

Technical Insight of KURARAY LIQUID RUBBER

# Silane modified LBR for SBR / Silica formulation

Elastomer R&D Department  
Elastomer Division

***kuraray***

# Agenda

Our silane-modified LBR; GS-L-BR is the latest development of KURARAY LIQUID RUBBER grades.

- 1) Silane modified LBR (GS-L-BR)
- 2) Evaluation in SBR / Silica formulation

# Silane modified LBR (GS-L-BR-188)

Grade Name [Development code]	Structure	Mw	Tg (°C)	Number of functional groups / chain	Viscosity at 38°C (Pa • s)
GS-L-BR-188 [SB-006]	Polybutadiene /Graft silane	38,000	-88	4	124

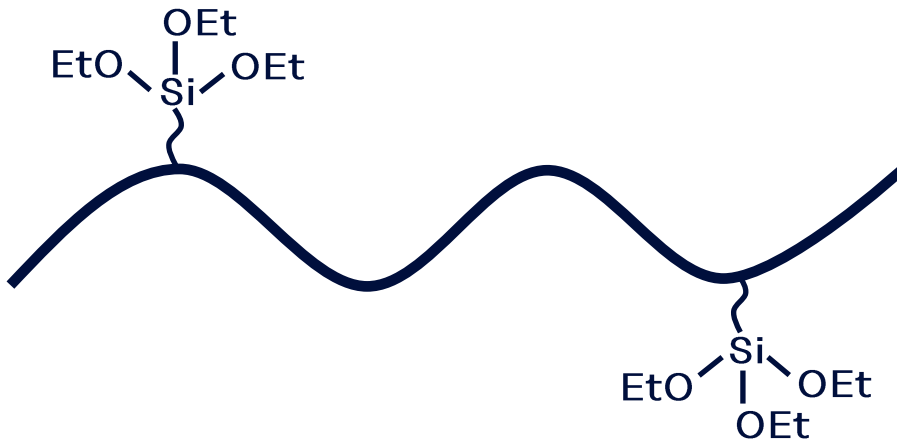


Image of GS-L-BR

- High reactivity with silica
- Improve silica dispersion
- Crosslinkable with base rubber

# Agenda

- 1) Silane modified LBR (GS-L-BR)
- 2) Evaluation in SBR / Silica formulation**

# Formulation & Mixing Conditions

(phr)	Control	GS-L-BR-188	
f-SSBR	80	80	80
BR	20	20	20
Silica	100	100	100
SCA	8	8	8
TDAE	35	29	23
GS-L-BR-188	-	6	12
Chemicals	ZnO 3.0, Stearic acid 2.5, 6PPD 2.5, Wax 2.0		
Sulfur	Sulfur 1.5		
Accelerators	DPG 0.5, CBS 0.35, TBTD 1.5		

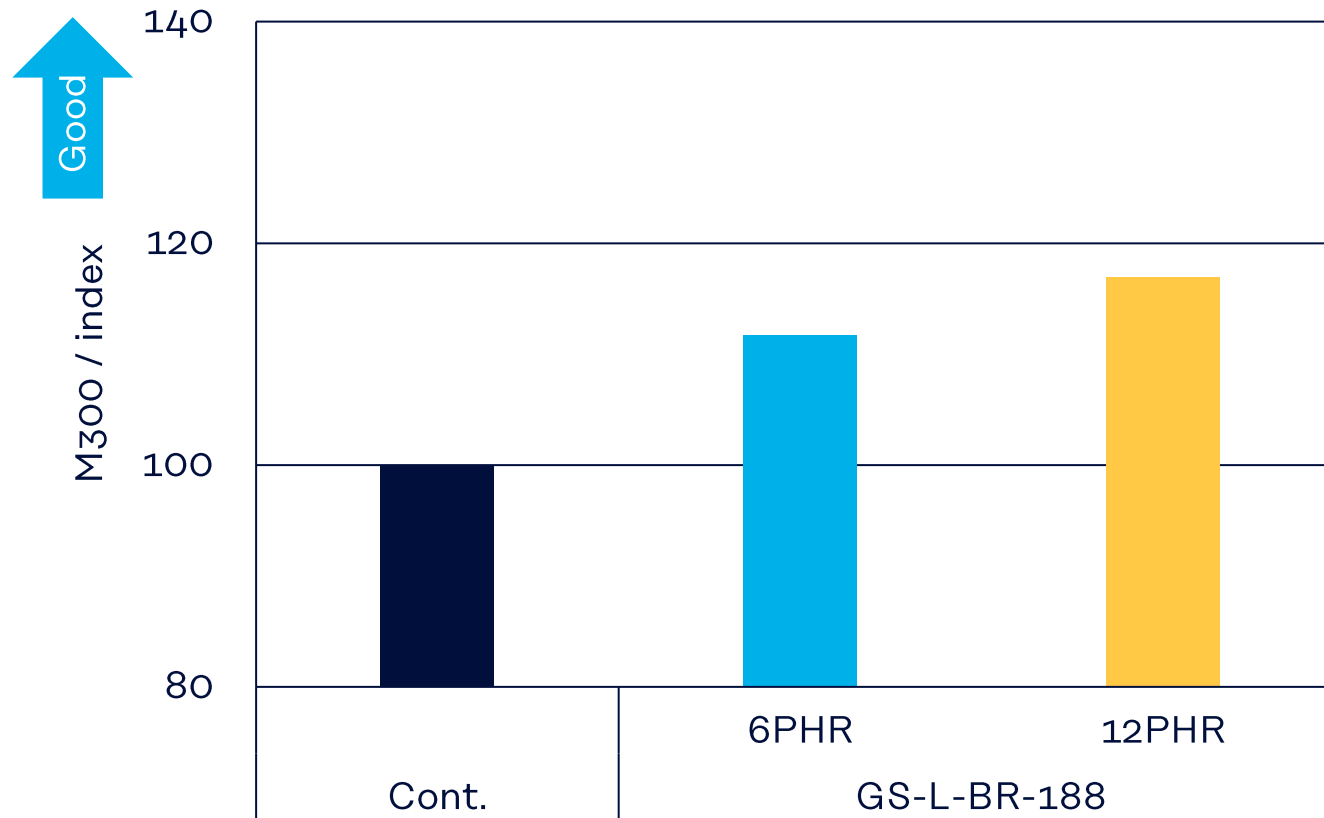
Mixing Conditions		
NP1	sec	Banbury-type mixer*
	0	Solid rubber (60°C)
	20	Silica, SCA, TDAE, LR, Chemicals
	180	Sweep
	360	Dump out (150-160°C)
NP2		Banbury-type mixer*
	0	1 <sup>st</sup> mixed compound(90°C)
	240	Dump out (150-160°C)
FM		Banbury-type mixer*
	0	Compound, Sulfur, Accelerators (50°C)
	75	Dump out (90-100°C)

