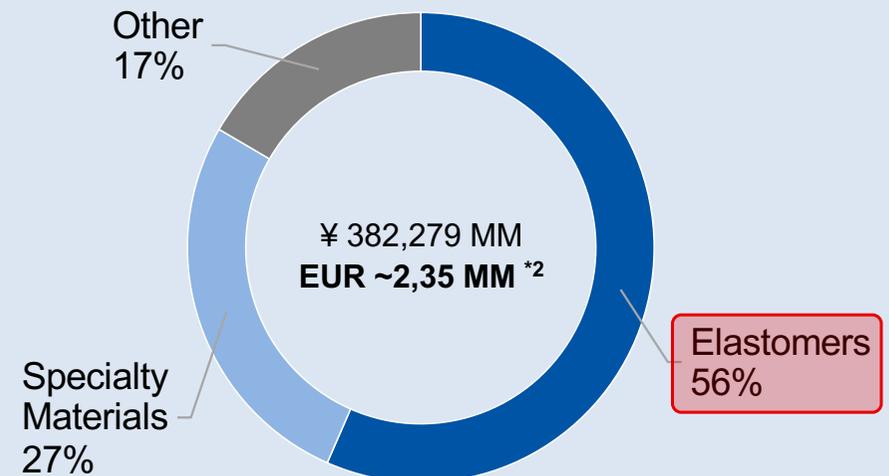


Company Profile

- Name: Zeon Corporation
- Established: April 12th, 1950
- Head Office: Tokyo, Japan
- Capital:^{*1} ¥ 24,2 MM
- Employees:^{*1} 4,462
- Consolidated Net Sales FY23: ¥ 382,279 MM

^{*1} as of March 31st, 2024

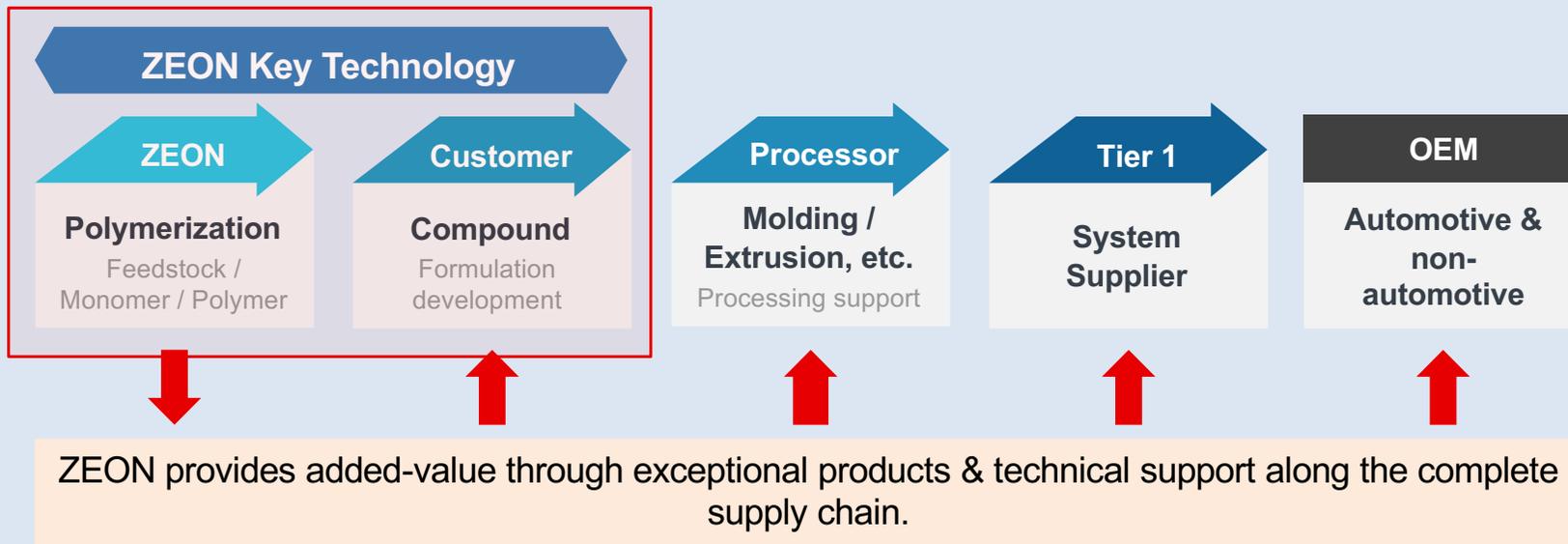
Sales by Business Division FY2023



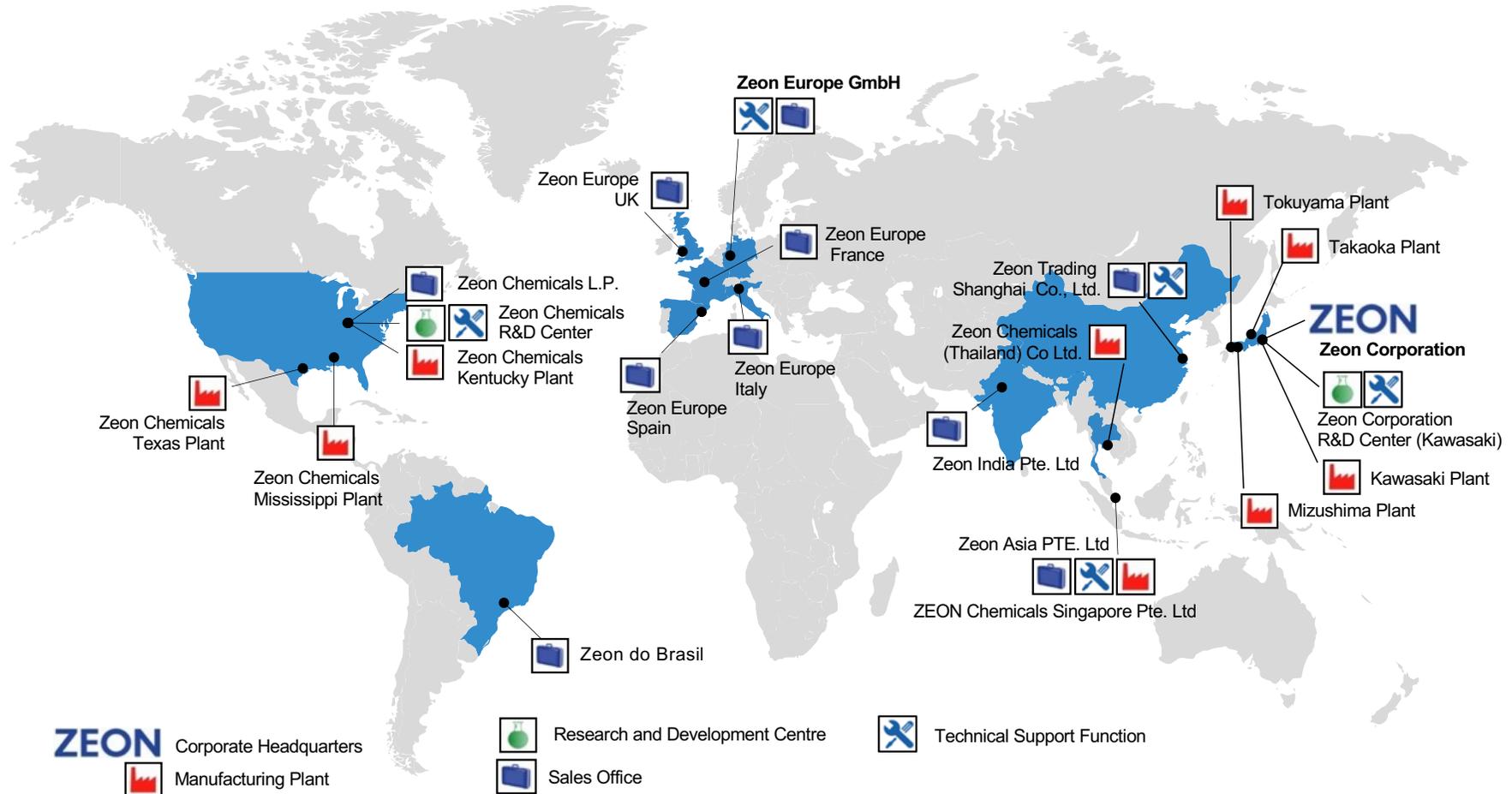
^{*2} Exchange Rate August 2024

Providing Solutions & Support along the Complete Value Chain

ZEON



Providing high-performance materials to customers worldwide

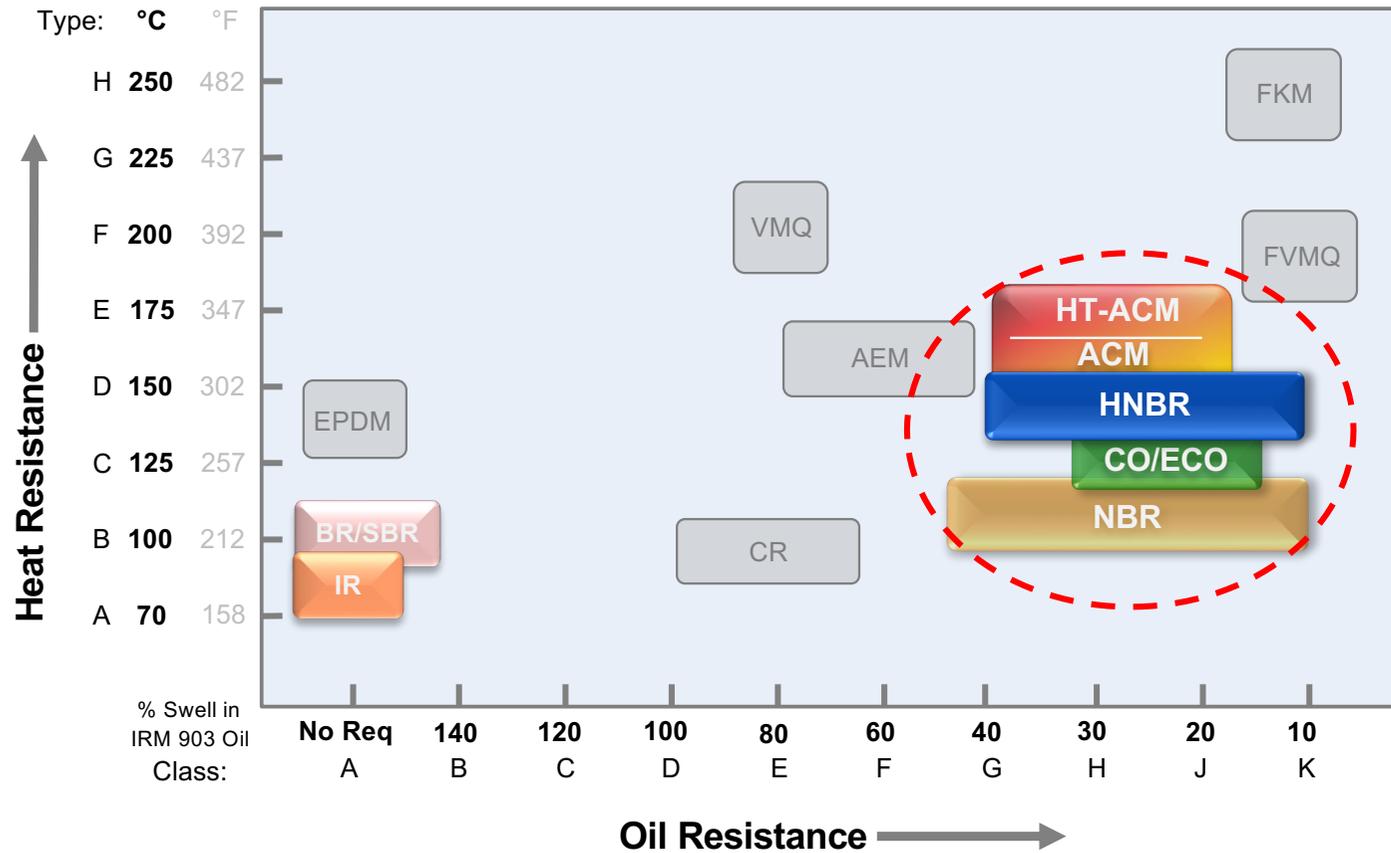


ZEON | Elastomer Portfolio Overview



ZEON elastomers serve in heat, oil, and fuel environments for automotive applications

(Based on the ASTM D2000 & SAE J200 Specification Systems)



**ZEON Flagship
Specialty Elastomer
Products**

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ZEON Elastomers in Powertrain and Drivetrain

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ZEON elastomers have a long history of use in automotive ICE powertrain and drivetrain. Many applications continue to use ZEON elastomers for new technologies in EV.

