What You Need to Know about Oil & Greases and Compatibility Testing

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Ken J. Brown, Eco Fluid Center Ltd.*
Ted Austin, Canoil Canada Ltd.
Wayne Mackwood, Chemtura Co. (now Lanxess)

***toll free 888 442-5008 or 416 466-3144 www.fluidcenter.com**

Agenda

Why mix?
What can you mix?
Possible Consequences
Viscosity Basics
Lube Oil Basics
Grease Basics
Compatibility Testing
Resources
Summary

Disclaimer: For info only because there are few fixed rules. Verify that any material is the most recent and applicable to your specific application.

Why would you mix?

- *Out of stock and something has to be done*
- *Product discontinued*
- *Need better performance.*
- *Need a safer or ‘green’ product.*
- *‘Changed distributor or supplier*
- *Other*
- *Save’ money*

What can you Safely Mix?

Lubricants for the same application, with the same performance characteristics, with similar additives, with the same base stocks and from the same manufacturer. Be careful!

Equivalent does not mean compatible.
Comparable does not mean compatible.
Compatible can have different meanings.
Same viscosity definitely does not mean compatible.

What can happen?

If there are compatibility problems this might not show up for some time and will require careful monitoring.

Problems might show up as more rapid filter plugging, varnish or sludge deposits, slow operation, foaming, higher temperatures and the like. Only in a few cases might it be immediately catastrophic. Different base stocks or detergent treats can also loosen deposits. This can cause a number of problems.

Need Help on Compatibility?

Google searches;

oil compatibility	**29,600,000 hits!**
steam turbine oil compatibility	**247,000 hits!**
grease compatibility	**302,000 hits!**

Useless? No, some good info but be very careful. You are very unlikely to find exactly your situation but there can be good guidelines.

First and Foremost - Viscosity

The viscosity of a fluid is a measure of its resistance to gradual deformation by stress. For liquids, it corresponds to the concept of "thickness".

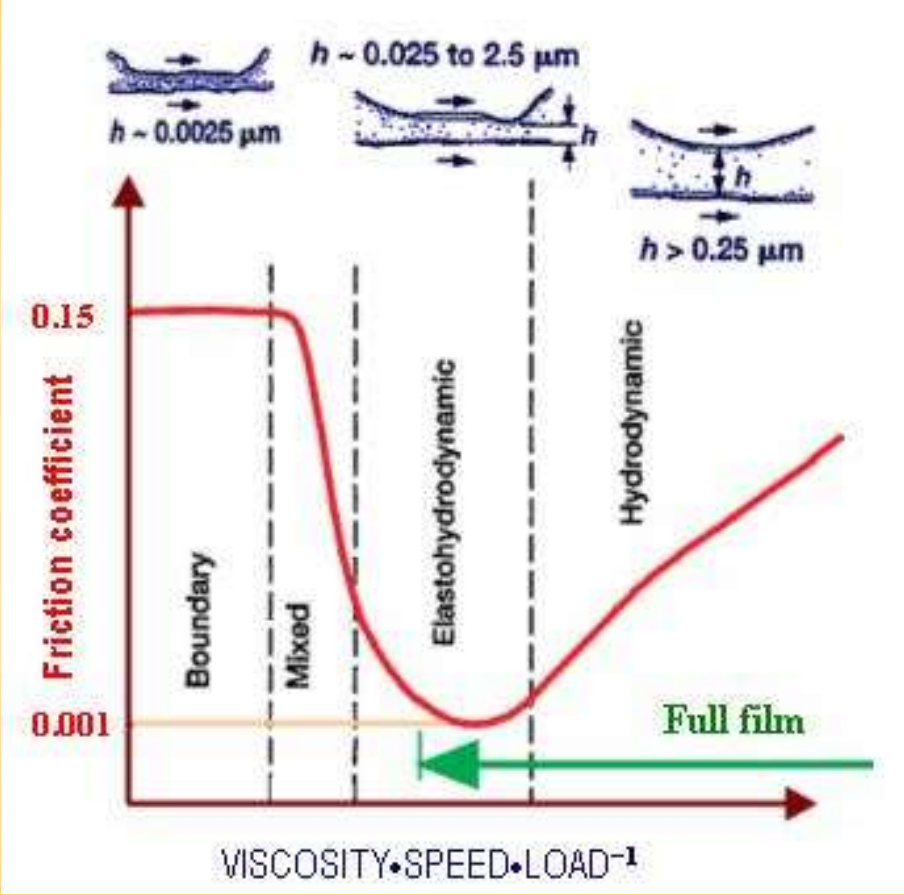
Ref: https://en.wikipedia.org/wiki/Viscosity

Viscosities of Common Fluids

	Centipoise (cP)	Centistokes (cSt)
Water	1.0	1.002
SAE 10 oil	70	80
Olive oil	100	110
SAE 30 oil	300	350
Glycerin	500	400
SAE 50 oil	800	910
Honey	2,000	1,430