\*MIXTRON® BB Mixer (by Kobe Steel, Ltd.)

## Summary of properties

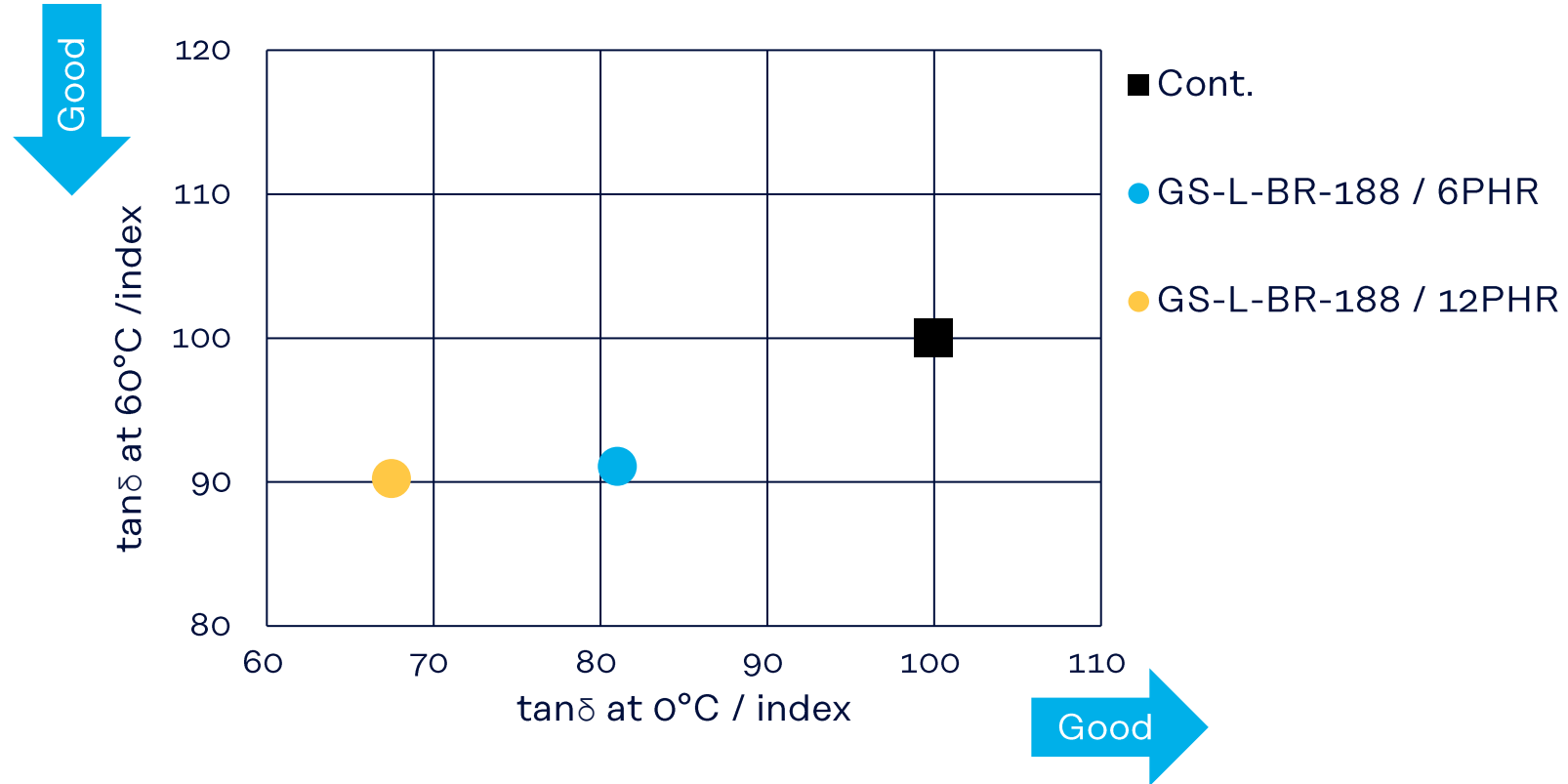
			Control	GS-L-BR-188	
				6phr	12phr
<b>Mooney Viscosity (ML1+4, @130°C)</b>			42.7	45.1	46.8
<b>Mechanical Properties</b>					
Hardness	Type A		63	62	64
EB	(%)		400	395	310
TB	(MPa)		20.9	23.0	17.9
M100	(MPa)		2.45	2.69	3.07
M300	(MPa)		13.9	15.5	16.3
<b>DMA (Dynamic Mechanical Analysis)</b>					
E'	0°C	(MPa)	11.0	9.45	9.31
	25°C	(MPa)	5.74	5.68	6.08
	60°C	(MPa)	4.15	4.31	4.71
tanδ	0°C	(-)	0.650	0.527	0.441
	25°C	(-)	0.291	0.235	0.214
	60°C	(-)	0.151	0.137	0.136
Payne effect (0.5%E'-5.0%E')	index		100	97	73
<b>Friction coefficient on Wet</b>					
20°C	index		100	97	94