Charged air hose
Oil cooler hose
Air intake duct
Wet shaft seal
Engine seals & gaskets
Transmission Sealing



Fuel hose
ESD
Damping
EGR hose



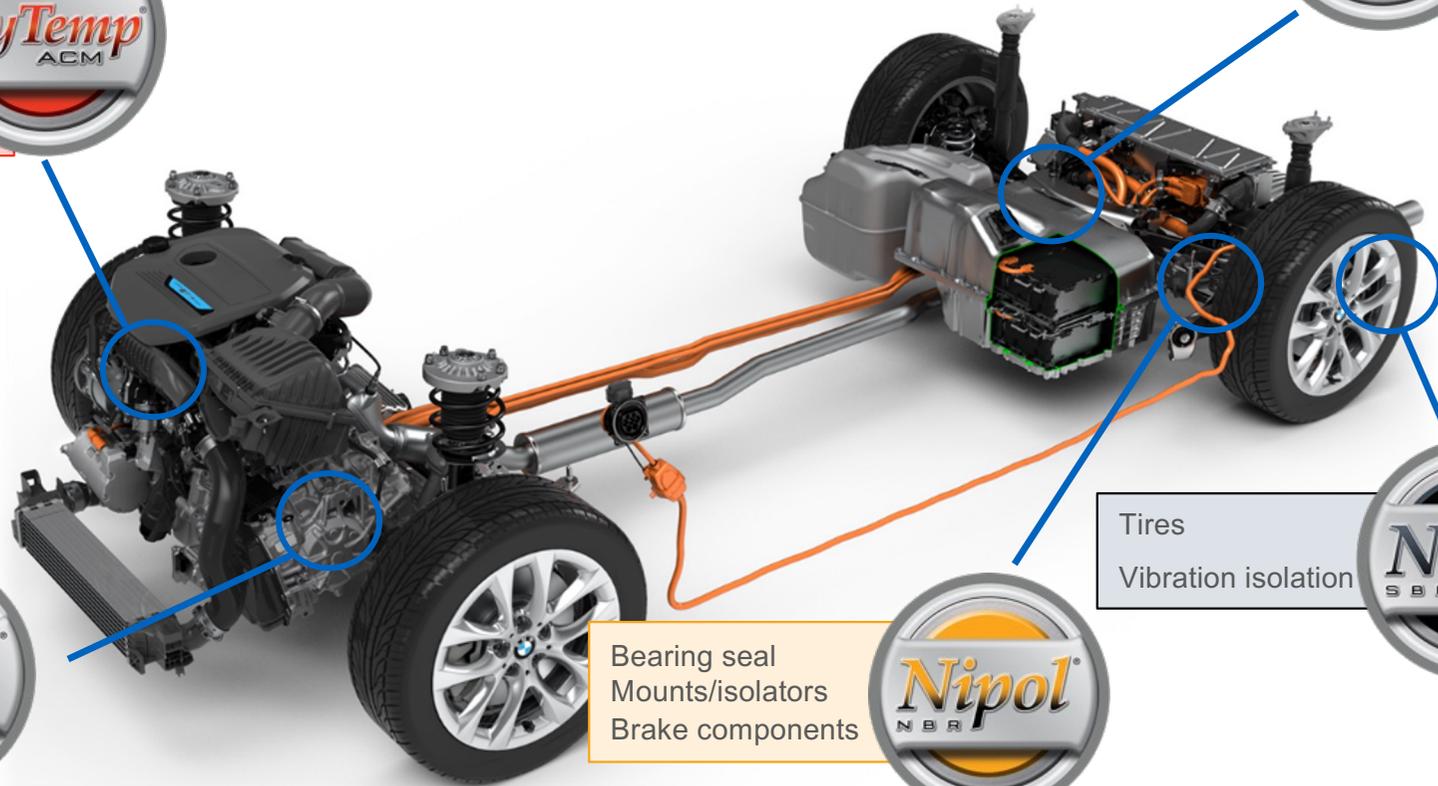
Wet/dry shaft seal
Camshaft belts
Bearing seal
Motor stators gasket



Bearing seal
Mounts/isolators
Brake components



Tires
Vibration isolation



Significantly **reduced** amount of elastomers used in BEV powertrain/drivetrain compared to ICE

- Air intake ducts
- Charged air hose
- Oil cooler hose
- Rotational shaft sealing
- Small gaskets and O-rings for connectors, inverter and motor sealing, oil pump, etc
- Valve cover and oil pan sealing
- EGR and breather hoses
- Transmission/transfer case vent hoses
- Engine mounts
- Fuel filler and vapor recovery hose

Observations: Many carry-over materials *and specifications* from ICE to EV for seal and gasket

- OEM / Tiers report temperatures to 150°C, some >160°C
- Most common materials
 - >ACM< / >AEM<
 - >HNBR<
- High rotational speeds of some EV motors require >FKM< or >PTFE< type dynamic shaft seal due to high heat from friction
- New oils and oil additive packages are being developed for BEV – may impact elastomer selection or compound considerations

