SPECIFICATION

Factory

LH

Specification designation

LIEBHERR OEM – FLUID APPROVAL SYSTEM

Version-Nr. Version Nbr. No. de version	Datum Date Date
1.1b	01.09.2022

Spezifikation-Ident Nr. / Specification ident No. /
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LH-00-FAS

Purpose Release of engine oils in Liebherr Diesel Engines-only

Use This specification is valid globally for Liebherr Diesel engines

General

The petrochemical design, the quality and the formulation of motor oils has a direct influence on the performance, the function and the efficiency of the engine. Liebherr uses high-performance industrial engines designed for the global market. Due to the high variety of different motor oil products and the different performance levels of which are partially standardized by international automotive testing organisations, Liebherr has introduced a registration system. This system is intended to reproduce the globally available and Liebherr-compatible engine oils registered at Liebherr. This allows the user to get approved engine oils as published approvals, which Liebherr has released and thus operate the diesel engine (only) correctly so that the warranty is maintained. Liebherr applications are not covered by the oil approval. Application manual information stays valid for approved oils.
Engine oil testing and approval is carried out by the operational fluid department at Liebherr Machines Bulle SA.

Information: In case of further information are needed you can contact us under:
FluidApproval (LMB) <liebherr.fluidapproval@liebherr.com>

Engine Oil Specification

Depending on the engine oil requirement, there are different release specifications, which are prerequisites for registration:
In the Diesel engine oil specification, LH-00-ENG (appendix), two engine oil classes are defined:

- LH-00-ENG $_{LA}$ for exhaust after-treatment systems
- LH-00-ENG without exhaust after-treatment.

- not implemented in actual version of LiFAS -

For gas engine oil specification, LH-00-GAS, there are three engine oil classes:

- LH-00-GAS $_{LA}$ for natural gas systems
- LH-00-GAS $_{MA}$ for operating gases with higher pollutant content in the gas
- LH-00-GAS $_{HA}$ for operating gases with very high pollutant content in the gas

For marine applications, the LH-01-ENG, which defines three engine oil classes, applies:

- LH-0 1 -ENG $_{LA}$ for systems with exhaust after-treatment and fuel with max 50ppm Sulphur content
- LH-0 1 -ENG $_{HA}$ for systems with marine fuels containing up to 2000 ppm Sulphur
- LH-0 1 -ENG $_{HT}$ for systems with marine fuels containing from 1000 ppm to 5000 ppm Sulphur

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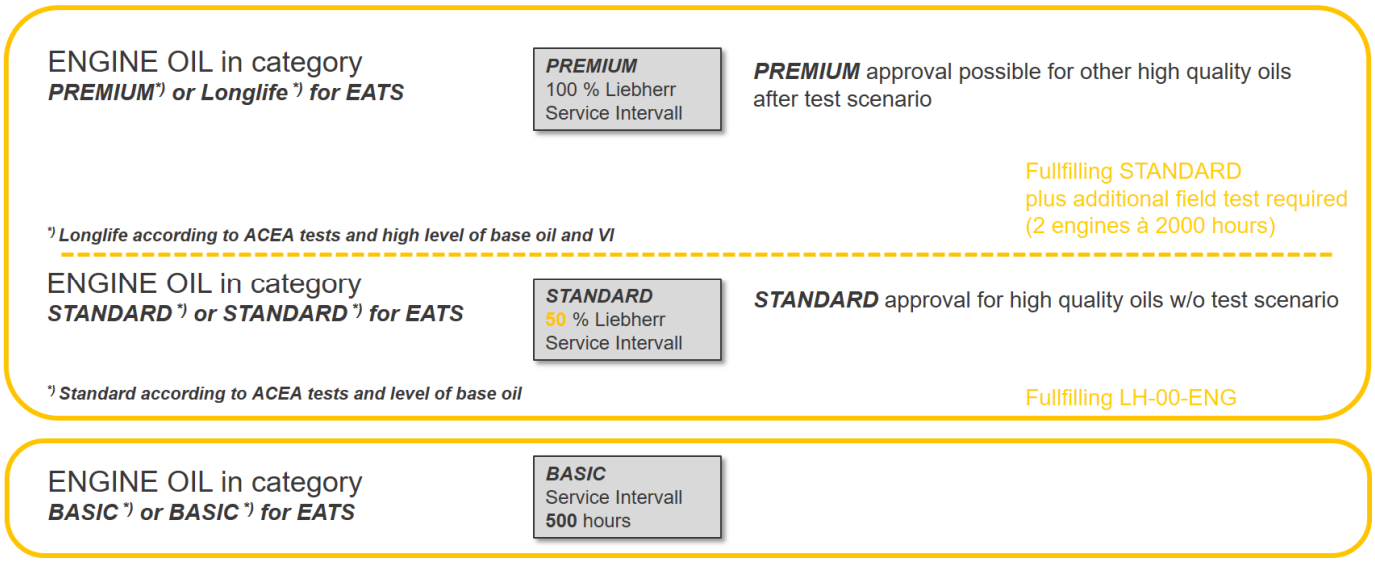
Depending on the power level, formulation of engine oil, the Liebherr engine test and the oil analysis the tested product will be assigned to one of three categories. This category will have an impact to the engine oil change interval.

