HPM: A Grease Spec-tacular!

STLE Houston Chapter

Shawne Edwards-Zollar

February 10, 2023

INDUSTRIAL GREASE

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Today's Topic

- What's Grease?
- Changes in Grease & its Impact
- HPM's relevance to current Industry

- GC-LB & HPM Specifications
- Navigating HPM spec
- Q & A

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What is in a grease? Hint – there are 3 things

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Thickener Types

- What is the most common thickener type?
- What other thickener types can you name?

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NLGI Grade

- What does the NLGI grade indicate?

- The NLGI ranges from 000 to 6. Which is the most viscous?

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Grease Trends

Sustainability and the Challenges to the Grease Industry

The Rise of Electric Vehicles

NLGI HPM Specification

Lithium HSE Classification

Lithium Availability

Thickener Growth

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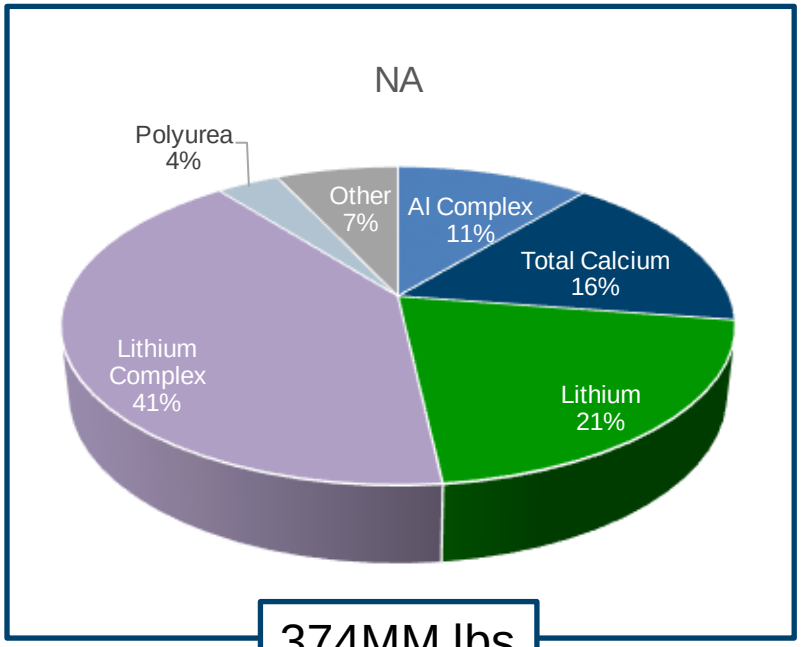
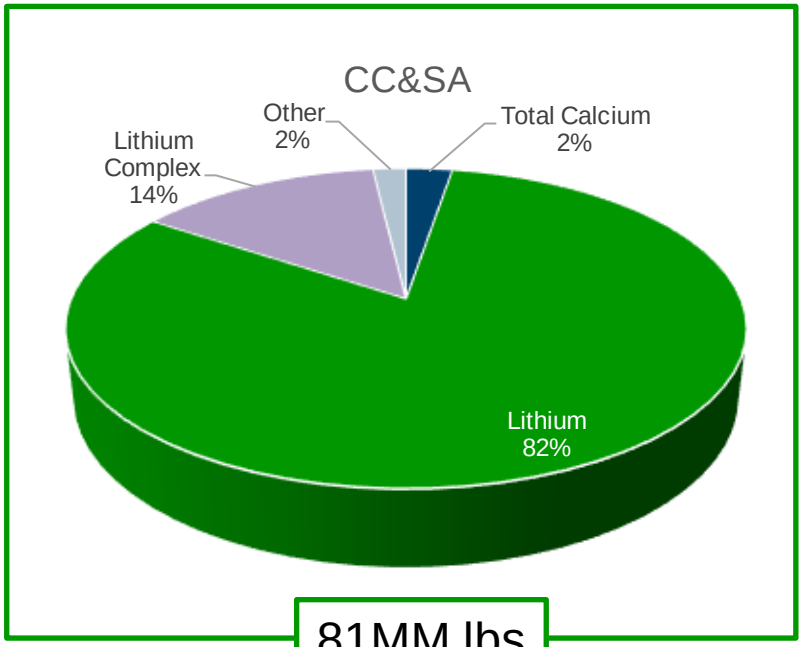
Americas Grease Production by Thickener Type – 454.7 MM lbs in 2021



374MM lbs



81MM lbs

>60% of grease production in NA is Li based
>95% of grease production in LA is Li based