# Analysis of 300% modulus [M300] for Silica-polymer interaction



- GS-L-BR-188 enhances silica-polymer interaction from the result of higher M300

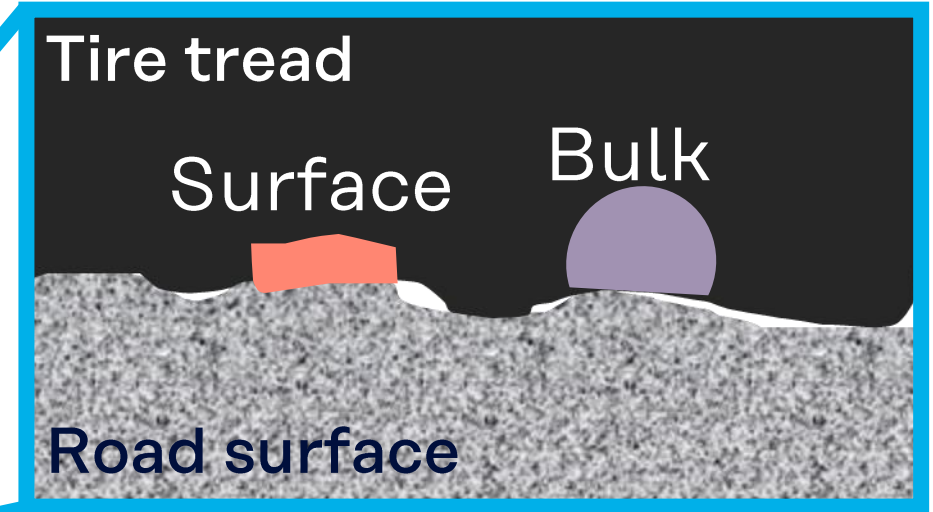
# DMA (Dynamic Mechanical Analysis)



- GS-L-BR-188 shows better rolling resistance  
tan δ at 0°C: Wet grip  
tan δ at 60°C: Rolling resistance



# Background



$$\text{Grip} = \text{Adhesion} + \text{Hysteresis}$$

In general,  $\tan\delta$  at  $0^\circ\text{C}$  is used as wet grip index.  
However actual wet grip is improved by multiple factors.  
Effect of Liquid Rubbers to Adhesion factor was evaluated.

# Measurement of Friction Performance



RTM friction tester



Size:  
Diameter 80mm  
Width 16mm



Road surface :  
Ice, Safety walk, Asphalt

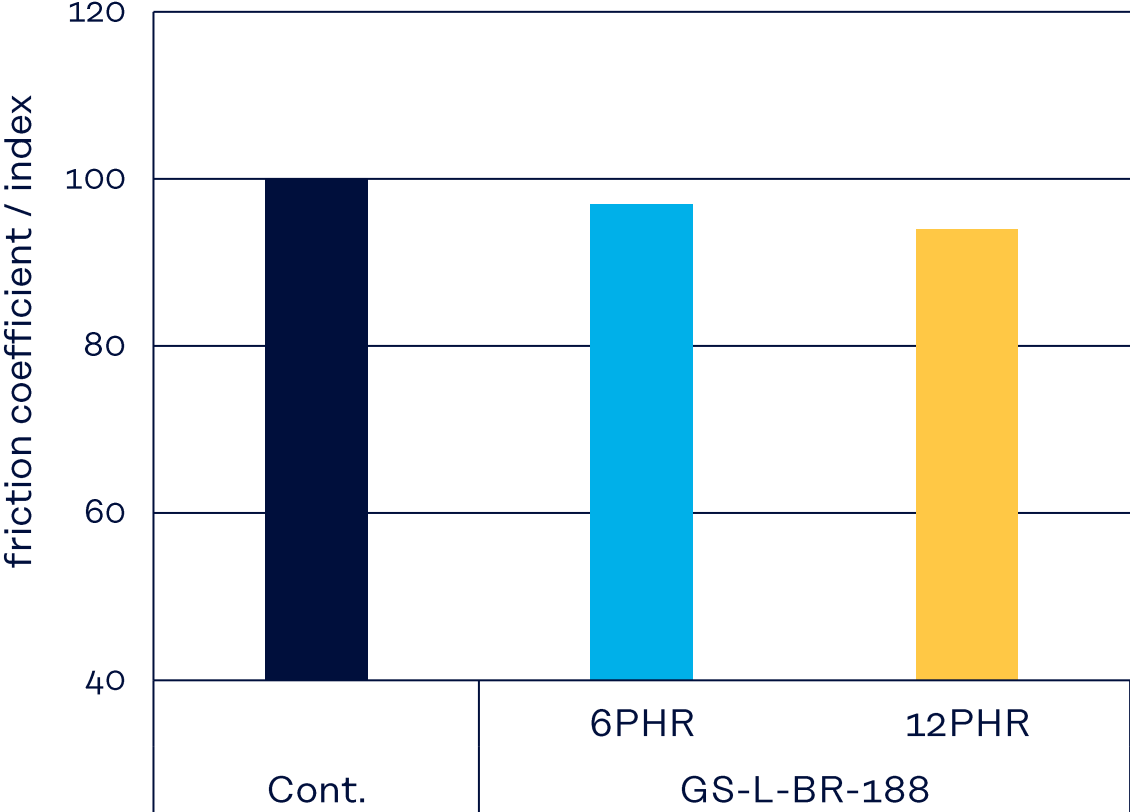
Mode :  
Ice, Wet, Dry grip, RR

- RTM measures grip performance comprised of Adhesion & Hysteresis.