Capillary Viscometer

Moving Surfaces - Stribeck Curve



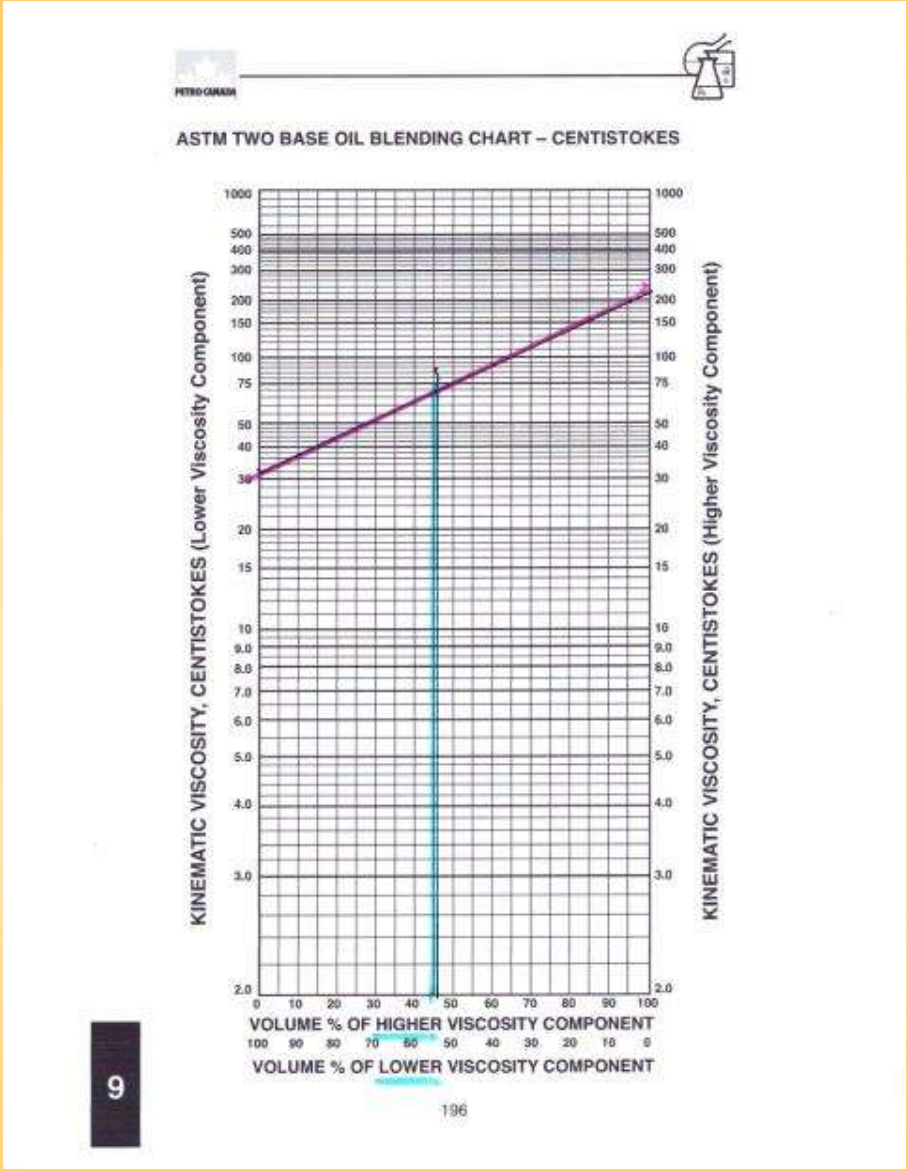
Surfaces in contact means wear.

ISO-VISCOSITY SYSTEM
FOR INDUSTRIAL FLUID LUBRICANTS [ASTM D 2422-97 (2007)]

ISO Viscosity Grade	Mid Point cSt @ 40°C	Kinematic Viscosity @40°C Limits			
		Minimum		Maximum	
		cSt	SUS	cSt	SUS
2	2.2	1.98	32.0	2.42	34.0
3	3.2	2.88	35.5	3.52	37.5
5	4.6	4.14	39.5	5.06	42.5
7	6.8	6.12	46.0	7.48	50.5
10	10	9.00	55.5	11.0	62.5
15	15	13.5	71.5	16.5	83.5
22	22	19.8	97.0	24.2	116
32	32	28.8	136	35.2	165
46	46	41.4	193	50.6	235
68	68	61.2	284	74.8	347
100	100	90.0	417	110	510
150	150	135	625	165	764
220	220	198	917	242	1121
320	320	288	1334	352	1631
460	460	414	1918	506	2344
680	680	612	2835	748	3465
1000	1000	900	4169	1100	5095
1500	1500	1350	6253	1650	7643
2200	2200	1980	9171	2420	11209
3200	3200	2880	13340	3520	16305

Ref: 2013 PC Lube Handbook

What to do if you have two different viscosity grade oils but not the one you need.