Source: NLGI 2021 Grease Production Survey

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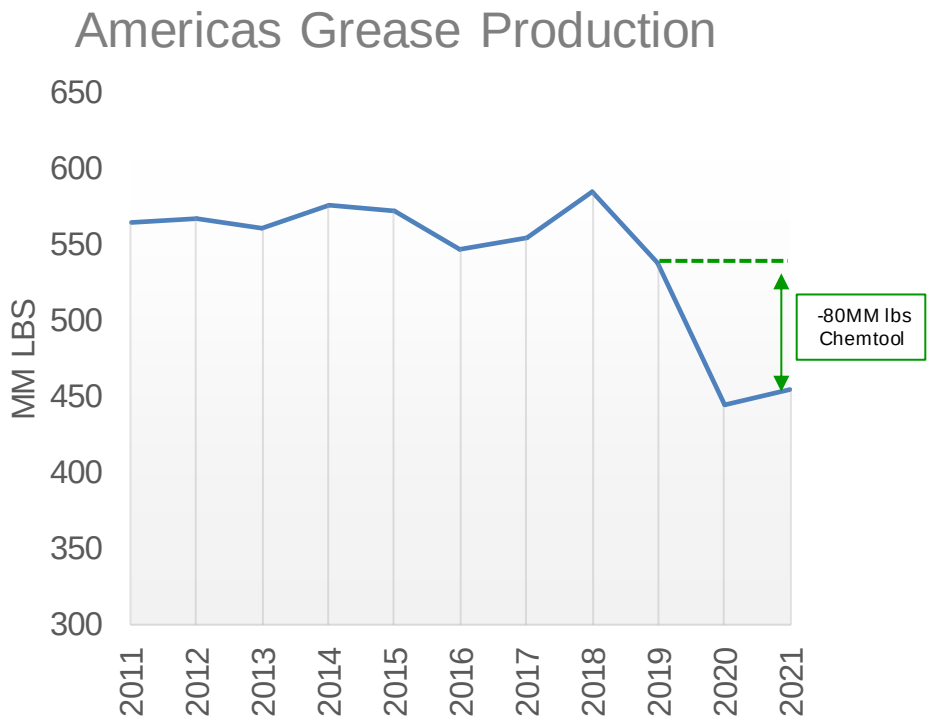
Americas Grease Production

- Total global production in 2021 was 2.62 Billion lbs
- The Americas accounts for 17% of global grease production
  - Americas recovery post pandemic is slower due to loss of Chemtool
- Overall global production trend is flat
  - Li thickener market share down globally 3% since 2018
  - Some areas of thickener growth (calcium sulfonate, polyurea, Al complex)



Source: NLGI Grease Production Survey 2011-2021

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Grease Trends

Raw material landscape changing

- Reduced Naphthenic availability & increased cost
- Reduced Group I production & less bright stock availability
- Lithium – Increased competition with batteries driving growth in alternative thickeners

Growing need for higher performing greases

- Better equipment protection desired
- Increasingly harsh conditions
  - Higher temperatures and higher loads
- Reduce total cost of ownership
- Extended service interval/sealed for life
- Noise reduction

Growth in key application areas:

- Wind Energy
- Automotive electrification
- Mining and Agriculture
- Steel and paper mills

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Impact of these trends on grease formulation

Raw material landscape changing

- Limited availability of bright stock drives focus onto alternatives such as OCP's or other polymers
- Lithium price increase helps bridge the gap between cost and performance driving the use of alternative thickeners (e.g. calcium sulphonate)

Growing need for higher performing greases

- More focus on thickener selection to gain performance improvements in sectors such as steel production
- Extended life refocuses on component chemistry for flexibility, plus better oxidation performance
- Noise reduction a major consideration in key sectors, such as wind & EV

Growth in key application areas

- Solutions for specific needs (e.g. fretting wear in wind turbines)
- Compatibility with seals & metallurgies (more testing)
- New specifications/standards & technology needed for auto electrification
- Next generation of specifications introduction (i.e. NLGI HPM)

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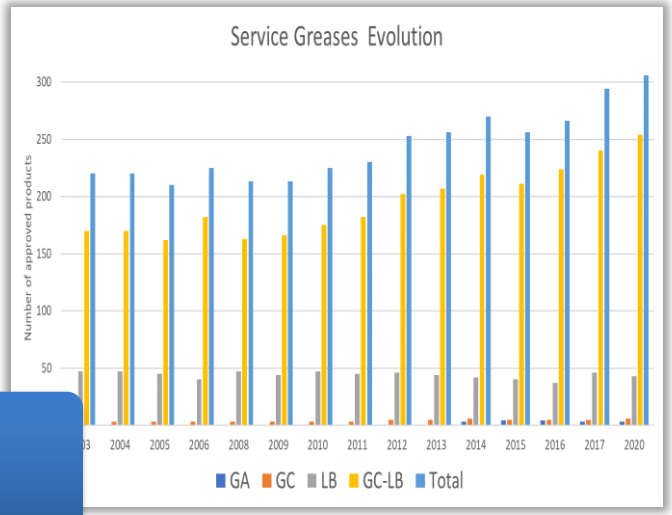
NLGI Specifications – Historical Perspective

1966 – Initial discussions held to develop automotive service grease specification between NLGI, ASTM, SAE

1989 – Publication of ASTM D4950 "Standard Classification and Specification for Automotive Service Greases"; NLGI begins certification of greases against new "GC-LB" specification.