Classifications (see in appendix Requirements for oil approval categories)

Basic	Meets Liebherr minimum requirement
Standard	Meets on high level Liebherr requirements LH-00-ENG
Premium	Meets on high level Liebherr requirements LH-00-ENG with proven performance in field test



Basic Requirements for the Engine oil

Engine oil must not change its properties during storage and must be compatible with other engine oil approved by Liebherr. These mixtures must not show any precipitation, layering or turbidity. The engine oil should not show visible solid contaminants and visible water included.
Engine oils approved in accordance with this standard should not contain any substances classified as prohibited or undesirable according to VDA Guideline 232-101 , VKIS-VSI-IGM- BGHM substance list or GADSL.
Designation and quantity of declarable substances in engine oil in accordance with VDA Guideline 232-101, VKIS-VSI-IGM-BGHM substance list or GADSL must be stated in the registration form.

The viscosity classes for mobile diesel engines can include the following SAE grades:

0W-30, 5W-30, 10W-30
0W-40, 5W-40, 10W-40

The viscosity classes for marine and stationary diesel engines can include the following SAE grades:

0W-30, 5W-30, 10W-30, SAE 30
0W-40, 5W-40, 10W-40, SAE 40

The viscosity class for gas engines is defined by SAE- 40.

Request of a Liebherr Release

To get a release for an engine oil in Liebherr Diesel Engines-only, the following steps have to be successfully concluded and the necessary data to be transmitted to Liebherr:

- Completed application for product release, see Registration request at Liebherr.
- Test results of CEC and ASTM test methods are only recognized if an accreditation according to DIN EN ISO / IEC 17025 or the ASTM Test Monitoring Center is available and regular and successful participation in laboratory tests can be proven. Only independent test bench laboratories (eg APL- Messtechnik Landau and ISP - Salzbergen GmbH) as well as approved test laboratories of additive manufacturers are allowed.
- Field test according to Engine Field Validation process for *Premium* classification.
- Results of laboratory tests are recognized if the external testing laboratory is accredited to DIN EN ISO / IEC 17025 and has successfully participated in ring tests with success. Appropriate certificates of qualification must be submitted.
- Copies of the original test reports must be enclosed with initial release and trade package releases (engine and laboratory tests).
- The product-relevant technical and safety data sheets

The release of a product will be granted for two years, but expires when there is a product change. A product may be renewed twice in the procedure.

Base Oil Interchange (BOI) Viscosity Grade Read Across (VGRA) and minor modification rules ATIEL / ATC Code of Practice and in API 1509 and the ACC Code of Practice are not applicable for Liebherr registered products.
Not reported changes will lead into immediate deletion of approval.