# Friction Coefficient on Wet Surface

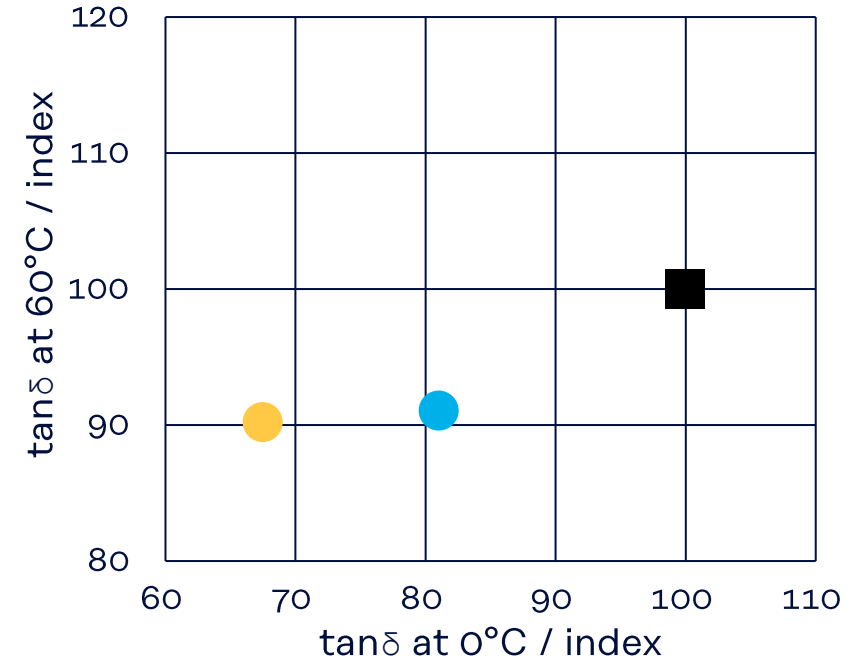
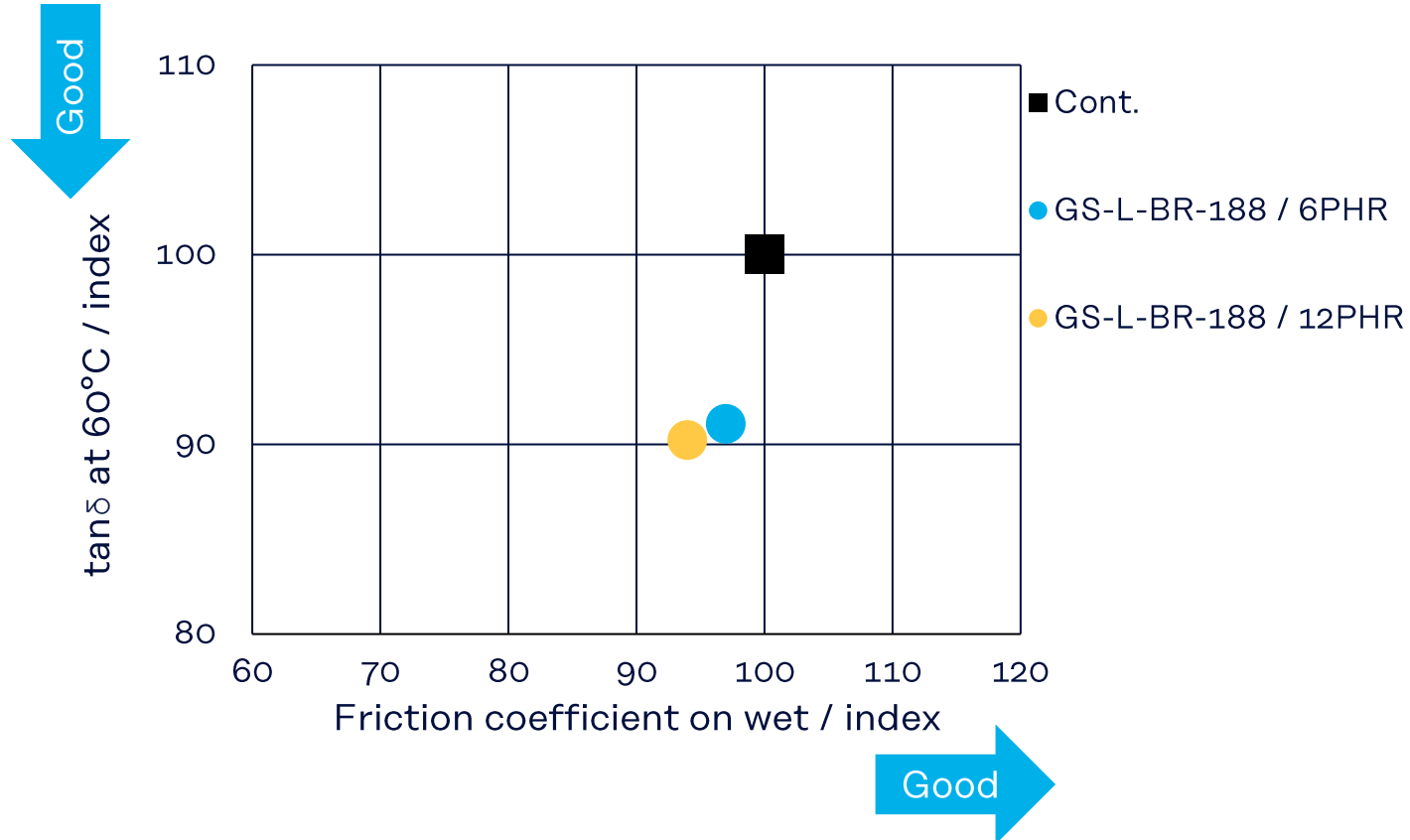
## Measured friction performance by RTM friction tester

Temperature 20°C  
Water temperature 20°C  
Initial circumferential speed 30km/h  
Load 50N  
Slip rate 0 to 40%  
Friction coefficient : Peak top value was read



- GS-L-BR-188 shows good wet grip despite its low  $\tan\delta$ .