2015 – NLGI establishes WG to discuss upgrades to GC-LB specification.

2019 – NLGI decides to move forward with proposal for new set of specifications in parallel to existing automotive service specifications.



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Specifications from NLGI - Dec 2020

GC-LB (ASTM D4950)	High-Performance Multiuse Specification (HPM)				
	HPM Core	+ Corrosion Resistance (CR)	+ High-Load (HL)	+ Water Resistance (WR)	+ Low-Temp (LT)

NLGI Serving the grease industry since 1933

Media Release
December 2, 2020

NLGI Launches High-Performance Multiuse (HPM) Grease Certification

Last year, NLGI began the advancement for a new High-Performance Multiuse (HPM) Grease Certification. Today, we're pleased to launch the HPM certification and sub-categories with enhanced performance in the following areas:

- HPM Core Spec
- HPM Grease Core with enhanced Water Resistance (HPM + WR)
- HPM Grease Core with enhanced Salt Water Corrosion Resistance (HPM + CR)
- HPM Grease Core with High Load Carrying Capacity (HPM + HL)
- HPM Grease Core with enhanced Low Temp Performance (HPM + LT)

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High-Performance Multiuse (HPM) Grease Specifications

- Overall Goal: Define new grease specification categories with higher performance and broader utility for the market
  - Increase communication between end-user and grease marketer/manufacturer
  - Will **NOT** replace GC-LB
- Additional Goal: Define greases that meet core HPM specification and sub-categories with tests and limits for *enhanced performance in the following areas*:
  - Water Resistance (WR)
  - High-Load Carrying Capacity (HL)
  - Salt Water Corrosion Resistance (CR)
  - Low-Temperature Performance (LT)
  - High-Temperature/Long Life (HT/LL?) *[under discussion for future]*
- Enhanced performance sub-categories must meet core HPM performance as well

HPM+WR
HPM+HL
HPM+CR
HPM+LT

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High-Performance Multiuse (HPM) Grease Specifications

Development Strategy

- Build specifications based on grease's ability to perform under identified conditions
- Set performance limits to be challenging yet achievable
- Strengthen certification and audit process compared to GC-LB

Benefits

- Increased product quality with higher level of audit/certification testing
- Unified guidance based on performance of grease
- Educate end-users regarding grease capabilities

Performance-based specification:

- Performance is the key
- Does not specify type of thickener, base oil, additive, or other raw material

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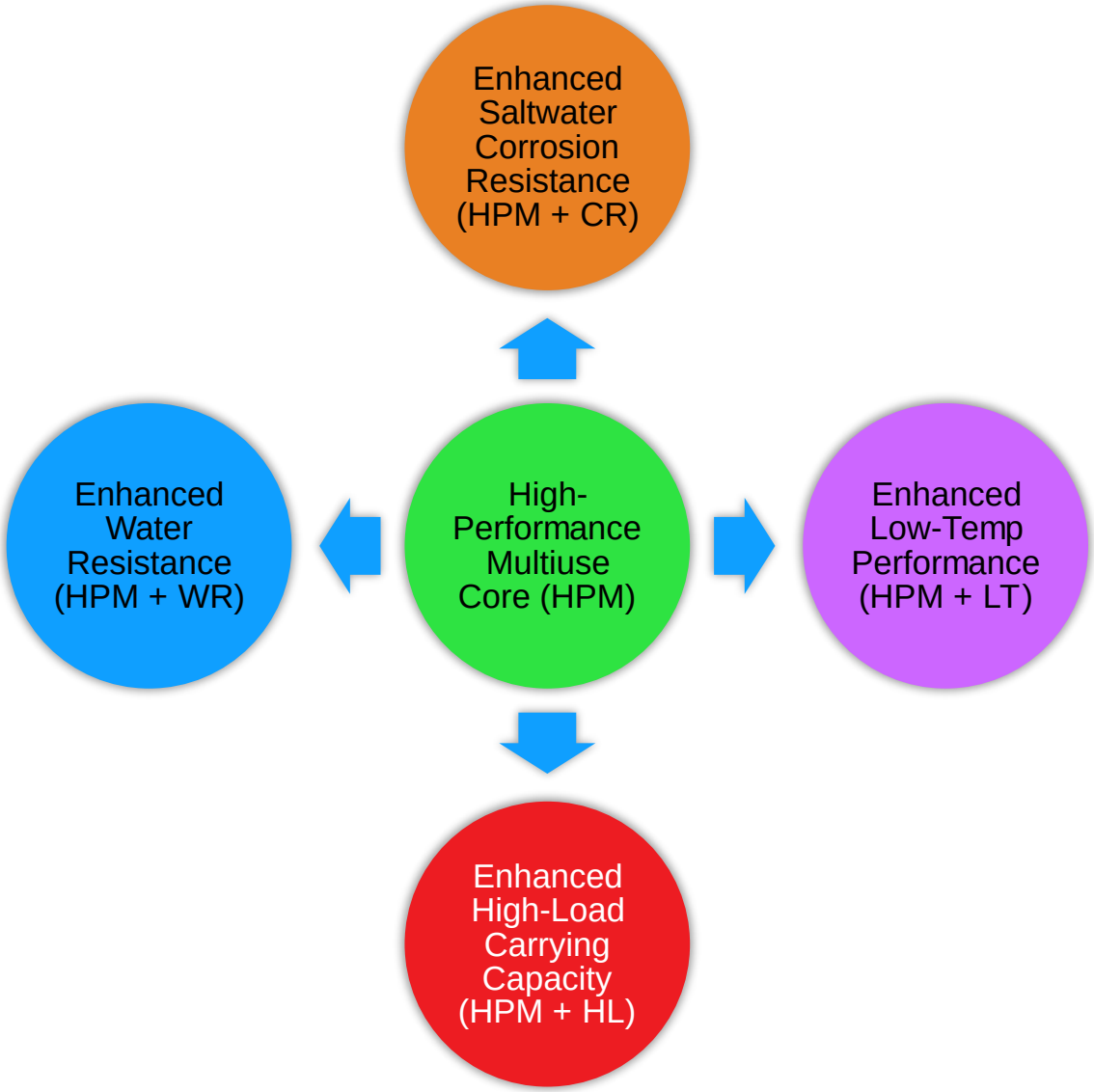
HPM Specifications Overview