Ref: 2013 PetroCanada Lubricants Handbook

SAE Automotive Engine Oils - Viscometrics

SAE Viscosity Grade	Viscosity (cP) at Temperature (°C), Max		Viscosity (cSt) at 100°C		High Shear Viscosity (cP) at 150°C and 10^6 S^{-1} Min
	Cranking	Pumpability	Min	Max	
0W	6200 at –35	60 000 at –40	3.8	—	—
5W	6600 at –30	60 000 at –35	3.8	—	—
10W	7000 at –25	60 000 at –30	4.1	—	—
15W	7000 at –20	60 000 at –25	5.6	—	—
20W	9500 at –15	60 000 at –20	5.6	—	—
25W	13000 at –10	60 000 at –15	9.3	—	—
20	—	—	5.6	Less than 9.3	2.6
30	—	—	9.3	Less than 12.5	2.9
40	—	—	12.5	Less than 16.3	3.5†
40	—	—	12.5	Less than 16.3	3.7††
50	—	—	16.3	Less than 21.9	3.7
60	—	—	21.9	Less than 26.1	3.7

† with 0W-40, 5W-40 and 10W-40 grades

†† with 15W-40, 20W-40, 25W-40 & 40 grades

API Engine Oil Service Categories

Use what is in your manual OR most recent.

Caution. Oils are backwards compatible but not the other way. Some retailers reportedly sell older versions.

For example API SA contains no additives. Not suitable for use in most gasoline-powered automotive engines built after 1930. Use in modern engines may cause unsatisfactory performance or equipment harm.

API Service Categories

SN introduced in October 2010, designed to provide improved high temperature deposit protection for pistons, more stringent sludge control, and seal compatibility.

API SN with Resource Conserving matches ILSAC GF-5 by combining API SN performance with improved fuel economy, turbocharger protection, emission control system compatibility, and protection of engines operating on ethanol-containing fuels up to E85.


ILSAC GF-5
ACEA A1/B1
API SN, SM, SL
API SERVICE SN
SAE
5W-20
RESOURCE CONSERVING
ÉCONOMISE L'ÉNERGIE
SAE 5W-20

API Service Categories
Diesel Engines

"For diesel engines, the latest category usually - but not always - includes the performance properties of an earlier category.

API FA-4 and the FA-4 Donut identify certain XW-30 oils specifically formulated for use in select high-speed four-stroke cycle diesel engines designed to meet 2017 model year on-highway greenhouse gas (GHG) emission standards.

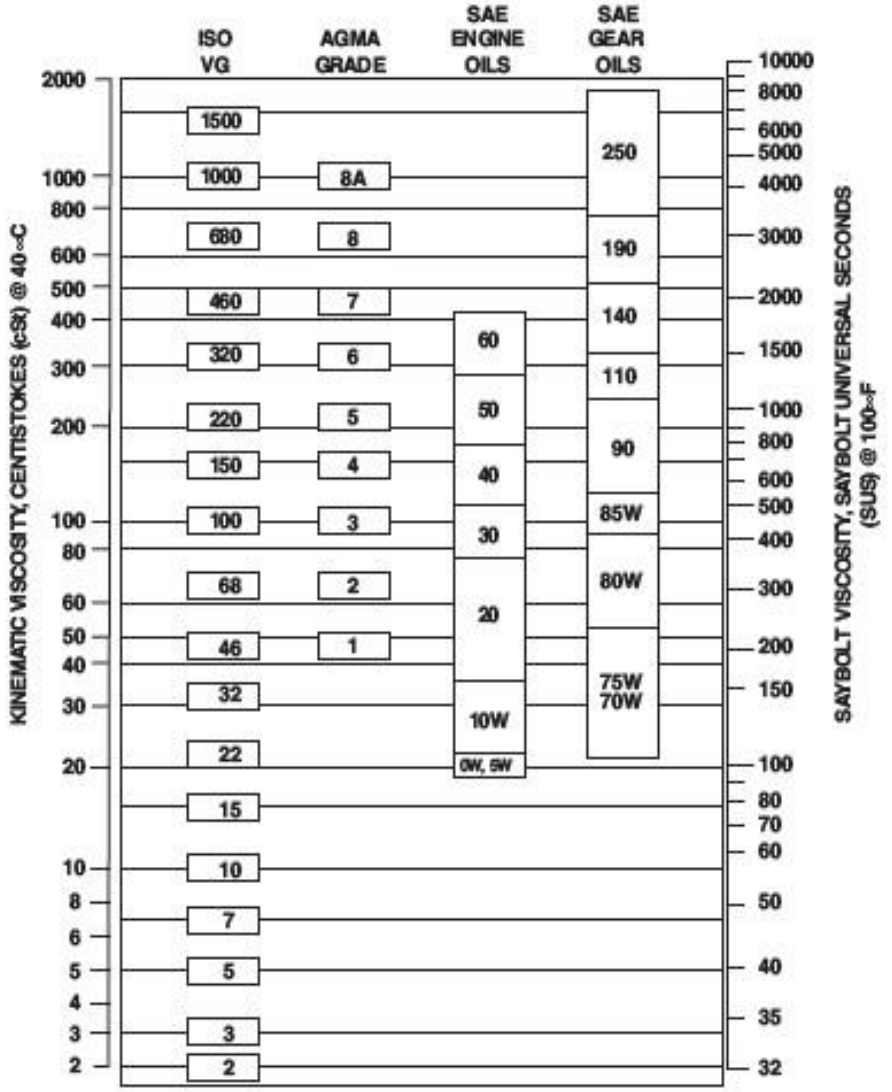
API FA-4 oils are not interchangeable or backward compatible with API CK-4, CJ-4, CI-4 PLUS, CI-4, and CH-4 oils. Refer to engine manufacturer recommendations to determine if API FA-4 oils are suitable for use."