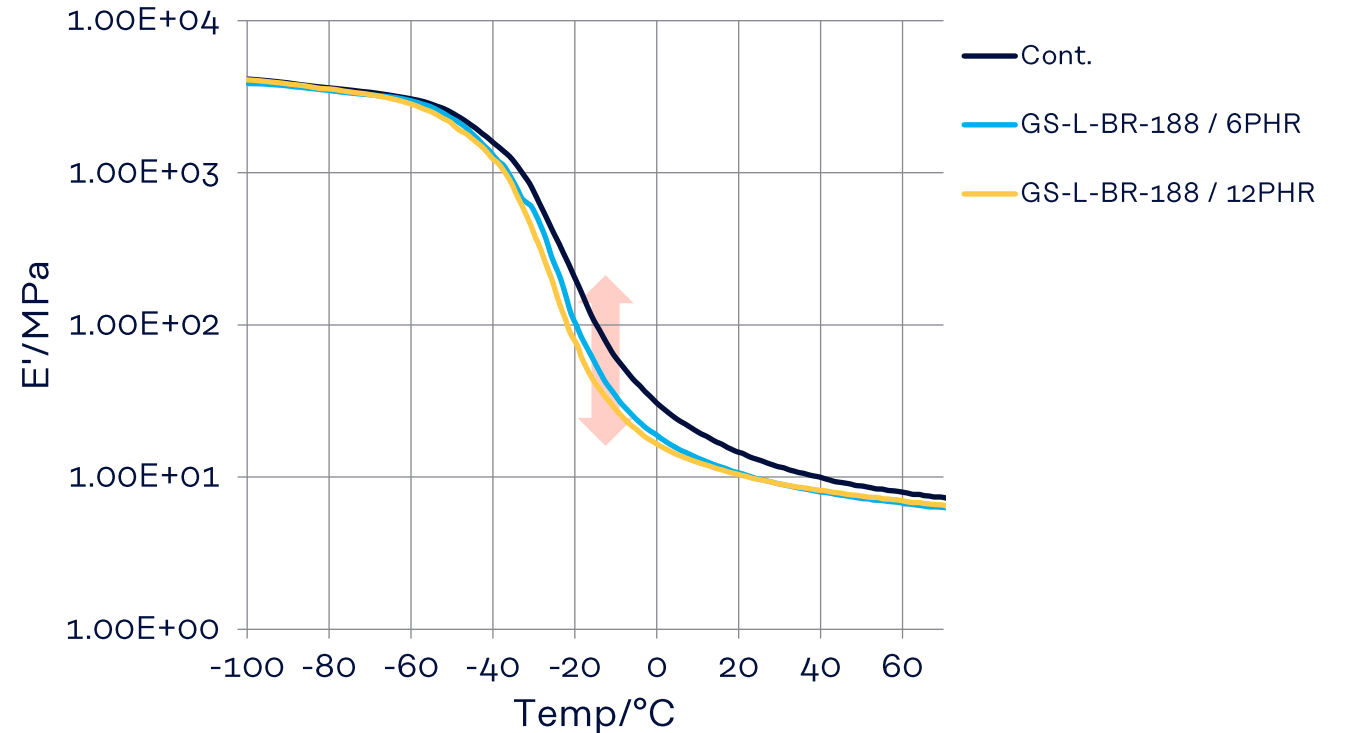
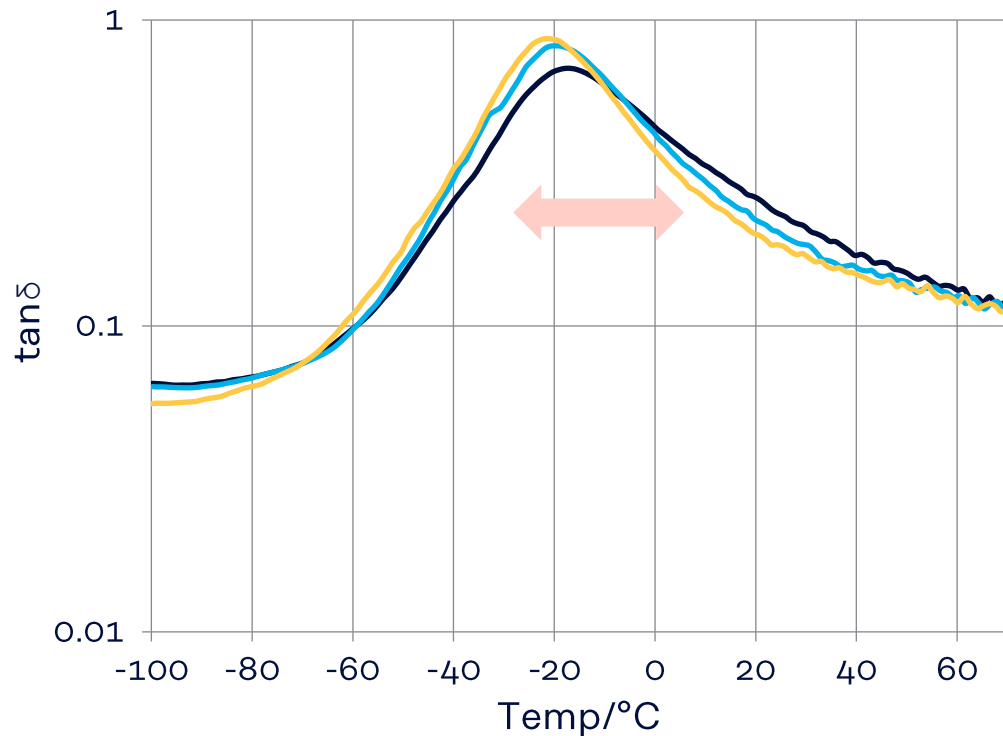
# Wet Grip vs Rolling Resistance (RR)



- GS-L-BR-188 shows good RR/Wet balance.