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HPM Core Specifications

GC-LB (ASTM D4950)	High-Performance Multiuse Specification (HPM)				
	HPM Core	+ Corrosion Resistance (CR)	+ High-Load (HL)	+ Water Resistance (WR)	+ Low-Temp (LT)

Test Name	Units	Method	HPM Core
Worked-60 Pen	dmm	D217	220 -340
Rust Prevention	rating	D1743	Pass
Emcor rust test (distilled water), max	rating	D6138	0,1
Four-Ball Wear, max	mm	D2266	0.60
Four-Ball Weld, min	kgf	D2596	250
Oxid. Stability, 100 hrs, 100 °C, max	ΔkPa (psi)	D942	35 (4.9)
Copper corrosion, 24 hours, 100 °C, max	rating	D4048	1b
NBR (ISO 13226), 168 hours at 125 °C	ΔHardness	D4289	-15 to +2
	Δ Vol %	D4289	-5 to +30
Prolonged worked penetration (Δ10k)	dmm	D217	+/- 30
Water Washout, % loss, max	wt.%	D1264	10
High-Temp Bleed (30 hrs, 100 °C), max	wt.%	D6184	7
Roll stability (2 hrs, RT)	dmm	D1831	+/-10%
Oil Separation (24 hrs @ 25 °C), % loss, max	wt.%	D1742	5
Low-Temp Torque Ball Bearing, -20 °C		D1478	
Starting torque, max	mNm(g·cm)		1000(10,200)
Running torque, max	mNm(g·cm)		100(1,020)

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HPM + Corrosion Resistance (CR)

GC-LB (ASTM D4950)	High-Performance Multiuse Specification (HPM)				
	HPM Core	+ Corrosion Resistance (CR)	+ High-Load (HL)	+ Water Resistance (WR)	+ Low-Temp (LT)

Test Name	Units	Method	HPM Core	+ Corrosion Resistance (CR)
Worked-60 Pen	dmm	D217	220 -340	
Rust Prevention	rating	D1743	Pass	
Bearing rust (10% SSW)	rating	D5969		Pass
Emcor rust test (distilled water), max	rating	D6138	0,1	
Emcor rust (100% SSW), max	rating	D6138		1 , 2
Emcor rust (0.5 N NaCl solution), max	rating	D6138		2 , 3
Four-Ball Wear, max	mm	D2266	0.60	
Four-Ball Weld, min	kgf	D2596	250	
Oxid. Stability, 100 hrs, 100 °C, max	ΔkPa (psi)	D942	35 (4.9)	
Copper corrosion, 24 hours, 100 °C, max	rating	D4048	1b	
NBR (ISO 13226), 168 hours at 125 °C	ΔHardness	D4289	-15 to +2	
	Δ Vol %	D4289	-5 to +30	
Prolonged worked penetration (Δ10k)	dmm	D217	+/- 30	
Water Washout, % loss, max	wt.%	D1264	10	
High-Temp Bleed (30 hrs, 100 °C), max	wt.%	D6184	7	
Roll stability (2 hrs, RT)	dmm	D1831	+/-10%	
Oil Separation (24 hrs @ 25 °C), % loss, max	wt.%	D1742	5	
Low-Temp Torque Ball Bearing, -20 °C		D1478		
Starting torque, max	mNm(g·cm)		1000(10,200)	
Running torque, max	mNm(g·cm)		100(1,020)	