SAE Gear Oils

SAE Viscosity Grade	Maximum Temperature for Viscosity of 150,000 cP, ˚C	Kinematic Viscosity at 100˚C, cSt Minimum
70W	-55	4.1
75W	-40	4.1
80W	-26	7.0
85W	-12	11.0

Ref: Petro-Canada 2013 Product Handbook

VISCOSITY EQUIVALENTS

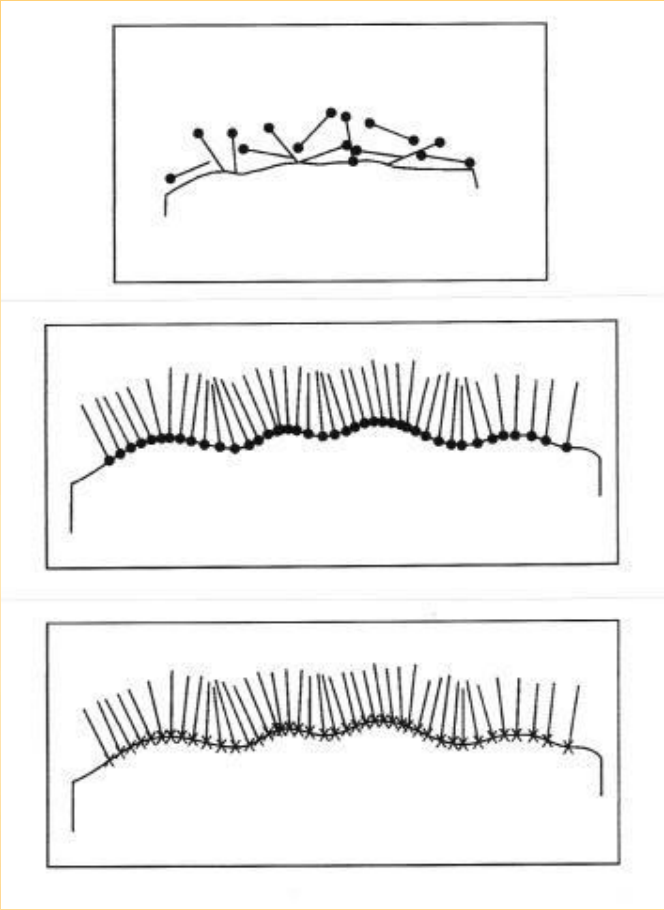


Typical Motor Oil Additives

- Viscosity Index Improvers (VI Improvers)
- Dispersants
- Detergents
- Extreme-pressure/antiwear agents
- Antioxidants/Inhibitors
- Antifoam agents
- Friction modifiers
- Metal deactivators
- Pour-point depressants
- Rust-corrosion inhibitors

https://www.americanchemistry.com/paptg

Additive Surface Interactions



Physically adsorbed – nonpolar molecules

Physically adsorbed – polar molecules

Chemisorbed film with chemical bonds

Ref: EPRI Nuclear Maintenance Applications Center: Lubrication Guide Revision 4

Lubrizol
Specification Comparison

Fire Resistant EHC Fluids

FYRQUELS		REOLUBE TURBOFLUIDS		TYPE	FEATURES
EHC	HYD	EHC	HYD		
EHC-N (Stauffer EHC)	220N	Turbofluid 46XC and OMTI	220X	Trixylenyl Phosphate Ester (TXP)	Lowest air release times, best hydrolytic stability and good overall.
EHC-S EHC Plus	220	Turbofluid 46B (Durad EHB)	HYD 46B	Butylated Phenol Phosphate Ester (TBPP)	Best bulk oxidation resistance.
-	-	Turbofluid 46	HYD 46	Isopropyl Phenol Phosphate Ester (IPPP)	Better hydrolytic stability than butylated synthetics.
EHC	-	-	-	Blend of Butylated Phenol and Trixylenyl Phosphate Ester	A compromise of the natural and synthetic.

How do You Test for Oil Compatibility?

Most tests involve heating up the mixture of the two oils, holding for a period of time, cooling and then looking for additive dropout. Conditions vary so verify.

Example: Caterpillar Final Drive and Axle Fluid Requirements FD-1 – heat to 400°F (204°C), cool to room temperature, centrifuge at 6000g for 30 minutes and examine for insoluble residue and separated components. But no functional tests!

Grease Mixing

Just like mixing oils can be a bad idea because the additives could be incompatible, mixing greases has the added risk of thickener incompatibility. In these cases the structure can fall apart and it is no longer a grease or at least softens or thickens too much.

Charts are available but these are generic. If in doubt or for an important piece of equipment run a compatibility test in different mixing ratios.