# DMA (Dynamic Mechanical Analysis)

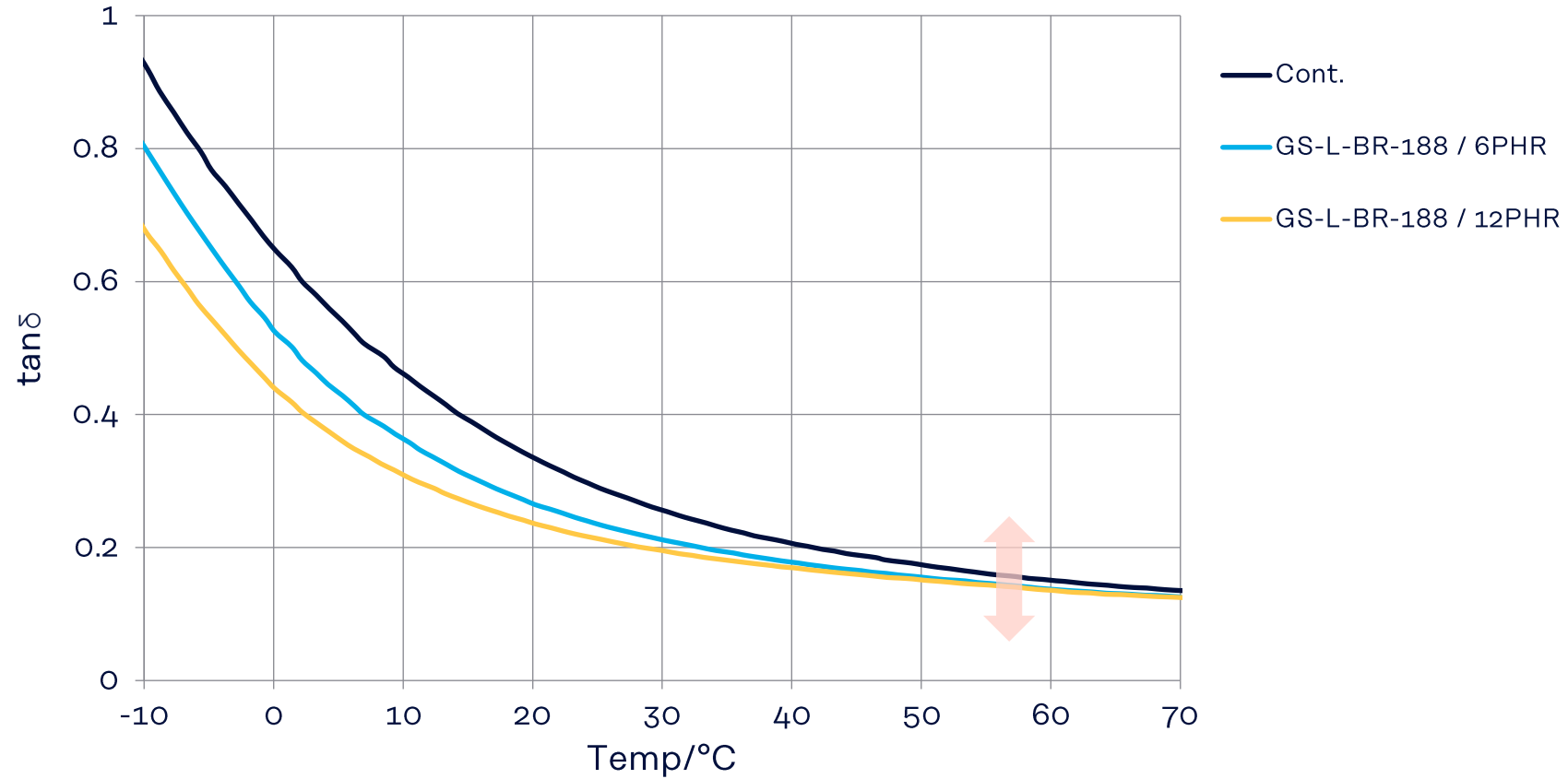
Static strain 0.5%  
Dynamic strain 0.1%  
Frequency 10Hz



- GS-L-BR-188 improves silica dispersion from the result of sharp  $\tan \delta$ .
- GS-L-BR-188 improves ice grip from the result of low  $E'$  at -20 $^{\circ}\text{C}$ .

# DMA (Dynamic Mechanical Analysis)

Static strain 10%  
Dynamic strain 2%  
Frequency 10Hz



- GS-L-BR-188 improves rolling resistance by lower  $\tan \delta$ .

# Summary

- GS-L-BR
  - improves dispersibility of silica
  - make crosslinking-bond with base rubber
  - improves silica-polymer interaction
- GS-L-BR-188
  - enhances interaction between silica-polymer
    - for better abrasion resistance
    - for better rolling resistance
  - showed good Wet/RR balance

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Precautions should be taken in handling and storage. Please refer to the appropriate Safety Data Sheet for further safety information. In using KURARAY LIQUID RUBBER, please confirm related laws and regulations, and examine its safety and suitability for the application.