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Corrosion Resistance (CR) Tests

- EMCOR Dynamic bearing corrosion (ASTM D 6138)
  - Bearings run for 8 hours, sit for 16 (3 cycles) then sit for 4 days
  - Distilled or salt water
  - Rate from 0 (no rust) to 5 (severe)
- Standard bearing corrosion (ASTM D1743 / D5969)
  - Bearing packed with grease, 48 hrs. at 52°C in humid atmosphere
  - Distilled or salt water
  - Evaluate for rust, run in triplicate

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HPM + High-Load (HL)

GC-LB (ASTM D4950)	High-Performance Multiuse Specification (HPM)				
	HPM Core	+ Corrosion Resistance (CR)	+ High-Load (HL)	+ Water Resistance (WR)	+ Low-Temp (LT)

Test Name	Units	Method	HPM Core	+ High-Load (HL)
Worked-60 Pen	dmm	D217	220 -340	
Rust Prevention	rating	D1743	Pass	
Emcor rust test (distilled water), max	rating	D6138	0,1	
Four-Ball Wear, max	mm	D2266	0.60	0.50
Four-Ball Weld, min	kgf	D2596	250	400
SRV step Load, (Procedure B at 80 °C), min	N	D5706		800
Fretting wear (weight loss), aver 2, max	mg	D4170		5
Fretting wear scar by SRV, max	mm	D7594		0.500
Oxid. Stability, 100 hrs, 100 °C, max	ΔkPa (psi)	D942	35 (4.9)	
Copper corrosion, 24 hours, 100 °C, max	rating	D4048	1b	
NBR (ISO 13226), 168 hours at 125 °C	ΔHardness	D4289	-15 to +2	
	Δ Vol %	D4289	-5 to +30	
Prolonged worked penetration (Δ10k)	dmm	D217	+/- 30	
Water Washout, % loss, max	wt.%	D1264	10	
High-Temp Bleed (30 hrs, 100 °C), max	wt.%	D6184	7	
Roll stability (2 hrs, RT)	dmm	D1831	+/-10%	
Oil Separation (24 hrs @ 25 °C), % loss, max	wt.%	D1742	5	
Starting torque, max	mNm(g·cm)		1000(10,200)	
Running torque, max	mNm(g·cm)		100(1,020)	

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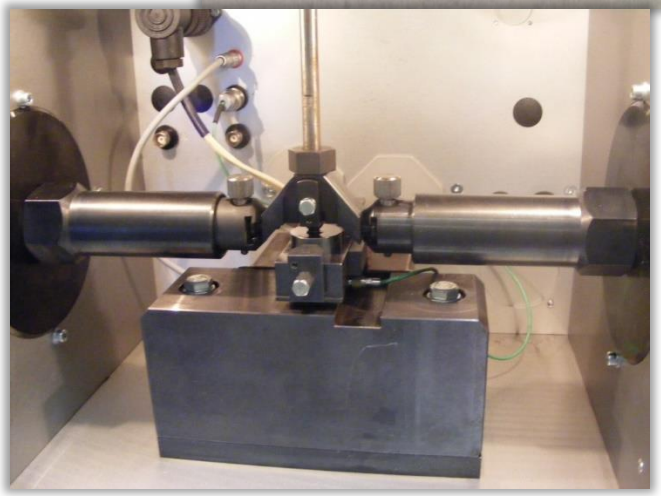
High Load (HL) Tests

- 4 Ball Wear (ASTM D2266)
  - 1h/75°C/1200rpm/ 40 kg (typical)
  - Wear scar
- 4 Ball EP (ASTM D2596)
  - Run at increasing loads
  - Weld point in kg
- Fafnir Fretting Wear (ASTM D4170)
  - Arc of 12°, frequency of 30.0 Hz, load of 2450 N, for 22 h at RT
  - Weight loss, mg
- SRV (Optimol)
  - Ball-on-disc tests
  - Step load (ASTM D5706)
  - Fretting wear (ASTM D7594)



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HPM + Water Resistance (WR)

GC-LB (ASTM D4950)	High-Performance Multiuse Specification (HPM)				
	HPM Core	+ Corrosion Resistance (CR)	+ High-Load (HL)	+ Water Resistance (WR)	+ Low-Temp (LT)