Use Example

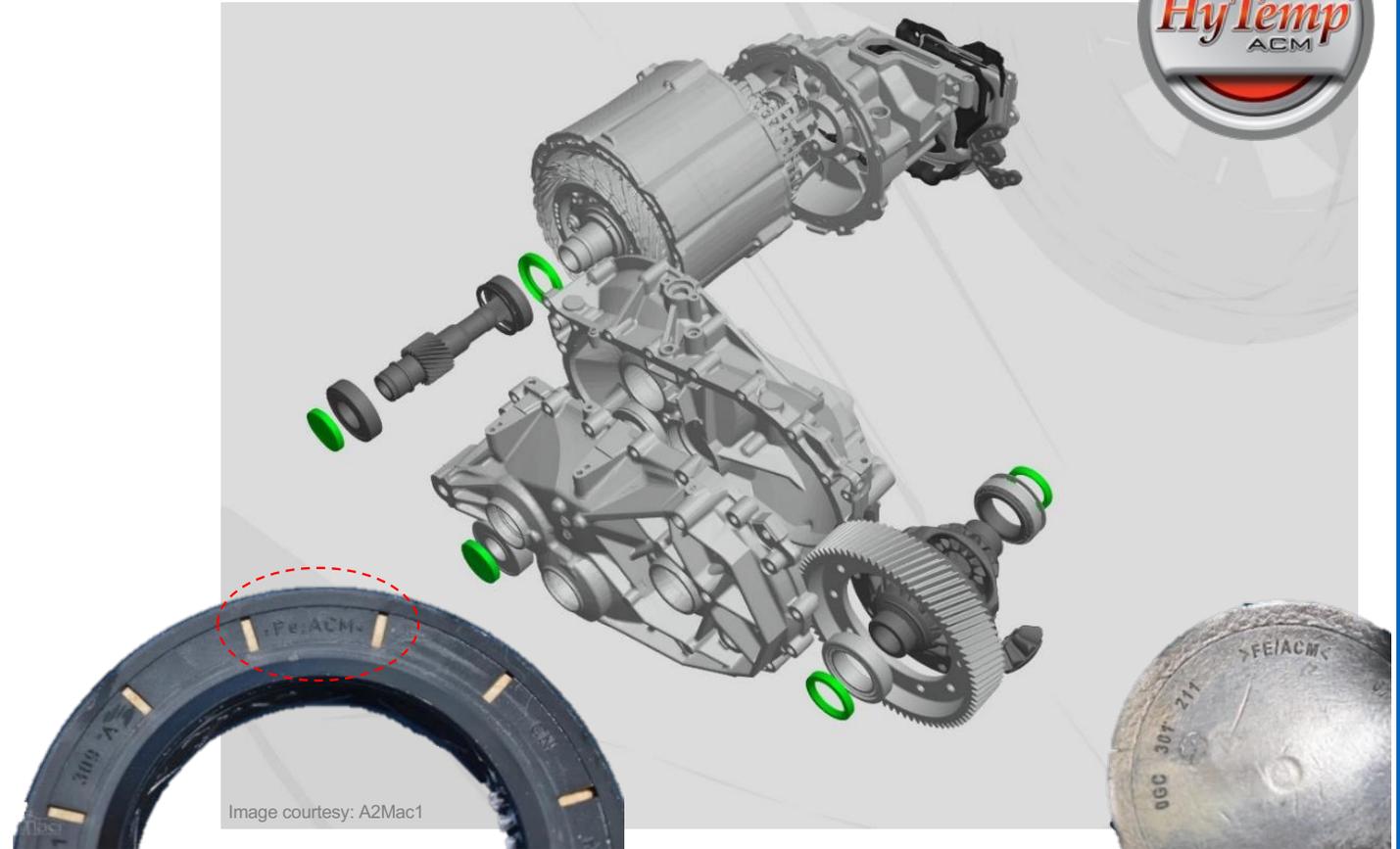


Model: VW ID.4
Year: 2021

Need:
High temperature
ATF and gear oil resistance
Cold Temperature Flexibility

Material: >ACM<

Sealing rotational seals and plugs



Use Example



Model: Tesla Model S Plaid
Year: 2021

Need:
Mechanical Strength
Temperature Resistance
ATF & Gear Oil Resistance

Material: >**HNBR**<

Rotary Shaft Seals

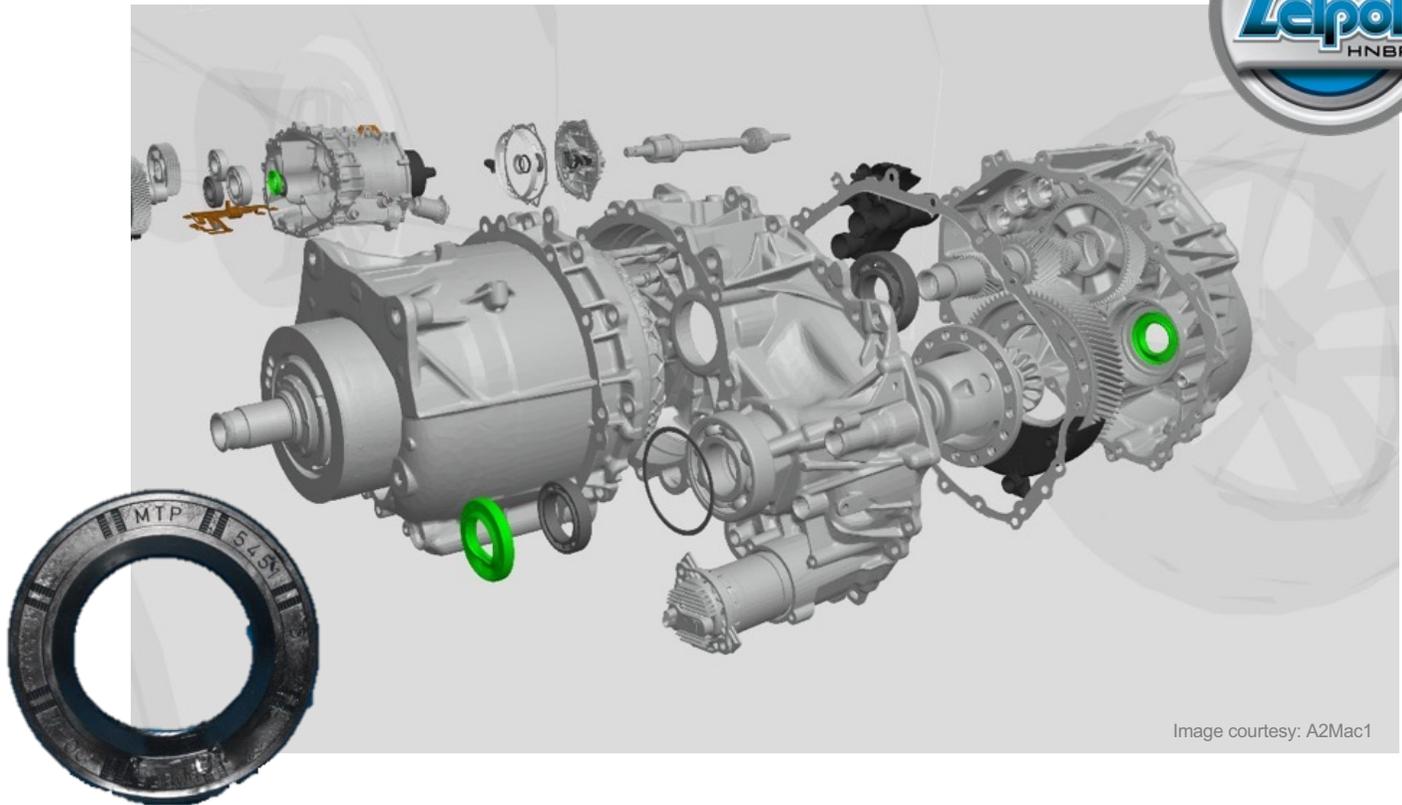


Image courtesy: A2Mac1

Use Example

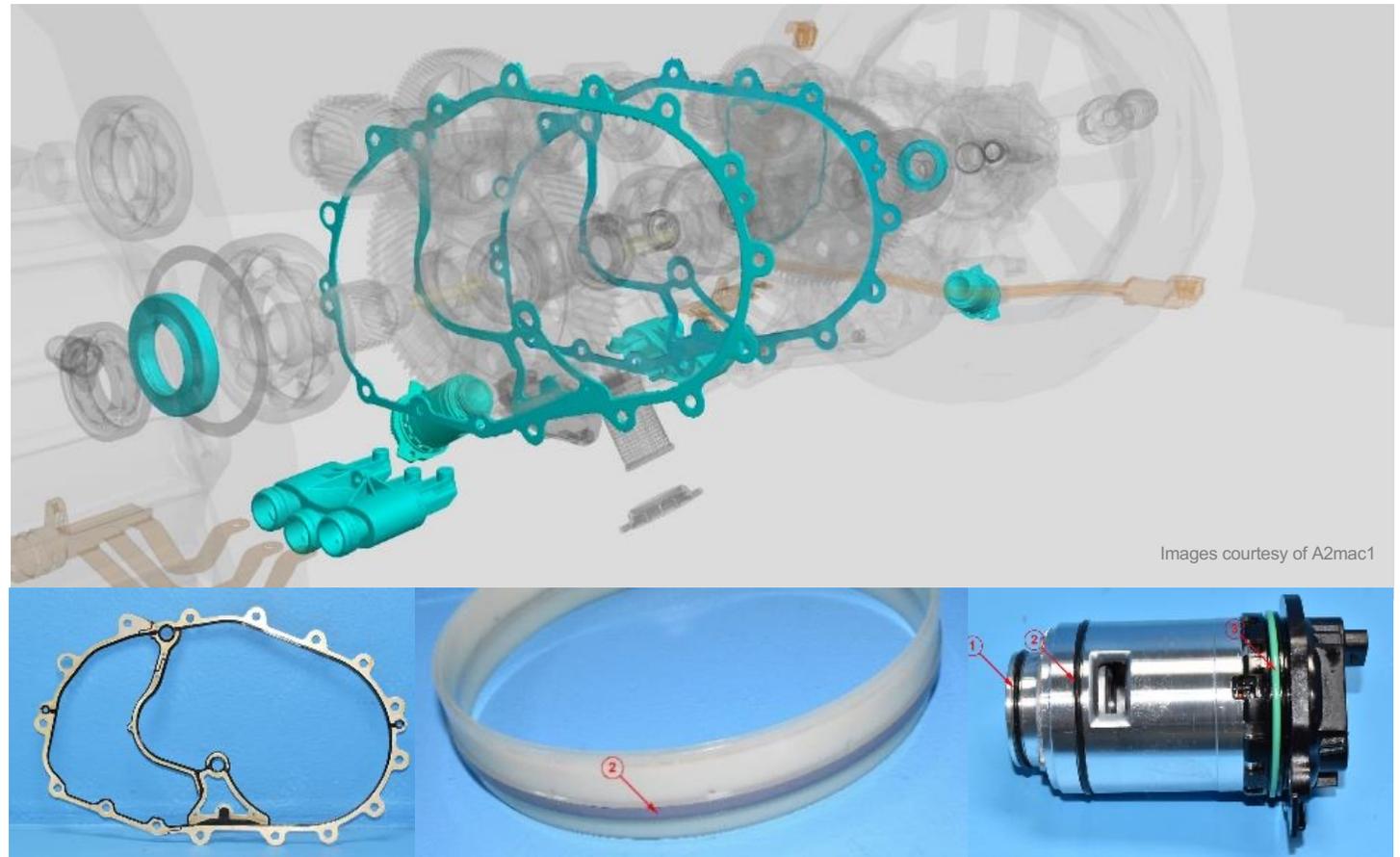


Model: Tesla Model S Plaid
Year: 2021

Need:
Mechanical Strength
Temperature Resistance
ATF & Gear Oil Resistance

Material: **>HNBR<**

Sealing components in Tesla EDU



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- 3. Elastomer Compatibility in New Generation Fluids for EV Powertrain and Drivetrain**
 - Drivetrain Lubrication
 - Thermal Management

EV fluids | new product lines for automotive fluid suppliers **ZEON**

Producer		new product line
Total		Quartz EV fluid
Shell		Shell E Fluids
Castrol		Castrol On
Exxon Mobil		Mobil EV
Fuchs		Fuchs BlueEV

... and many more

New fluids are developed by all leading automotive fluid suppliers to meet specific requirements for EV applications

- Too many fluids to test all of them, many under development or changing
- Different additives of fluid can have different effect on polymer
- Two major areas of eFluids identified:
 - (1) Drivetrain Lubrication
 - (2) Thermal Management
- ZEON is collaborating with many leading fluid suppliers and is willing to work with Tiers in testing or compound development for specific fluids

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Drivetrain Lubrication – Test Matrix Overview

Zeon is testing a broad range of gear oils and ATF's currently used or promoted for use in EV. Similar classes of fluids can have very different results due to additive packages, etc.

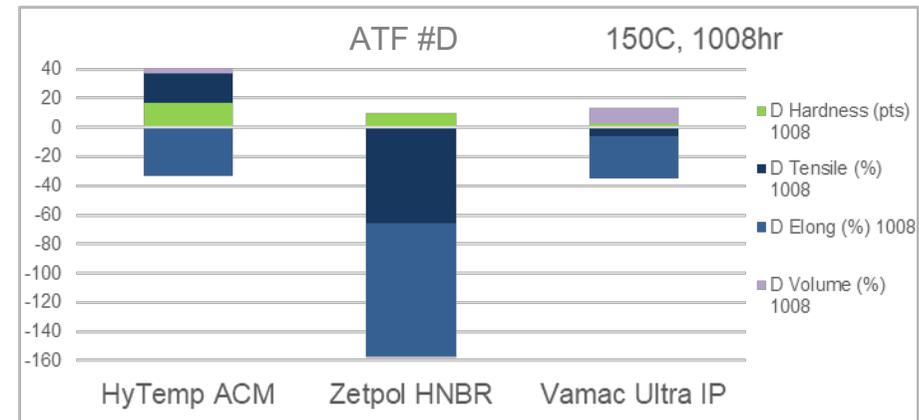
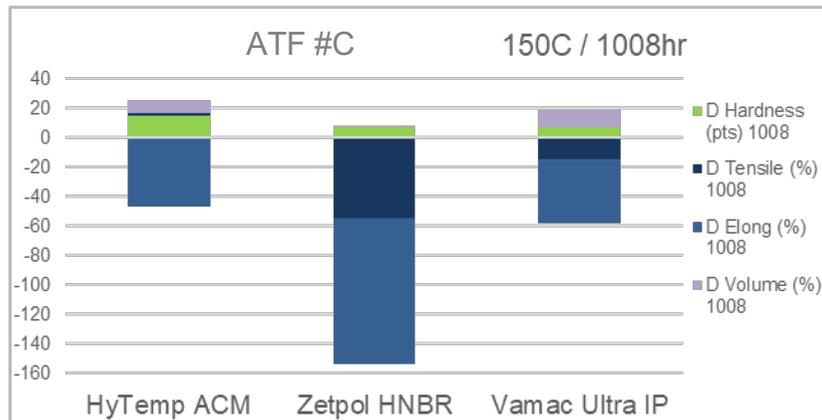
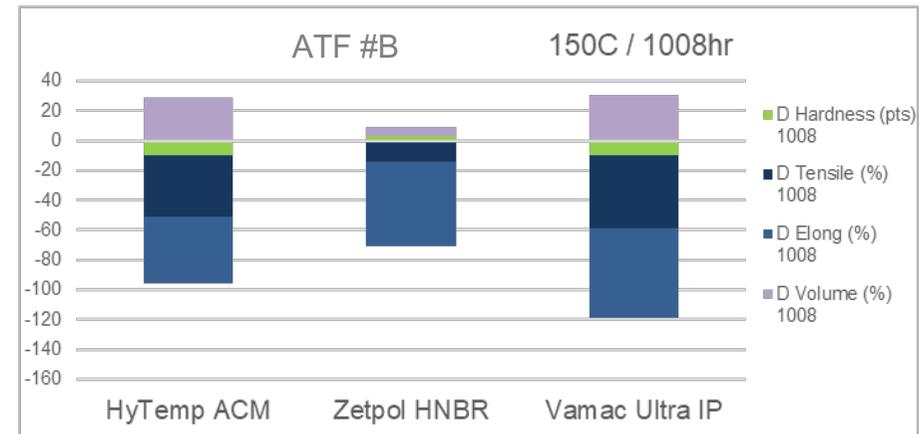
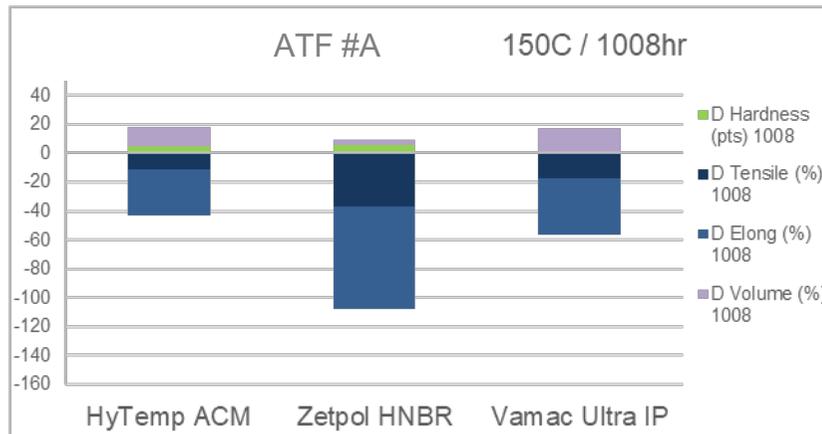
Understanding elastomer chemistries + collaboration with fluid / seal suppliers is essential for proper material selection.