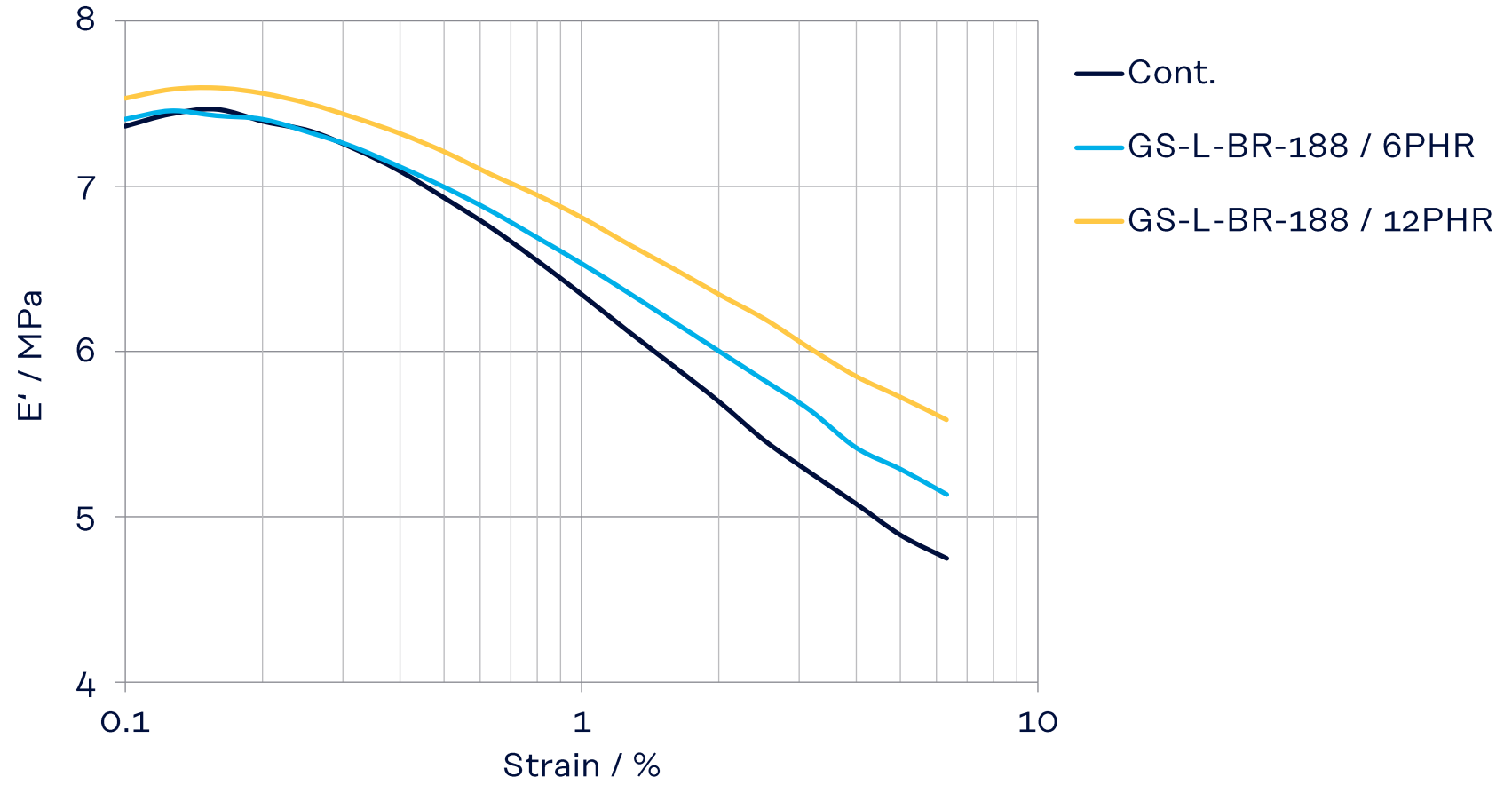
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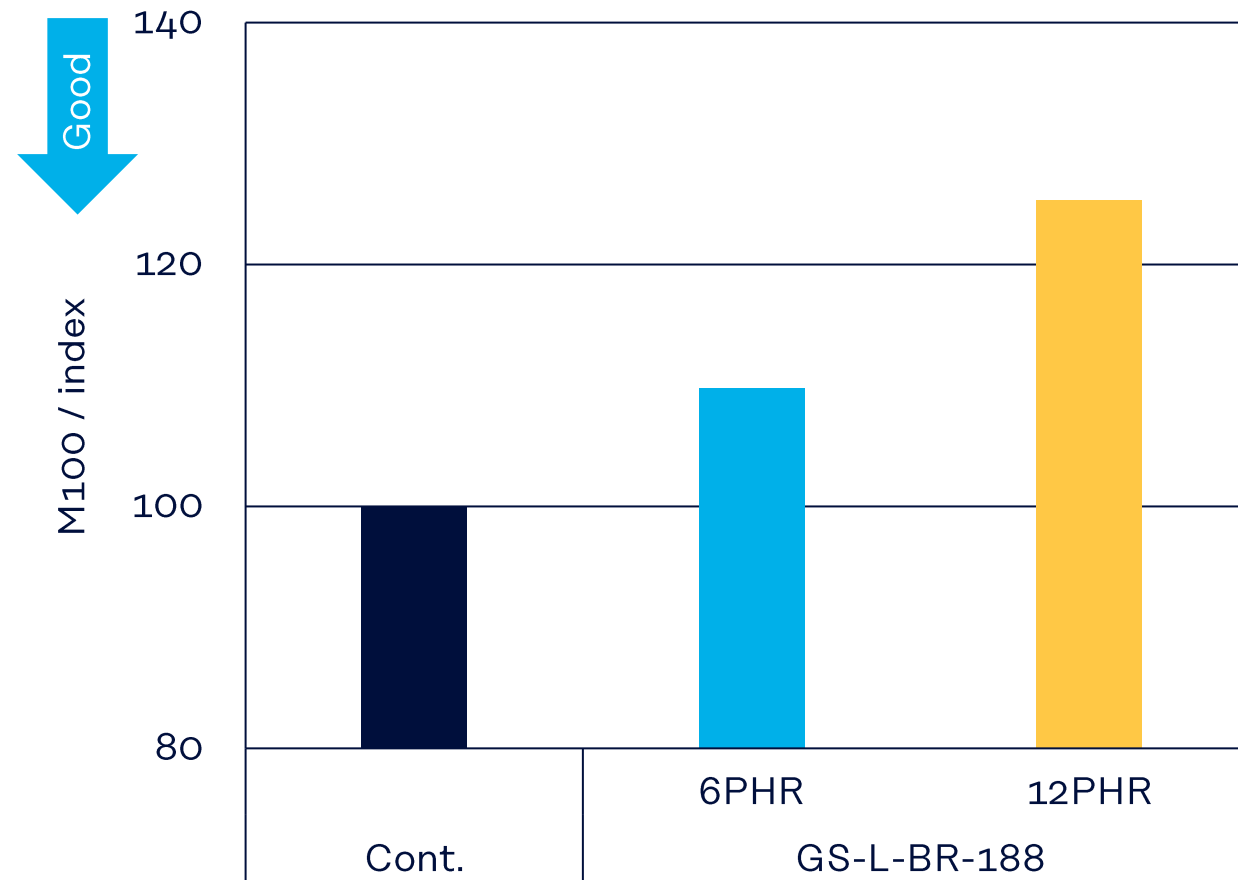