Test Name	Units	Method	HPM Core	+ Water Resistance (WR)
Worked-60 Pen	dmm	D217	220 -340	
Rust Prevention	rating	D1743	Pass	
Emcor rust test (distilled water), max	rating	D6138	0,1	
Four-Ball Wear, max	mm	D2266	0.60	
Four-Ball Weld, min	kgf	D2596	250	
Oxid. Stability, 100 hrs, 100 °C, max	ΔkPa (psi)	D942	35 (4.9)	
Copper corrosion, 24 hours, 100 °C, max	rating	D4048	1b	
NBR (ISO 13226), 168 hours at 125 °C	ΔHardness	D4289	-15 to +2	
	Δ Vol %	D4289	-5 to +30	
Prolonged worked penetration (Δ10k)	dmm	D217	+/- 30	
Water Washout, % loss, max	wt.%	D1264	10	5
Water spray off, max	wt.%	D4049		40
Wet roll stability (pen change)	dmm	D8022		+/- 15%
High-Temp Bleed (30 hrs, 100 °C), max	wt.%	D6184	7	
Roll stability (2 hrs, RT)	dmm	D1831	+/-10%	
Oil Separation (24 hrs @ 25 °C), % loss, max	wt.%	D1742	5	
Low-Temp Torque Ball Bearing, -20 °C		D1478		
Starting torque, max	mNm(g·cm)		1000(10,200)	
Running torque, max	mNm(g·cm)		100(1,020)	
Low-Temp Torque @ -40 °C, max	N-m	D4693		

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Water Resistance (WR) Tests

Water Washout (ASTM D1264)

- Ball bearing packed with grease and rotated at 600 r/min ± 30 r/min
- Measure the average of duplicate tests as the % wt. of grease washed out (60 min ± 1 min) at the test temperature

Water Spray Off (ASTM D4049)

- Grease is coated on a stainless steel panel and sprayed with water at the specified test temperature and pressure
- Measure of the resistance of the grease to water spray-off on the panel after 5 min ± 15 s to the nearest 1.0 %

Wet roll stability (ASTM D8022)

- Grease sample is mixed with water sheared at 20 °C to 35 °C for a specified time in a roll stability apparatus
- Report the difference of the final cone penetration reading minus the initial penetration reading between the cone penetration before working and the cone penetration after

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HPM + Low-Temperature (LT)

GC-LB (ASTM D4950)	High-Performance Multiuse Specification (HPM)				
	HPM Core	+ Corrosion Resistance (CR)	+ High-Load (HL)	+ Water Resistance (WR)	+ Low-Temp (LT)

Test Name	Units	Method	HPM Core	+ Low-Temp (LT)
Worked-60 Pen	dmm	D217	220 -340	
Rust Prevention	rating	D1743	Pass	
Emcor rust test (distilled water), max	rating	D6138	0,1	
Four-Ball Wear, max	mm	D2266	0.60	
Four-Ball Weld, min	kgf	D2596	250	
Oxid. Stability, 100 hrs, 100 °C, max	ΔkPa (psi)	D942	35 (4.9)	
Copper corrosion, 24 hours, 100 °C, max	rating	D4048	1b	
NBR (ISO 13226), 168 hours at 125 °C	ΔHardness	D4289	-15 to +2	
	Δ Vol %	D4289	-5 to +30	
Prolonged worked penetration (Δ10k)	dmm	D217	+/- 30	
Water Washout, % loss, max	wt.%	D1264	10	
High-Temp Bleed (30 hrs, 100 °C), max	wt.%	D6184	7	
Roll stability (2 hrs, RT)	dmm	D1831	+/-10%	
Oil Separation (24 hrs @ 25 °C), % loss, max	wt.%	D1742	5	
Low-Temp Torque Ball Bearing, -20 °C		D1478		
Starting torque, max	mNm(g·cm)		1000(10,200)	
Running torque, max	mNm(g·cm)		100(1,020)	
Low-Temp Torque Ball Bearing, -30 °C		D1478		
Starting torque, max	mNm (g·cm)			1000(10200)
Running torque, max	mNm (g·cm)			100(1020)
U. S. Steel Mobility, -20 °C, min	g/min	LT-37		10
Low-Temp Flow (Kesternich), -30 °C, max	mbar	DIN 51805-2		1400

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Low-Temperature (LT) Tests

- Kesternich – Low Temperature Flow properties (DIN 51805-2)
  - Sample is conditioned to agreed upon temp. For 2 hrs.
    - 0°C to -50°C
  - Pressure is increased at intervals of 30 sec until the gas escapes and the grease 'moves'
  - Temp. and pressure (hPa) are recorded
- U. S. Steel Mobility, LT-37
  - Limits >10 g/min @-20°C (-4°F)
- D1478 Low-Temp Torque
  - Pack bearing with sample, then lower to test temp. And hold for 2hrs.
  - Bearing starts slow rotation (1 rpm)
    - Starting torque recorded
  - After 1 hour
    - Running torque recorded

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NLGI GC-LB vs HPM Core

GC-LB (ASTM D4950)	High-Performance Multiuse Specification (HPM)				
	HPM Core	+ Corrosion Resistance (CR)	+ High-Load (HL)	+ Water Resistance (WR)	+ Low-Temp (LT)