System	Chemical Type	Supplier	Fluid ID	OEM / Tier	Test Cond.	Completion date (estimate)	HT-ACM	HNBR (-25C Tg)	HNBR (-40C Tg)	NBR (-12C Tg)	NBR (-51C Tg)	AEM Ultra-IP	FKM (-30C)	FKM (-12C)	EPDM	CPE		
Drivetrain Lubrication	ATF / ETF	Lead (undisclosed)	Many Fluids and conditions Evaluated				135C	168hr complete										
			Fuchs	ATF-9 (6009)	Tesla	150C	1008hr complete											
			Mobil1	Syn LV ATF HP	GM	135C	1008hr complete											
			Motorcraft	Mercon ULV	Ford	150C	1008hr complete											
			Nissan	Matic Fluid S	Nissan	150C	504hr complete											
			Fuchs	Pentosin EG FFL-2	VW	130	1008hr complete											
						150	1008hr complete											
			Shell	EF6	BMW	130	1008hr complete											
						150	1008hr Complete											
						Spirax S6 D971	Daimler	135	1008hr complete									
						150C												
	Gear Oil	Fuchs	Titan 132B	American Axle	135C	1008hr complete												
			Titan EG 52529	VW	130C	1008hr complete												
		Mobil	PTX 75W-90 EV Drive EP	Ligom/Trelleborg														
	Bearing Grease	Castrol	ON e-grease															
			EV Grease EM100															
			EV Grease WB100															
		Mobil	XHP222 (GM)		80	TBD												
						150	TBD											
		DOW	Molykote 111															
	Shell	E6																

compatibility assesment:	
Rating	Criteria @ 1008 h
Green	Δ TB/EB <-30% HC <+ 10
Light Green	Δ TB/EB <-50% EB > 100% VC 10-20% HC <+ 10
Yellow	Δ TB/EB <-50% EB > 100% VC 10-20% HC <+ 10
Light Red	Δ TB/EB -50% ~-60% EB < 100% VC 25% HC >+ 15
Red	significant loss
Grey	not tested

Important to understand how each fluid will impact the elastomer → ‘Off the shelf’ seal solution may not be optimal material

Below example demonstrates how **four different ATFs** from the **same fluid supplier** can have varying effect on polymers:

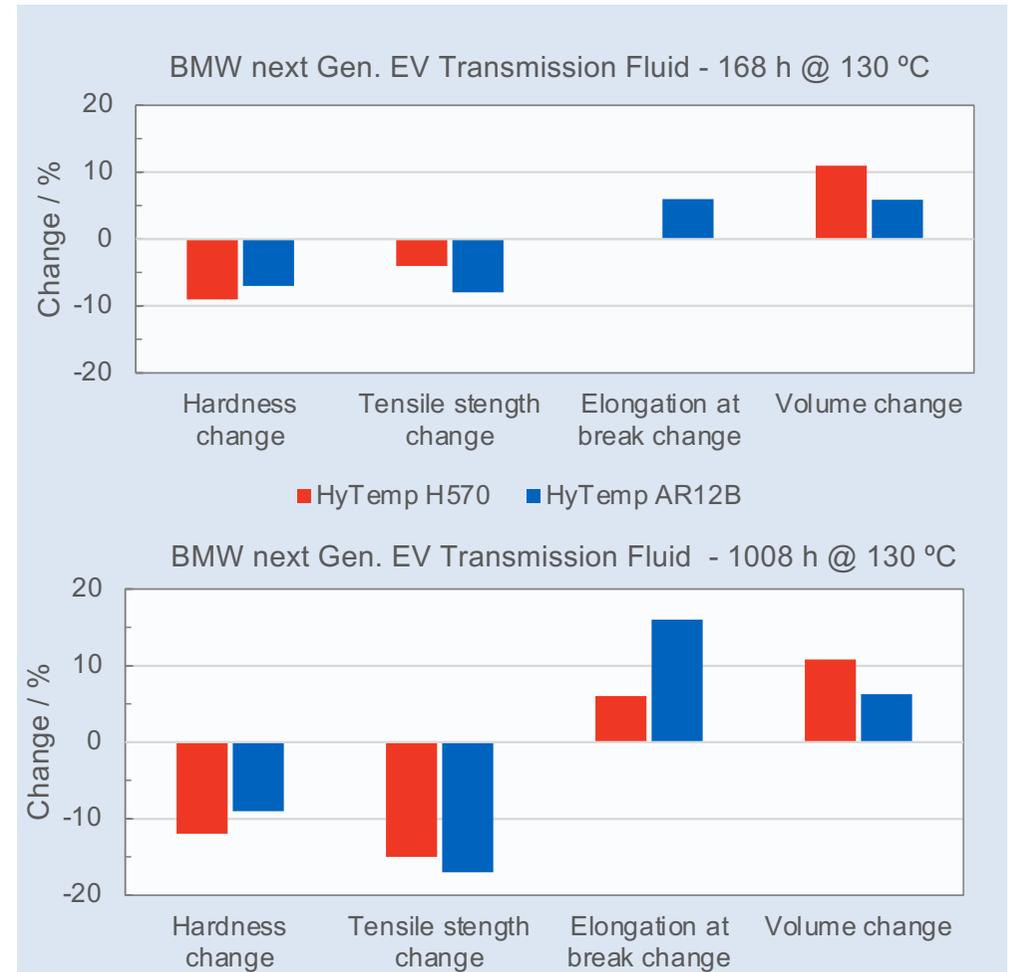


ACM | EU OEM transmission fluid

Ingredient	HyTemp H570	HyTemp AR12B
Polymer Characteristic	LT-improved Sealing Grade	Std. Sealing grade
HT-ACM Polymer	100	100
N550	55	50
Process Aid #1	0,5	0,5
Antioxidant	2	2
Process Aid #2	1	1
DBU Salt – Polymer bound	2	2
Diamine Curative	0,6	0,6
Total	161,1	156,1

Original Properties, PostCured		
Hardness A, (pts)	66	61
Modulus @ 100 % (MPa)	4,3	4,5
Tensile (MPa)	8,8	10,0
Elongation, (%)	203	217

Compression Set – Air, 1008h, 130°C, ISO 815-1 Method B		
Set (%)	40	38

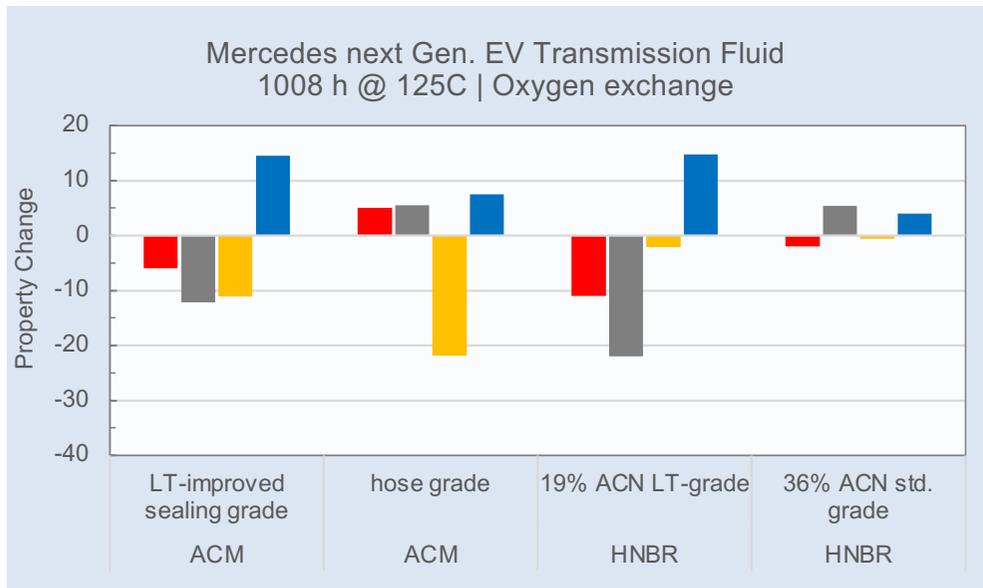
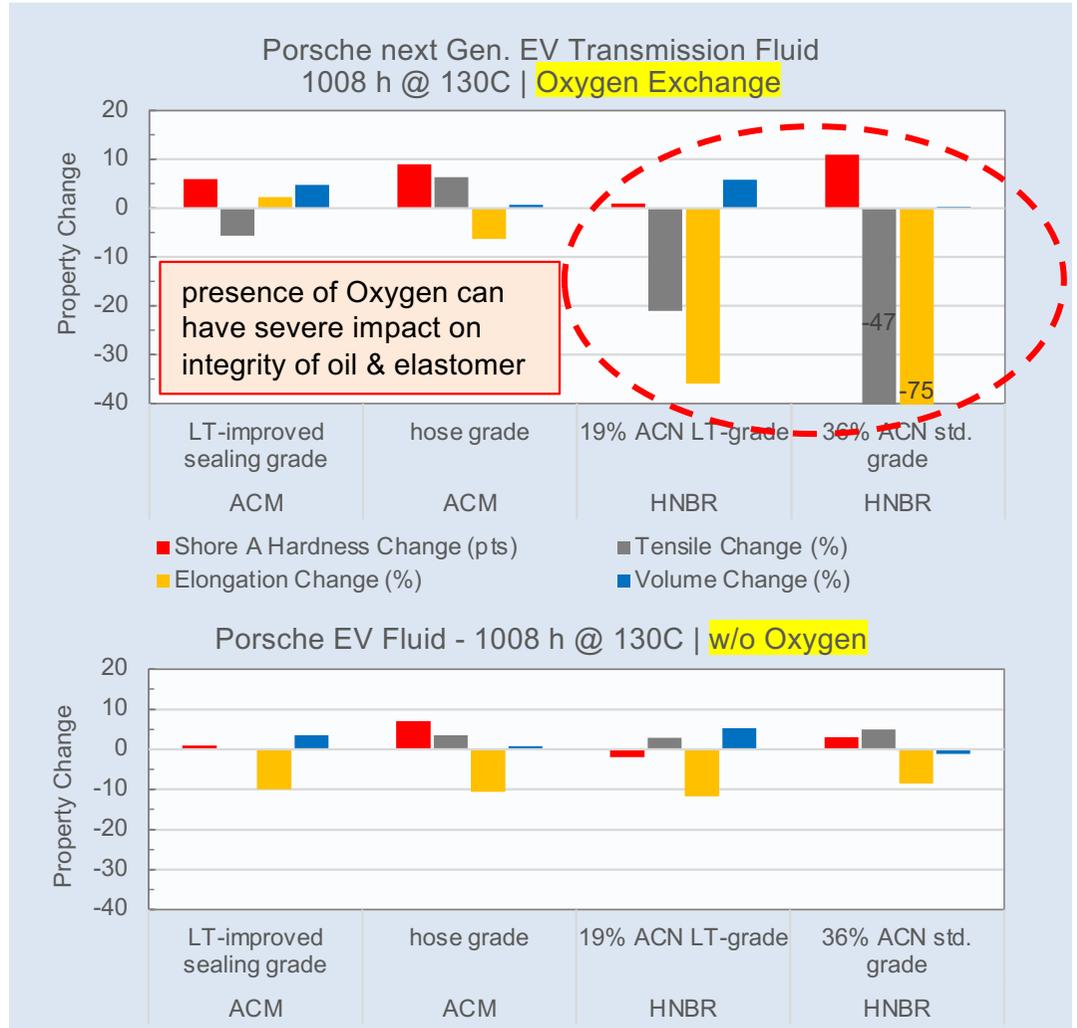


HyTemp ACM shows excellent resistance to BMW next. Generation EV transmission Fluid

ACM & HNBR | Further EU OEM transmission fluid testing

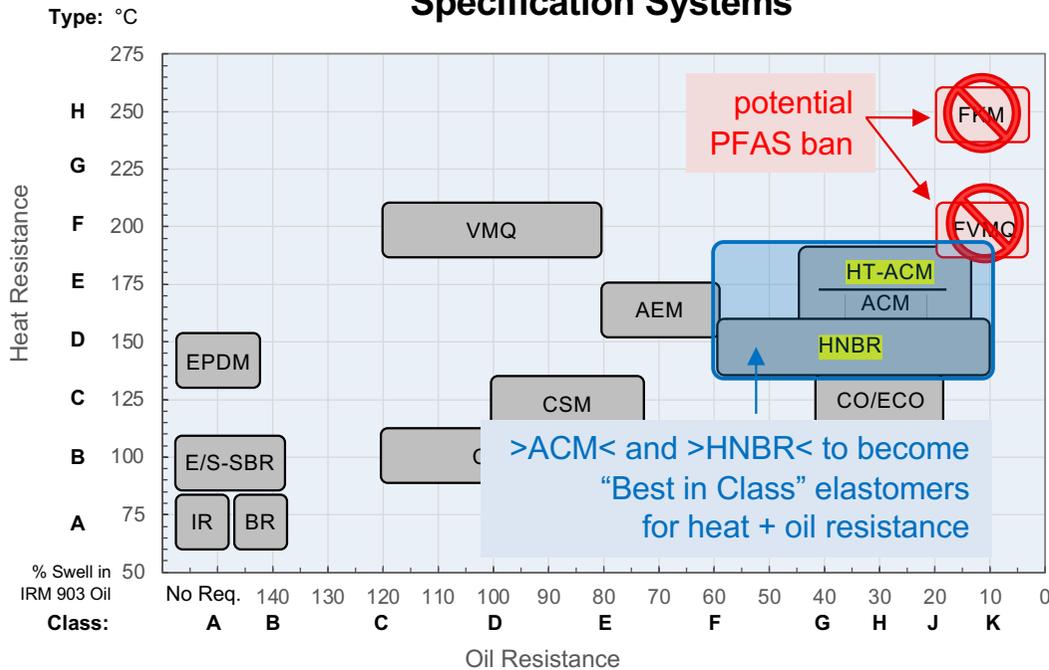


Grade Name	HyTemp H570	HyTemp AR212XP	Zetpol 4300	Zetpol 2000L
Elastomer Type	ACM	ACM	HNBR	HNBR
Characteristics	LT-improved sealing grade	hose grade	19% ACN LT-grade	36% ACN std. grade
Cure system	diamine	diamine	peroxide	peroxide
Iodine value / g/100g	-	-	max. 10	max. 7