How Do You Test for Grease Compatibility

EPRI: Involves 25/75, 50/50, and 75/25 mixtures (10/90 and 90/10 are sometimes also used) of two components stirred with a handheld electric mixer before aging at 250°F (121°C) for 72 hours. The starting materials get the same treatment. Then, after cooling to room temperature, the 60-stroke worked penetrations are run on all samples. Incompatibility is determined if the penetration changes by 30 points. Dropping points can also be run on the treated samples.

Ref: EPRI Nuclear Maintenance Applications Center: Lubrication Guide Revision 4

Compatible or not and does it matter?

ASTM D6185: Standard Practise for Evaluating Compatibility of Binary Mixtures of Lubricating Greases

"Compatibility **cannot be predicted** with certainty from foreknowledge of grease composition. Generally, greases having the same or similar thickener types will be compatible. Uncommonly, even greases of the same type, although normally compatible when mixed, can be incompatible because of incompatible additive treatments. Thus, compatibility needs to be judged on a **case-by-case basis**."

ASTM D6185: Standard Practise for Evaluating Compatibility of Binary Mixtures of Lubricating Greases

Uses a step by step approach to assess thickener compatibility.

First: Mixes 50:50 and check the dropping point. If no significant change test 10:90 and 90:10.

Second: Test mixtures in a 100,000 stroke worked penetration test. If no significant change continue.

Finally: Heat mixtures to 120°C (248°F) for 70 hours. Check penetration.

Grease compatibility chart

	Thickener	1	2	3	4	5	6	7	8	9	10	11
1	Ca Sulfonate Complex		NC	NC	FC	FC	NC	FC	FC	NC	NC	NC
2	Aluminum Complex	NC		NC	FC	NC	NC	NC	NC	NC	FC	NC
3	Barium	NC	NC		FC	NC	NC	NC	NC	NC	FC	NC
4	Anhydrous Calcium	FC	FC	FC		SC	FC	FC	FC	NC	?	NC
5	Calcium Complex	FC	NC	NC	SC		NC	NC	FC	FC	NC	NC
6	Clay	NC	NC	NC	FC	NC		NC	NC	NC	FC	NC
7	Lithium	FC	NC	NC	FC	NC	NC		FC	NC	?	SC
8	Lithium Complex	FC	NC	NC	FC	FC	NC	FC		NC	FC	SC
9	Polyurea	NC	NC	NC	NC	FC	NC	NC	NC		?	NC
10	Silica Gel	NC	FC	FC	?	NC	FC	?	FC	?		FC
11	Sodium	NC	NC	NC	NC	NC	NC	SC	SC	NC	FC	

LEGEND

FC Fully compatible

SC Somewhat compatible - mixtures soften, but, remains grease like

NC Not compatible - mixtures soften severely and do not remain grease like

Ref: Chemtura Co.

		Aluminum Complex	Lithium	Polyurea	Lithium Complex	Barium Complex	Silica	Clay
		VULTREX™ MPG	PRECISION™ General Purpose EP2	Chevron SRI 2	PRECISION™ XL EP 2		THERMEX™	
Lithium	PRECISION™ General Purpose EP 2	Yes 140						
Polyurea	Chevron SRI 2	Yes 130	Yes 145					
Lithium Complex	PRECISION™ XL EP 2	Yes 150	Yes 170	Yes 158				
Barium Complex		Yes 168	Yes 153	Yes 173	Yes 160			
Silica	THERMEX™	Yes 115	No (*)	No 80	No (*)	Yes 173		
Clay		No 58	No 95	No (*)	Yes 183	Yes 173	No 75	
Calcium Sulphonate Complex	PEERLESS™ OG-2	No 98	Yes 125	No 95	Yes 125	Yes 140	No (*)	No 95

Notes:

1. The number quoted indicates the temperature, in degrees Celsius, at which incompatibility sets in.
2. (*) Indicates the mixture is incompatible at all temperatures.

Ref: PetroCanada Lubrication Handbook

Reference: Limitorque Type SMB Instruction and Maintenance Manual. Reference Bulletin SMBI-82D, Issue 9/90

The eight minimum lubricant qualities are:

1. Should contain an “EP” (extreme pressure) additive.
2. Must be suitable for the temperature range intended.
4. Must not create more than 8% swell in Buna N or Viton.
5. Must not contain any grit, abrasive, or fillers.
6. Must slump - prefer NLGI grade 0 to 1.
7. Must not be corrosive to steel gears, ball or roller bearings.
8. Dropping point must be above 316°F for temperature ranges of -20°F to 150°F.

Test	Fresh Grease	Thermally aged	Aged and irradiated
100% NEP	DP, Evap, HPDSC, POD, FTIR, YS	DP, HPDSC, POD, FTIR, YS	DP, HPDSC, POD, FTIR, YS
50/50	DP, Evap, HPDSC, POD, FTIR, YS	DP, HPDSC, POD, FTIR, YS	DP, HPDSC, POD, FTIR, YS
80/20	DP, Evap, HPDSC, POD, FTIR, YS	DP, HPDSC, POD, FTIR, YS	DP, HPDSC, POD, FTIR, YS
100% MOV LL	DP, Evap, HPDSC, POD, FTIR, YS	DP, HPDSC, POD, FTIR, YS	DP, HPDSC, POD, FTIR, YS

Ref: Comparative Analysis of Nebula and MOV Long Life Greases for Limitorque Main Gearbox Applications, EPRI 1003483, Dec 2002

NLGI AUTOMOTIVE SERVICE GREASE CATEGORIES

Category	Service	Performance
LA chassis	Frequent relubrication intervals (<3200 km). Mild duty (non-critical applications).	Oxidation resistant, shear stable, and corrosion and wear protective.
LB chassis	Prolonged relubrication intervals (>3200 km). Mild to severe duty (high loads, vibration, exposure to water).	Oxidation resistant, shear stable, and corrosion and wear protective even under heavy loads and in presence of aqueous contamination. Temperature range -40°C to 120°C.