# APPENDIX

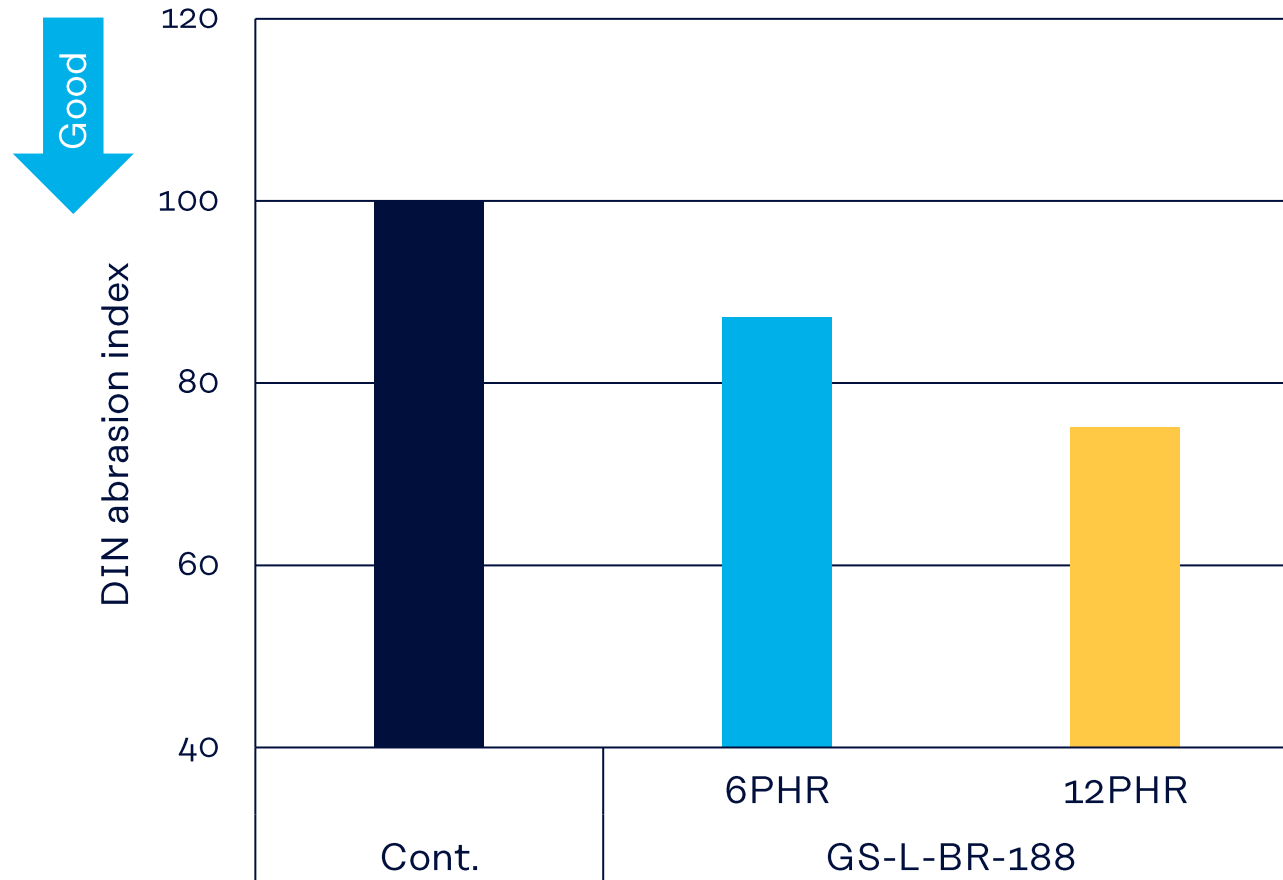
# Payne effect



# Analysis of 100% modulus [M100] for silica-silica interaction



# DIN abrasion resistance



- GS-L-BR-188 is able to improve abrasion resistance significantly.

# Raw material

Material	Product Name	Manufacturer	Note
Styrene-butadiene rubber	JSR HPR355	JSR Corporation	Styrene content: 27% Mooney Vis. @100°C: 44 Tg: -24°C
Butadiene Rubber	JSR BR01	JSR Corporation	Cis content: 95% Mooney Vis. @100°C: 45
Silica	ULTRASIL® 7000GR	Evonik Industries AG	Specific surface area (N2) 175 m <sup>2</sup> /g
Silane Coupling Agent	Si 75®	Evonik Industries AG	
TDAE	VIVATEC 500	H&R GmbH Co. KGaA	