Test Name	Units	Method	NLGI GC-LB	HPM Core
Worked-60 Pen	dmm	D217	220 - 340	220 -340
Rust Prevention	rating	D1743	Pass	Pass
Emcor rust test (distilled water), max	rating	D6138		0,1
Four-Ball Wear, max	mm	D2266	0.6	0.60
Four-Ball Weld, min	kgf	D2596	200	250
Four-Ball LWI, min	kgf	D2596	30	
Fretting Protection, max	mg	D4170	10	
Dropping Point, min	°C (°F)	D566/D2265	220 (428)	
High-Temp Life, max	hrs	D3527	80	
Oxid. Stability, 100 hrs, 100 °C, max	ΔkPa (psi)	D942		35 (4.9)
Copper corrosion, 24 hours, 100 °C, max	rating	D4048		1b
CR Volume Change	Δ Vol %	D4289	0 to 40	
CR Hardness Change	ΔHardness	D4289	-15 to 0	
NBR Volume Change	Δ Vol %	D4289	-5 to 30	
NBR Hardness Change	ΔHardness	D4289	-15 to 2	
NBR (ISO 13226), 168 hours at 125 °C	ΔHardness	D4289		-15 to +2
	Δ Vol %	D4289		-5 to +30
Prolonged worked penetration (Δ10k)	dmm	D217		+/- 30
Water Washout, % loss, max	wt.%	D1264	15	10
High-Temp Bleed (30 hrs, 100 °C), max	wt.%	D6184		7
Roll stability (2 hrs, RT)	dmm	D1831		+/-10%
Oil Separation (24 hrs @ 25 °C), % loss, max	wt.%	D1742	6	5
Leakage, grams loss, max	g	D4290	10	
Low-Temp Torque Ball Bearing, -20 °C		D1478		
Starting torque, max	mNm(g·cm)			1000(10,200)
Running torque, max	mNm(g·cm)			100(1,020)
Low-Temp Torque @ -40 °C, max	N-m	D4693	15.5	

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Combinations

- Corrosion Resistance
- High Load
- Water Resistance
- Low Temperature
- Other Combinations Possible

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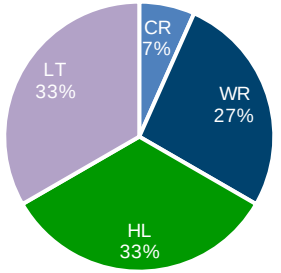
NLGI HPM Statistics – November 2022

Registered Branded Product	Supplier	CORE	Corrosion Resistance	Water Resistance	High Load	Low Temperature
Acinol 152 HQS (US) – All Colors	Axel Americas	CORE+		+WR		+LT
Axellence 652 HQ (US) – All Colors	Axel Americas	CORE+				+LT
Castrol Molub-Alloy 860/460-1 ES	BP Lubricants USA, Inc.	CORE				
Castrol Tribol™ GR SW 460-1	BP Lubricants USA, Inc.	CORE+	+CR		+HL	+LT
Gadus® S3 V220C 2	Shell	CORE+			+HL	
GLEITMO 680 XT	FUCHS Lubricants Co.	CORE				
LML Lithium Complex Grease	Loadmaster Lubricants, LLC	CORE+		+WR		
Mobilgrease XHP™ 222	ExxonMobil Oil Corporation	CORE+		+WR		
MOLYKOTE® Multilub Synthetic High Performance Grease	Molykote Specialty Lubricants	CORE+				+LT
Peerless™ LLG	Petro-Canada Lubricants, an HF Sinclair Brand	CORE				
Peerless™ OG2 Red	Petro-Canada Lubricants, an HF Sinclair Brand	CORE				
RENOLIT CXS BGR	FUCHS Lubricants Co.	CORE+			+HL	+LT
RENOLIT CXS CRM 1	FUCHS Lubricants Co.	CORE				
RENOLIT LX 2	FUCHS Lubricants Co.	CORE				
STABYL LX 460 SYN	FUCHS Lubricants Co.	CORE+			+HL	
Valvoline™ Cerulean Plus #2	Valvoline, Inc.	CORE		+WR	+HL	
Valvoline™ Extreme Red	Valvoline, Inc.	CORE				

17 Greases Listed as of 11/21/22

8 greases (47%) are CORE only

Performance Tag Breakdown



3 greases (18%) have multiple tags

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HPM Specification - Implementation

- The website is now live and accepting applications
  - www.CenterforQA.com/hpm-about
- CQA will collect samples and carry out testing as part of certification and audit program