LB can often be used in place of an LA grease but not visa versa.

GA wheel bearings	Frequent relubrication intervals. Mild duty (non-critical applications).	Temperature range -20°C to 70°C.
GB wheel bearings	Mild to moderate duty (cars, trucks in urban and highway service.)	Oxidation and evaporation resistant, shear stable, and corrosion and wear protective. Temperature range -40°C to 120°C with occasional excursions to 160°C.
GC wheel bearings	Mild to severe duty (vehicles in frequent stop-and-go service, trailer hauling, mountain driving, etc.)	Oxidation and evaporation resistant, shear stable, and corrosion and wear protective. Temperature range -40°C to 120°C with frequent excursions to 160°C and occasional excursions to 200°C.

GC can often be used in place of a GB or GA grease but the other way.

National Lubricating Grease Institute (NLGI)
"G" WHEEL BEARING GREASE CATEGORIES

Category	Test	Property	Acceptance Limit
GA			
GB			
GC	D217	Consistency, worked penetration, mm/10	220-340[A]
	D566 or	Dropping Point, °C, min	220
	2265	Low Temperature Performance, torque	
	D4693	at -40°C, N@ m, max	15.5
		Water Resistance at 80 C, %, max	15
	D1264	Oil Separation, mass %, max	6
	D1742	Rust Protection, rating, max	Pass
	D1743	Wear Protection, scar diameter, mm, max	0.9
	D2266	High Temperature Life, hours, min	80
	D3527	Elastomer NBR-L Compatibility,	
	D4289	Volume change, %	-5 to +30
		Hardness change, Durometer-A points	+2 to -15
		Leakage Tendencies, g, max	10
	D4290	EP Performance:	
	D2596	Load wear index, kgf, max	30
		Weld point, kgf, min	200

What Makes it ‘Green’

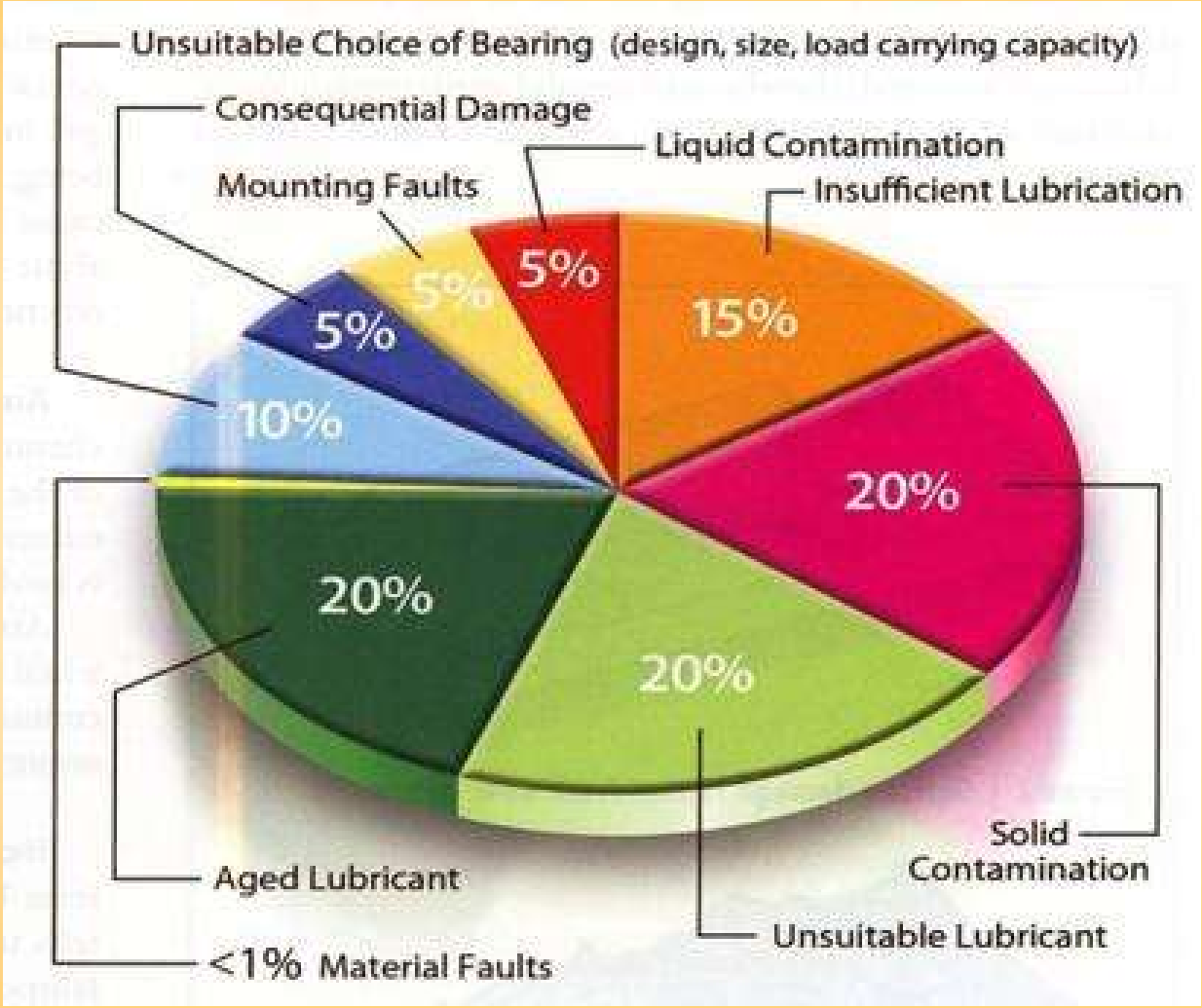
- More biodegradable
- Less aquatic toxicity
- Does not bio accumulate
- Does not contain mineral oil
- Does not contain more than ‘X’ additives
- Sustainable/renewable ingredients
- Recyclable
- Reusable
- Lasts longer
- No heavy metals, VOC, or halogens or?
- Recyclable container
- Less wear, more efficient or better somehow