Impact of potential PFAS ban on specialty elastomer landscape

Based on the ASTM D2000 & SAE J200 Specification Systems



- For future – PFAS regulation may restrict or ban use of fluorinated materials: >FKM<, >FVMQ<, >PTFE<
- If fluoroelastomers are restricted, the next-best sealing material are:

>ACM<:

- -40 °C to >175 °C continuous use
- Excellent resistance to hydrocarbon-based fluids
- Not recommend to be used in polar fluids (e.g. coolant / water)

>HNBR<:

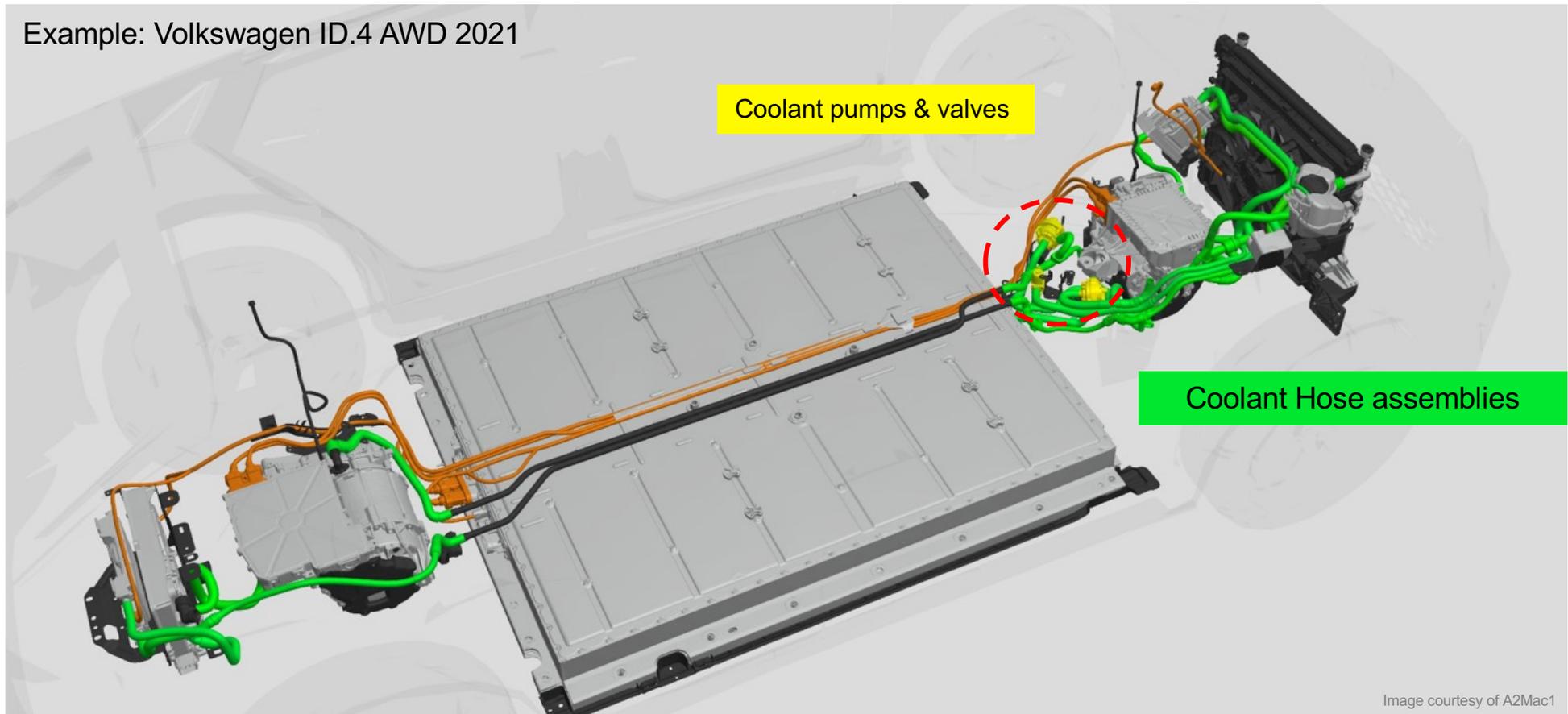
- -45 °C to +150 °C continuous use
- Excellent universal resistance vs. (automotive) service fluids, hydrocarbon-based fluids, but also vs. polar fluids, aqueous media (coolant / water) and acids & bases.

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Elastomers in EV Thermal Management Systems

Most common cooling technology for EV is cold plate or tubes internal to the battery.
Cooling medium is **water/glycol** (EV + ICE)

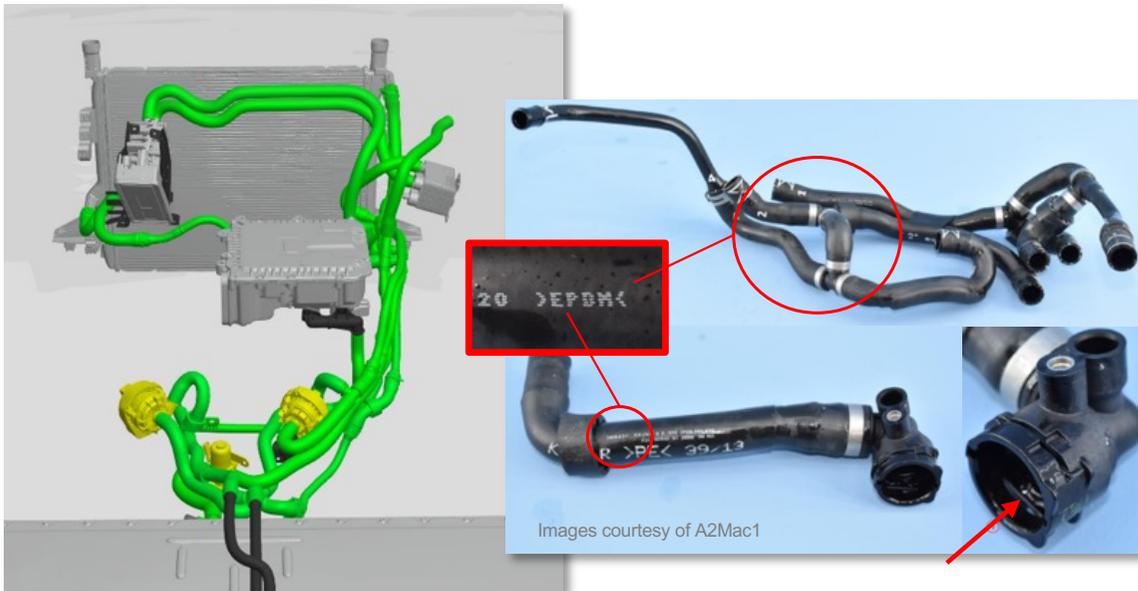
Example: Volkswagen ID.4 AWD 2021



Elastomers in EV Thermal Management Systems

Elastomers used with plastics in EV thermal management

- Coolant pumps – O-rings and gaskets
- Coolant hoses
- Hose connector seals and O-rings



Predominant *elastomer* for use in water/glycol cooling system is >EPDM<

>EPDM< is in competition to plastics due to weight and cost saving (e.g. >PA12<)

Battery Enclosure Sealing – Pressure Relief Valve

ZEON

VW id.6

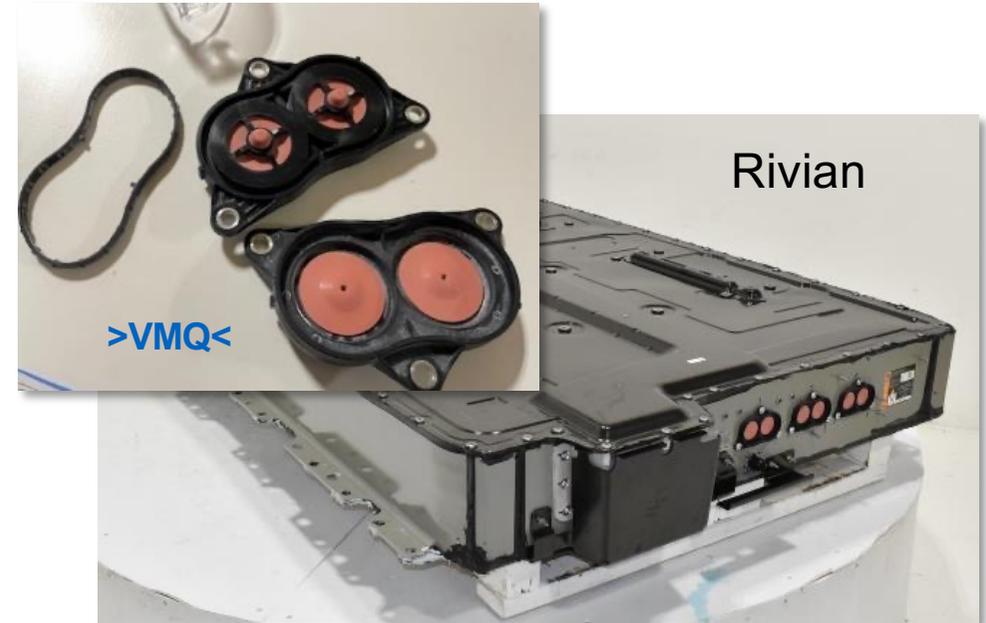


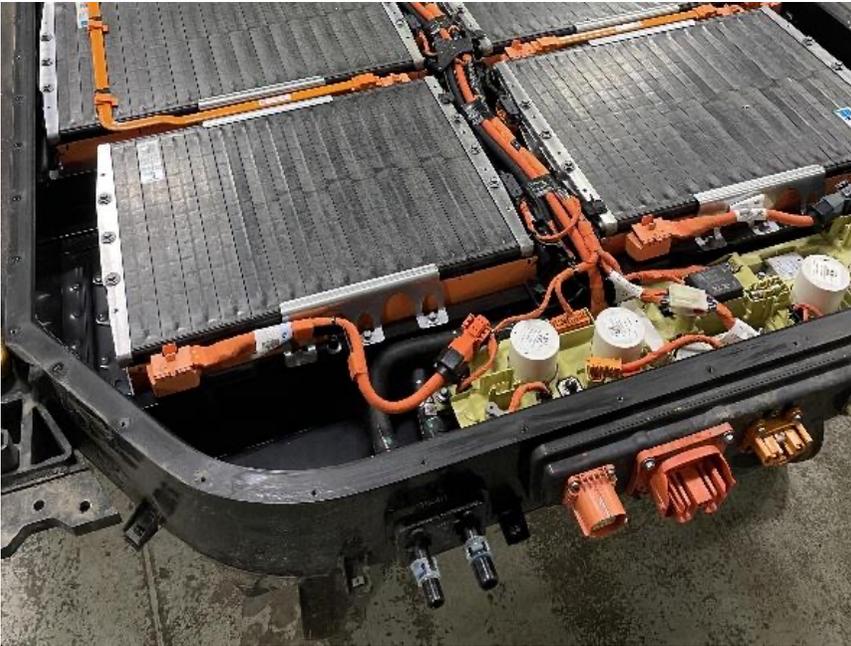
Image courtesy: A2Mac1

Battery Enclosure Sealing – Frame Seal

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PIP: 'press in place'
FIP: 'form in place'

Ford: Extruded or lathe cut >EPDM<



BMW: >VMQ< (PIP or FIP)



Rivian: PIP >EPDM<



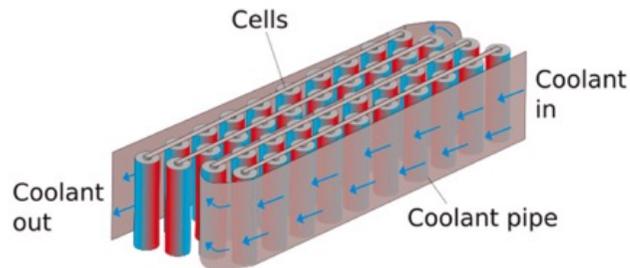
Thermal management fluids

Customer need of fast charging requires improved EV thermal management concepts.