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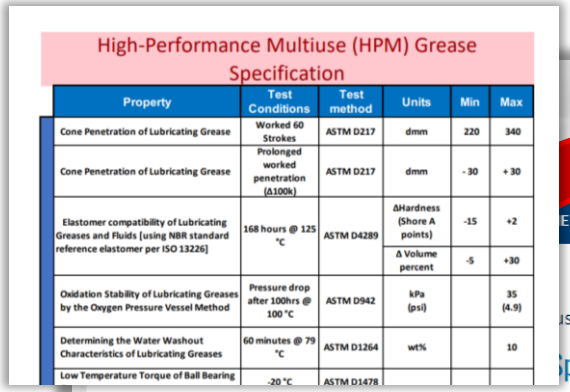
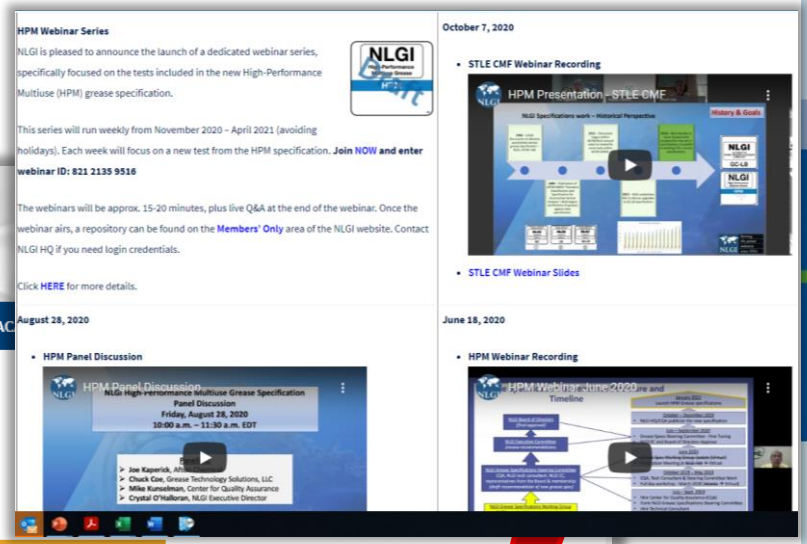
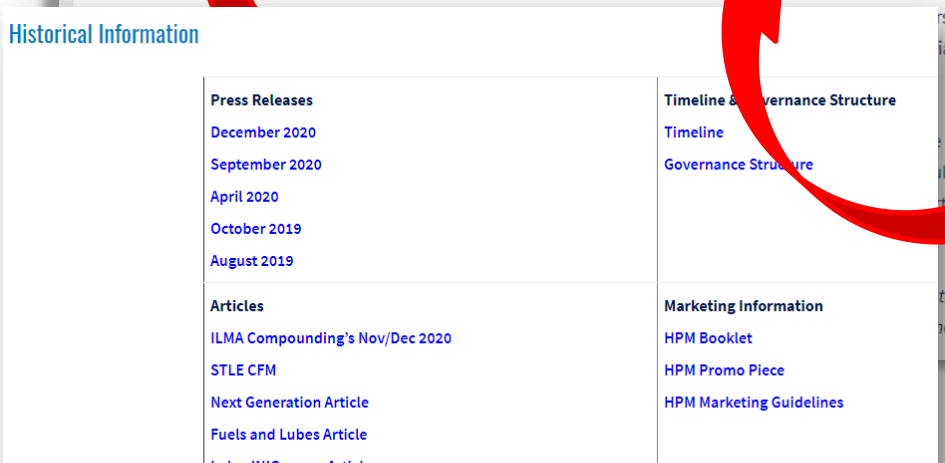
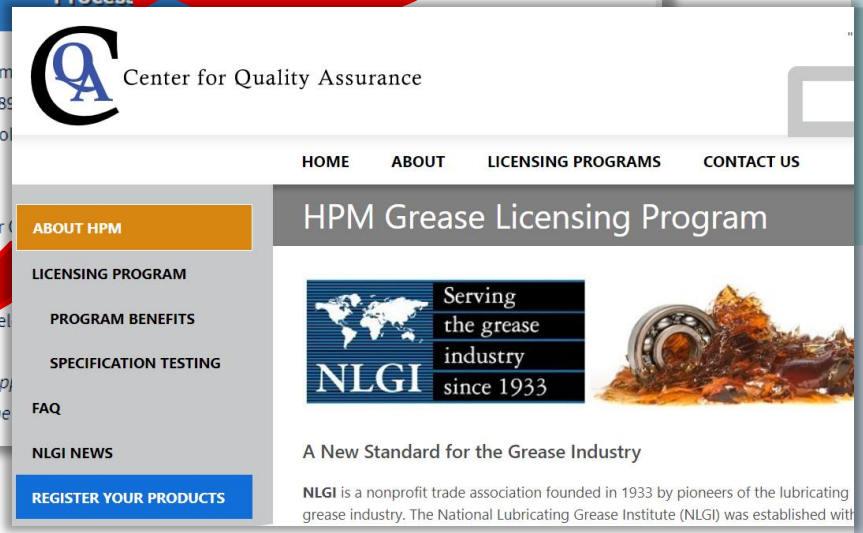
More information on HPM at www.NLGI.org









Questions

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