BIODEGRADABLE FLUIDS

	MINERAL OIL	GLYCOLS	VEGETABLE OILS	SYNTHETIC ESTERS
DENSITY AT 20℃ (KG/M³)	880	1100	940	930
VISCOSITY INDEX	100	100 to 200	100 to 200	120 to 220
SHEAR STABILITY	good	good	good	good
POUR POINT (℃)	-15	-40 to +20	-20 to +10	-60 to -20
COLD FLOW PROPERTIES	good	very good	poor	very good
MISCIBILITY WITH MINERAL OIL	-	not miscible	good	good
SOLUBILITY IN WATER	not miscible	very good to poor	not miscible	not miscible
SEAL SWELLING TENDENCY	slight	shrinking	indifferent	fair
BEHAVIOUR AGAINST PAINT	good	poor	good	good*
BIODEGRADABILITY (CEC) %	10 to 30	10 to 99	70 to 100	10 to 100
OXIDATION STABILITY	good	good	fair	good
HYDROLYTIC STABILITY	good	-	poor	fair
SLUDGE FORMING TENDENCY	good	-	poor	fair
RELATIVE COST (MINERAL OIL = 1)	1	2 to 4	2 to 3	4 to 20

REF: Stempfel NLGI/91

So How Are We Doing?



Ref: 'Lubricant management for non-circulating sumps', M. Johnson, TLT (Tribology and Lubrication Technology), August 2009 pp 16-23

Performance Tests

This is best based on your specific equipment, lubes, skill sets and criticality but there are still good guidelines readily available.

ASTM D6244 Standard Practice for In-Service Monitoring of Lubricating Oil for Auxiliary Power Plant Equipment

For gear/circulating oils, hydraulic oils, diesel engine oils, turbine type oils, air compressor oils, EHC (PO_4 esters) and EHC Mineral Oils.

Turbine Performance Tests

ASTM D4378 Standard Practice for In-Service Monitoring of Mineral Turbine Oils for Steam, Gas and Combined Cycle Turbines.