Several EU OEMs have announced new platforms that will implement **immersion cooling** using **dielectric fluids** (electrical-insulative) in the future.

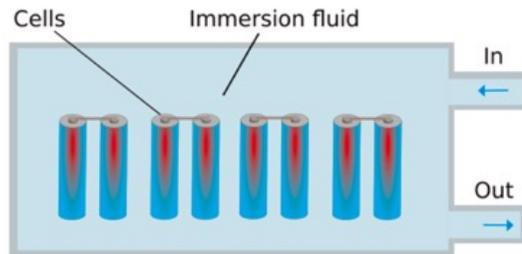
Next-gen. coolant systems can require use of specialty elastomers with improved media resistance.

Traditional Indirect liquid cooling



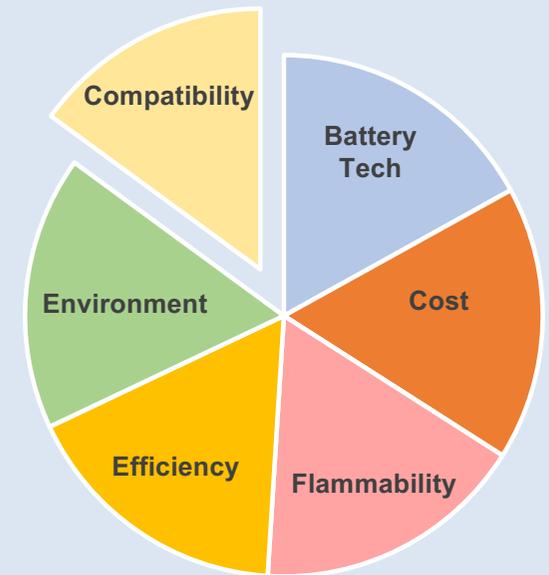
Source: Journal of Power Sources 525 (2022) 231094

NEW Battery immersion cooling



Many considerations for changing cooling system from water/glycol → dielectric fluid

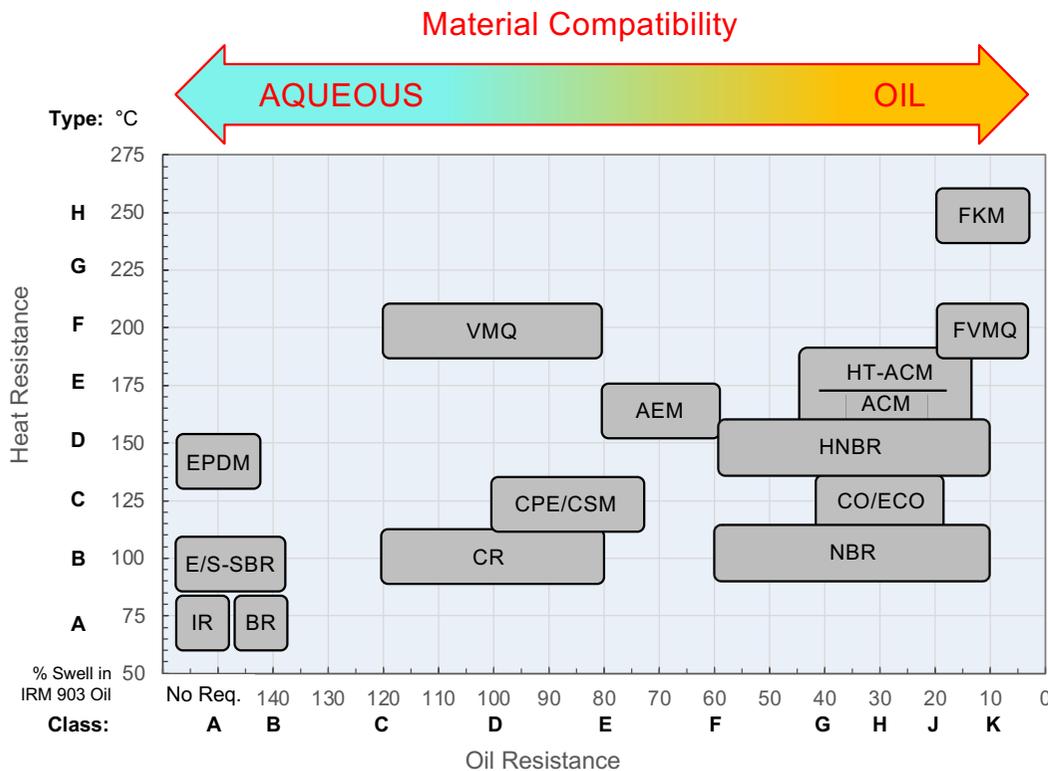
What is the impact to elastomer requirements?



Evaluation of Elastomers in Dielectric Fluids

ZEON has studied compatibility of elastomers in a range of dielectric fluid types

Based on the ASTM D2000 & SAE J200 Specification Systems



Relevant fluids can be categorized in three groups:

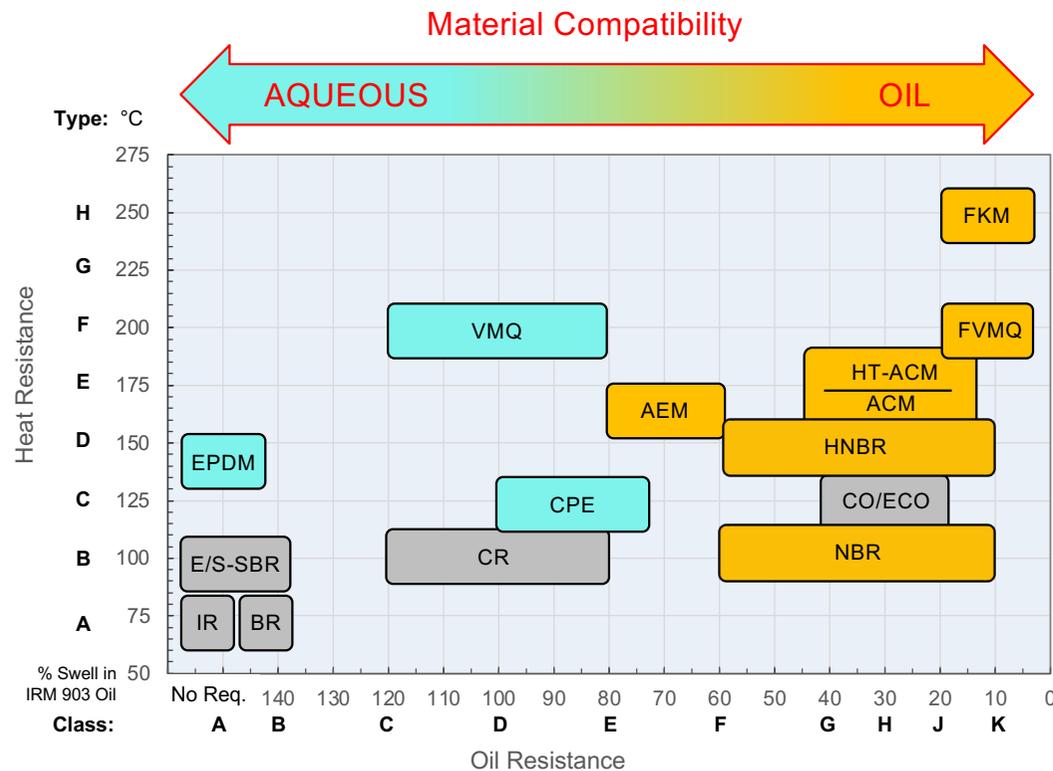
- (1) Single phase Hydrocarbon Oils (Poly-alpha Olefine | PAO)
- (2) Single phase Ester based
- (3) Hydrofluoroether based

Dielectric Fluid chemistry \neq water / glycol
All dielectric fluids \neq All dielectric Fluids

Evaluation of Elastomers in Dielectric Fluids

Elastomers evaluated consist of both aqueous and oil resistant types used in automotive

Based on the ASTM D2000 & SAE J200 Specification Systems



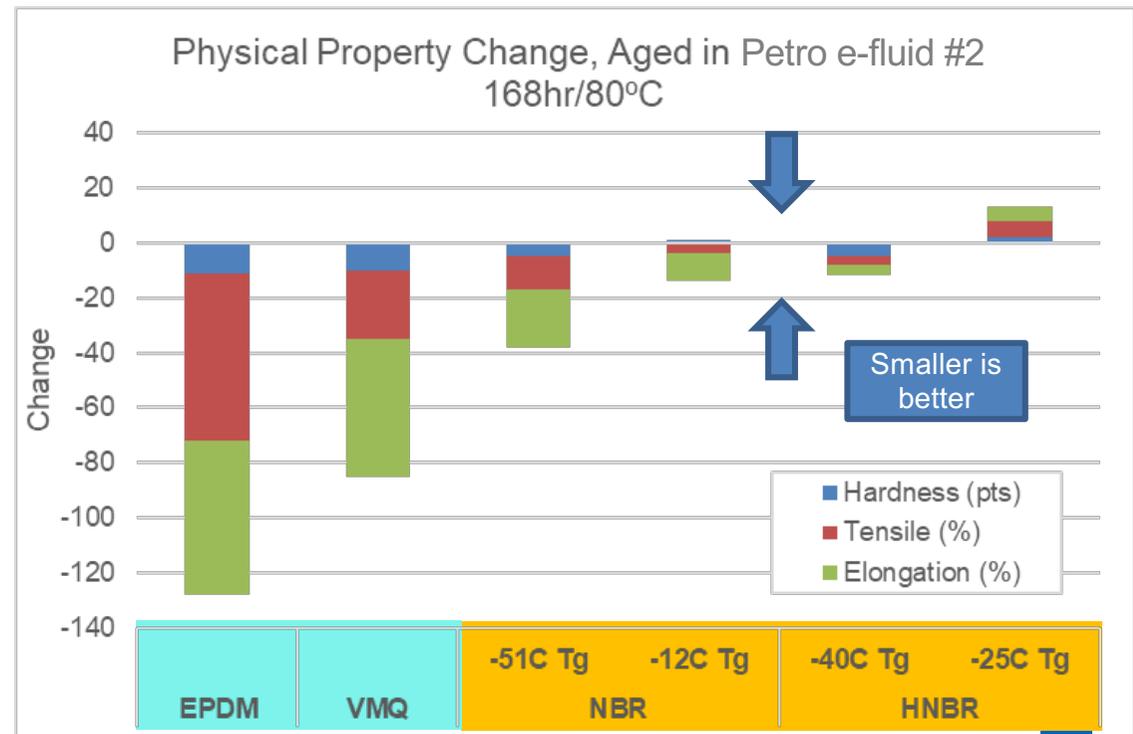
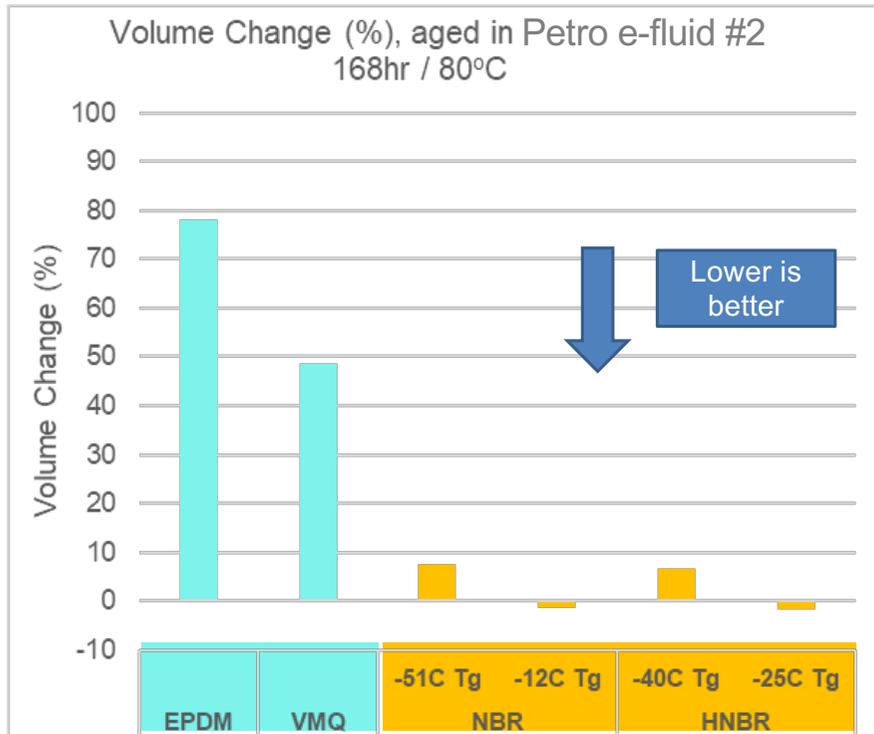
Compatibility	Material Type	Variation
Aqueous	>EPDM<	med. diene low ethylene
	>VMQ<	seal producer supplied
	>CPE<	35% Cl content
Oil	>NBR<	-51°C T _g -12°C T _g
	>HNBR<	-40°C T _g -25°C T _g
	>ACM< / >AEM<	~ -28°C T _g
	>FKM<	-30°C T _g -12°C T _g