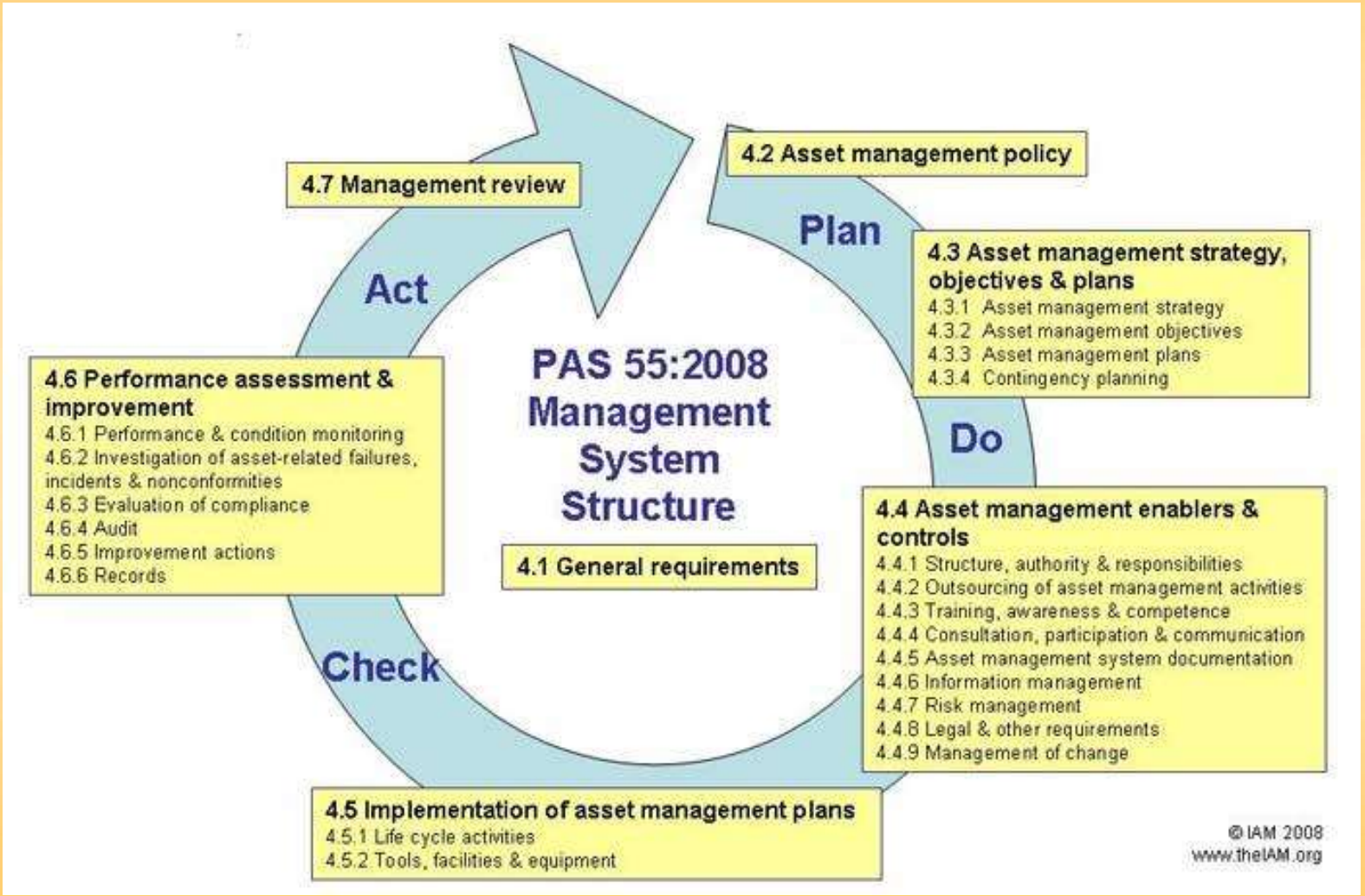
Plus, the OEM requirements and industry knowledge!

CAUTION: Do not mix oils with detergent additives such as motor oils or STP with steam turbines oils if demulsibility is important.

Proactive – How Do You Compare?

Ref: IAEA-TECDOC-1551 Implementation Strategies and Tools for Condition Based Maintenance at Nuclear Power Stations

PAS55
(Publically Available Specification)
ISO 55000



Other Resources

ASTM D7155: Standard Practise for Evaluating Compatibility of Mixtures of Turbine Lubricating Oils.
"does not evaluate such mixtures"

ASTM D7752: Standard Practise for Evaluating Compatibility of Mixtures of Hydraulic Fluids.

ASTM D6185: Standard Practise for Evaluating Compatibility of Binary Mixtures of Lubricating Greases.

EPRI Lube Note: www.epri.com
API: www.api.org

Plus OEM documents

Other Resources

ISO 6743-4:2015 establishes the detailed classification of fluids of Family H (Hydraulic systems).

ISO 12922:2012 specifies the minimum requirements of unused fire-resistant and less-flammable hydraulic fluids.

ISO 6743-3:2003 establishes the detailed classification of lubricants for use in family D, air compressors, gas compressors and refrigeration compressors.

ISO 6743-9:2003 establishes a detailed classification of family X (Greases).

Summary

1. When mixing different lubricants it is only prudent to verify compatibility plus to record such documentation.
2. If not sure or if the assurances are vague, consider at least some testing. The cost should be much less than the possible consequences.
3. There are many procedures to assess compatibility. Use the one most suited to your specific lubricant and application.
3. Considerable information and resources are available to help ensure that the risks are minimized.

Caution!

Many oil 'compatibility' tests only check for additive dropout and not performance.
Similarly, many grease 'compatibility' tests only check for changes in the thickener as indicated by the penetration or dropping point.

For low consequence applications do at least some of the relevant performance tests.
For important applications do all the required performance tests as given by the OEM or as expected for that application.

Our MUG Presentations

'All-in-one, An Update On MOV Long Life', 2003

'MOV Long Life Limitswitch Applications', 2004

'MOV Long Life Condition Monitoring', 2005

'MOV Long Life Condition Monitoring Update', 2006

'MOV Grease Stem Wear Testing', 2007

'Commercial Grade Dedication and In-service MOV Long Life Grease Testing', 2008

'MOV Long Life - Reducing Oil Seepage', 2009

'Semifluid Grease For Oil Filled MOV's', 2010

'MOV Long Life Grease – A Decade Later', 2013

'MOV Stem Grease Wear Testing – Update', 2014

'Understanding Low Temperature Greases', 2015