Dielectric Fluid – Hydrocarbon Oil (PAO)

Elastomers in Hydrocarbon based Dielectric Fluids

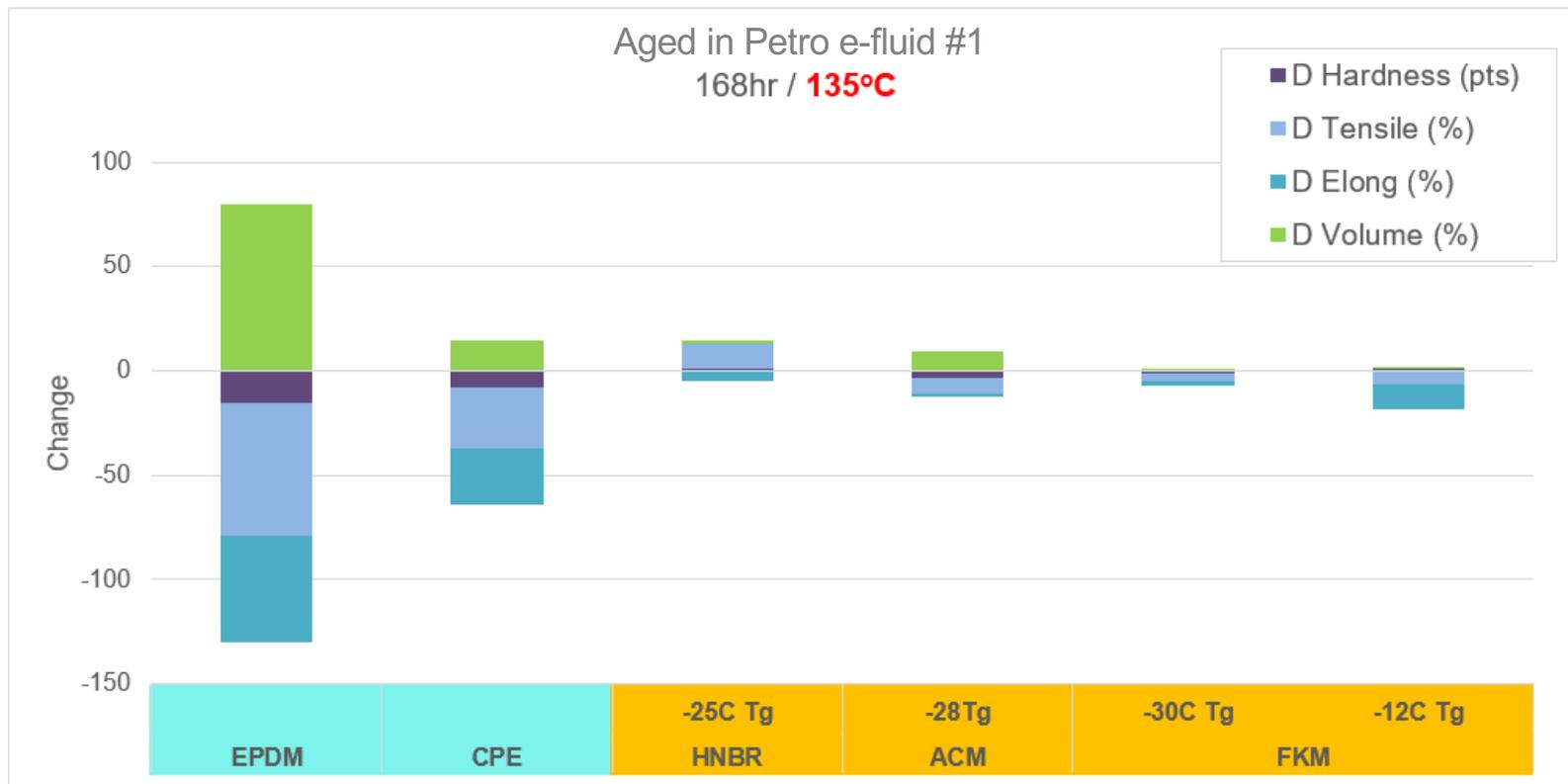
As expected, oil resistant elastomers perform well in Hydrocarbon based type fluids

Fluid Type	EPDM	VMQ	CPE	NBR		HNBR		HT-ACM / AEM	FKM	
				-51°C Tg	-12°C Tg	-40°C Tg	-25°C Tg		-30°C Tg	-12°C Tg
Hydrocarbon Based (PAO)	⊘	⊘	⊘	✓	✓	✓	✓	✓	✓	✓



Elastomers in Hydrocarbon based Dielectric Fluids

Even at elevated temperature, high temperature, oil resistant elastomers continue to perform well in Hydrocarbon based type fluids

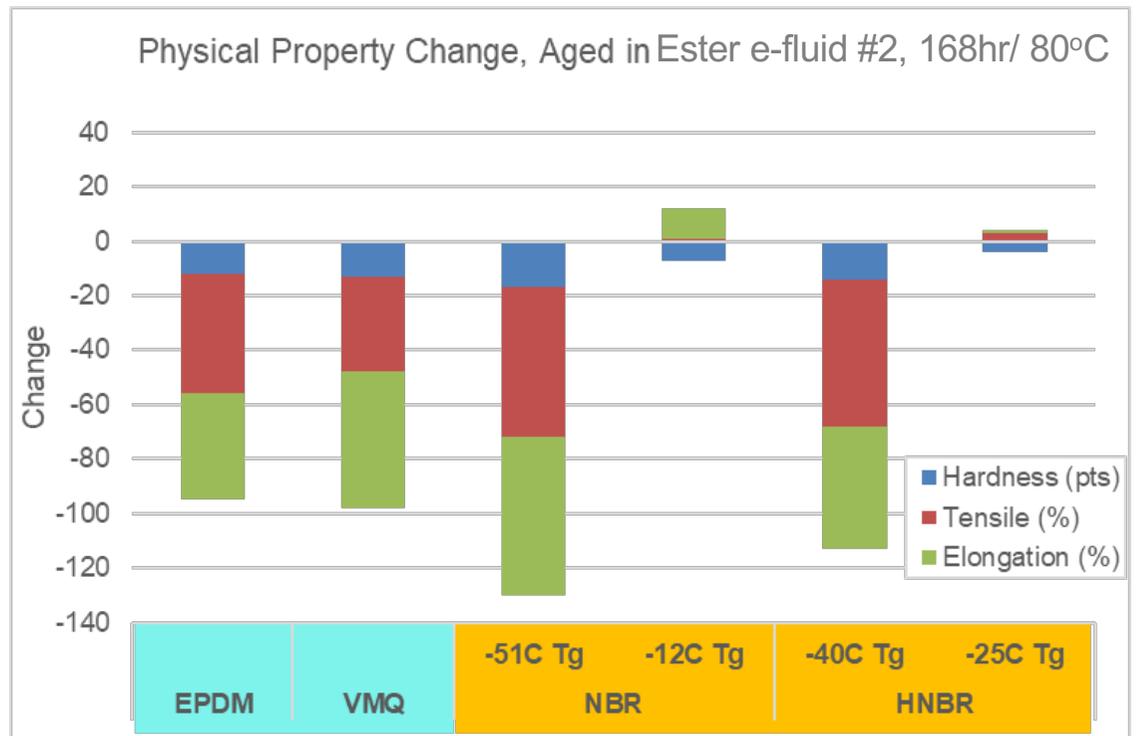
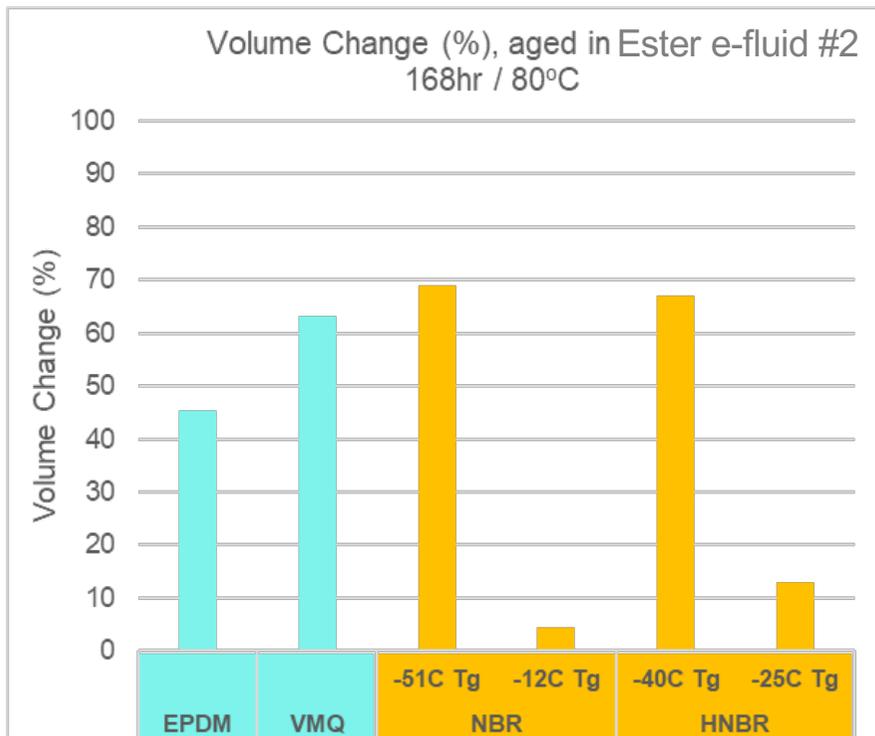


Dielectric Fluid – Ester

Elastomers in Ester Dielectric Fluids

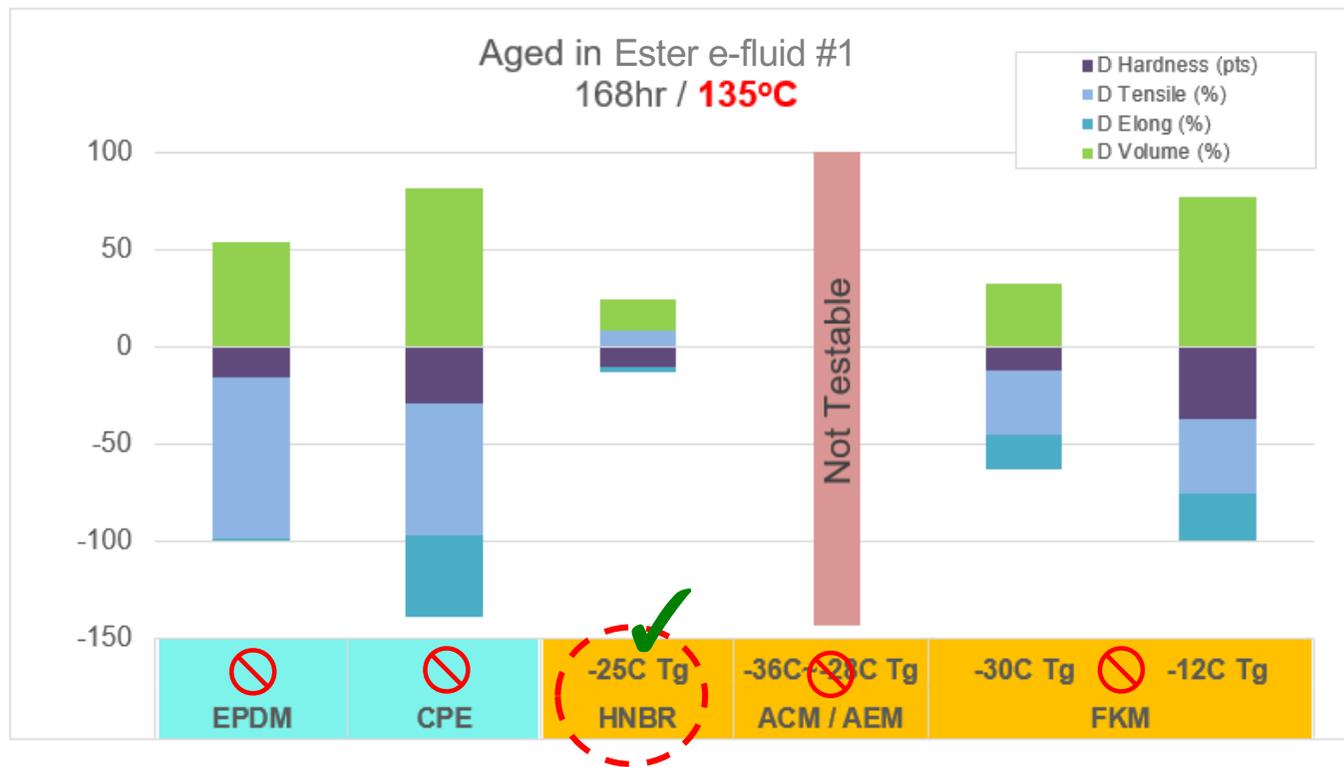
Ester type fluids have varying effect on polymers, even within same family of polymer

Fluid Type	EPDM	VMQ	CPE	NBR		HNBR		HT-ACM / AEM	FKM	
				-51°C Tg	-12°C Tg	-40°C Tg	-25°C Tg		-30°C Tg	-12°C Tg
Ester	⊘	⊘	⊘	⊘	✓	⊘	✓	⊘	▽	⊘



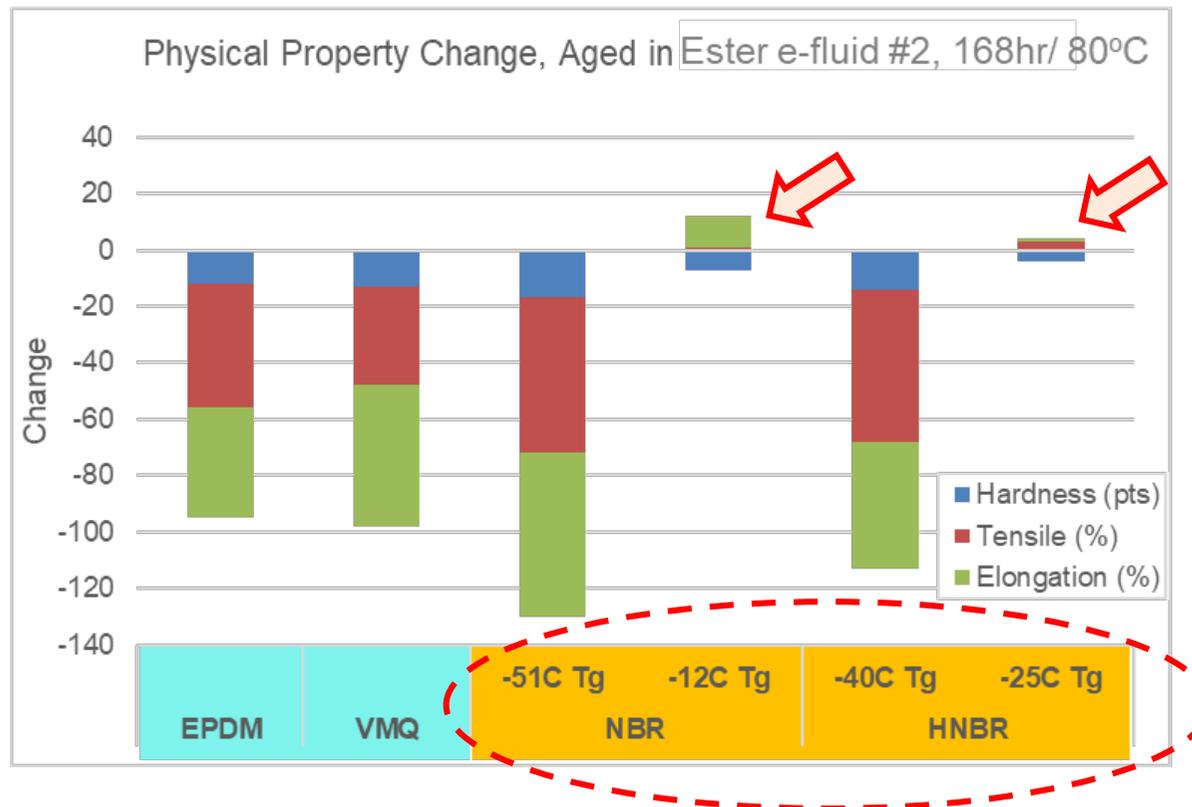
Elastomers in Ester Dielectric Fluids

Zetpol HNBR maintains compatibility with ester type dielectric fluids at high temperature



Elastomers in Ester Dielectric Fluids

Understanding polymer chemistry can help predict performance in functional application



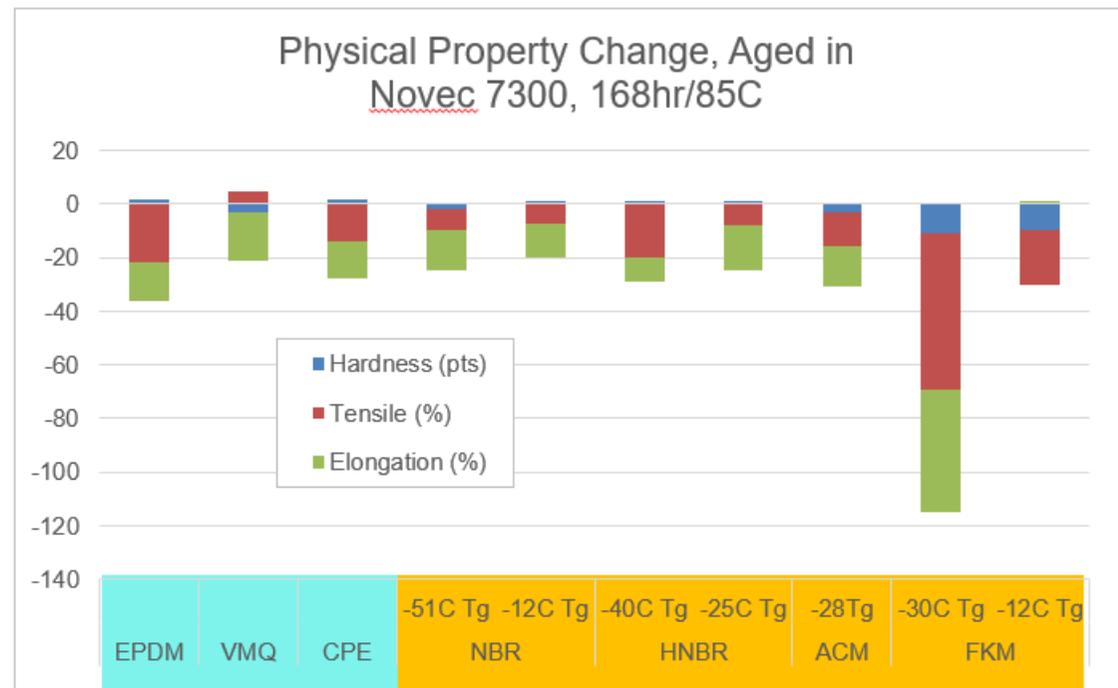
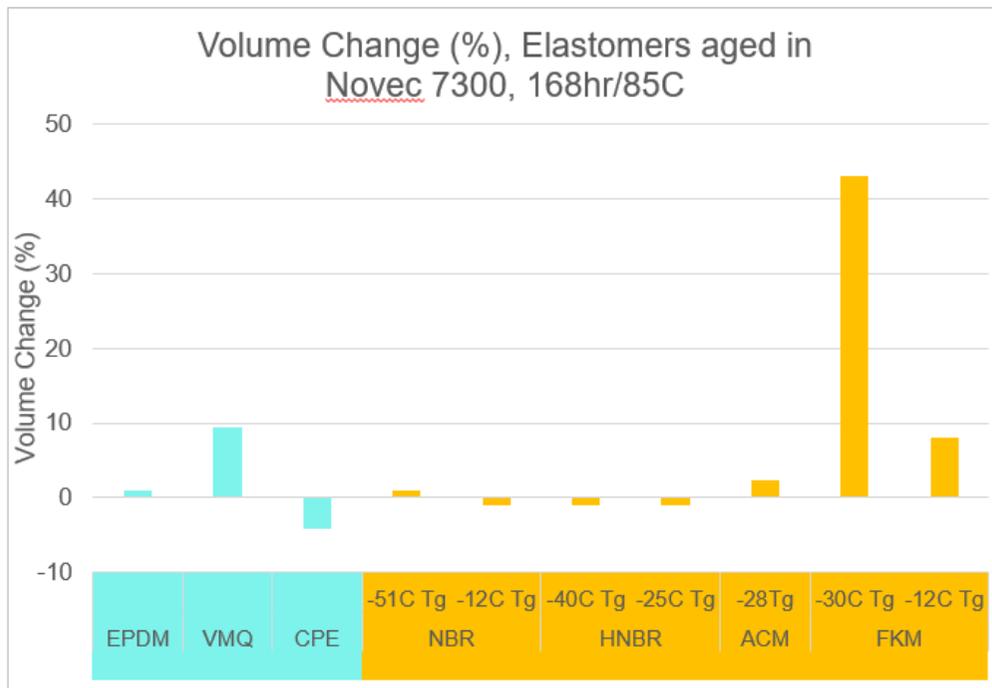
Dielectric Fluid – Hydrofluoroether

Elastomers in Hydrofluoroether Dielectric Fluids

Hydrofluoroether solvent immersion resulted in similar compatibility with many elastomer types

Fluid Type	EPDM	VMQ	CPE	NBR		HNBR		HT-ACM / AEM	FKM	
				-51°C Tg	-12°C Tg	-40°C Tg	-25°C Tg		-30°C Tg	-12°C Tg
Fluoroether	✓*	⊘	⊘	✓	✓	✓	✓	✓	⊘	✓

* Fluid turned dark brown upon immersion



Elastomers suitable for water/glycol coolant may not be compatible with dielectric fluids

		Aqueous-resistant materials			Oil-resistant elastomers							
		EPDM	VMQ	CPE	NBR		HNBR		ACM	FKM		
					Tg -51°C	Tg -12°C	Tg -40°C	Tg -25°C		Tg -30°C	Tg -12°C	
trad. Fluids	Water / Glycol (<100°C)	✓	✓	▽	▽	▽	✓	✓	▽	✓	✓	
	Dielectric Fluids	Hydrocarbon based (PAO)	⊘	⊘	▽	✓	✓	✓	✓	✓	✓	✓
		Ester	⊘	⊘	⊘	⊘	✓	⊘	✓	⊘	▽	⊘
	Hydrofluoro-ether	✓*	✓	✓	✓	✓	✓	✓	✓	⊘	✓	
		✓ Suitable			▽ Maybe suitable		⊘ Not suitable					

>EPDM< and >VMQ< are used in glycol coolant, but not suitable for use in oils or esters.

Depending on temperature requirements, **Nipol** >NBR< and **HyTemp** >ACM< are well-suited for use in Hydrocarbon-oil based coolants. **Zetpol** >HNBR< is compatible with all dielectric fluids tested.

Thank you for your attention!

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