Registration request at Liebherr

To register a product please sign in and register under https://liebherr.fluidapproval.com/
All application documents, including all test reports, analysis diagrams, manufacturer information and data sheets must be submitted in digital form.
The applicant will then receive a registration confirmation.Once the cost of registration have been paid, the registration process begins at Liebherr. For this process to succeed, the above requested data must be entered by the requester.
Liebherr undertakes to use all data provided by the applicant only for its own purposes and to evaluate the release application and to treat the data confidentially.
For help please send an email to: FluidApproval (LMB) <liebherr.fluidapproval@liebherr.com>

Reference sample

For the approval procedure, 1 liter product reference samples must be submitted to:

c/o FluidApproval.com
LiFAS #12345678 (Liebherr FMP approval #)
SGS Speyer
Am Neuen Rheinhafen 12 A
D – 67346 Speyer
Germany

These have to be analyzed and compared for product identity of the previously submitted sample. If these results are positive, the extension procedure can be started by registering with Liebherr.
Applications which become a paid order after expiry of the validity of the release of the product at Liebherr can no longer be considered as renewal and must be considered as a new registration.

Engine Field Validation process for engine oil approval

See Appendix

Publication of the Liebherr Release

If the requested product / engine oil formulation can be confirmed with an engine oil formulation tested for Liebherr, the product listing for Liebherr approved engine oils is listed on the homepage at https://liebherr.fluidapproval.com/. In addition the manufacturer may use this listing with the Liebherr specification code on the back of its product as OEM approval.

Rejection of a Liebherr OEM Release

If the submitted product cannot be evaluated positively for reasons of quality, sample cleanliness, insufficient data or an unknown formulation, the applicant will be informed without further information and the product will not be released.
The costs for the analyzes and the application will not be refunded.

Incorrect Information

If results or data are culpably incorrectly stated by the applicant and Liebherr releases an original, reblended or rebranded oil in accordance with the above specification and an engine damage occurs as a result of the oil quality, the applicant commits himself to undertaking such damage to Liebherr indemnify and exempt claims of third parties. If the applicant culpably breaches the conditions of this specification and if this causes damage to Liebherr, he also agrees to indemnify Liebherr for such damages and indemnify him against claims of third parties.
The applicant commits himself, not to state recommendations for the applications of Liebherr, (such as with regard to oil change intervals, viscosity classes etc.), which do not comply with Liebherr's regulations.

Costs for applicants

Registration Costs

	one Region	two Regions	three Regions	four Regions	Global
Group I	4'000 €	5'500 €	6'500 €	7'500 €	8'000 €
Group II					
Group III					
Group IV					
Group V					

All costs are for a product without VAT

A breakdown by regions has taken place, because it is not reasonable for each manufacturer to register the respective product for all regions.
For different regions, there are some other formulations for the same product and conversely. These must be approved separately as a distinct formulation or product.
A written release will only be issued if the resulting fee has been paid and all tests have been passed.

Registration regions

Due to products of the same name and thus differences that are not obvious to the user, Liebherr approves engine oils for different regions, to ensure that the correct engine oil is used in Liebherr relevant applications. Depending on the product, there are market and formulation-relevant influences that determine whether a product can be used in the individual regions.
In order to be granted worldwide approval, the product must be formulated uniformly on a global basis and be designed to meet regional requirements.

Group Region I

- Western Europe : Denmark, Germany, Finland, France, Italy, Netherlands, Norway, Austria, Sweden, Switzerland
- Japan, Korea, Republic (South Korea)

Group Region II

- Australia, Canada, United States of America, United Kingdom
- Bulgaria, Estonia, Greece, Croatia, Latvia, Lithuania, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Czech Republic, Ukraine, and Northern Ireland, Southern Ireland

Group Region III

- People's Republic of China, Russian Federation, Turkey,
- Central America

Group Region IV
- South America,
- South East Asia

Group Region V
- Africa,
- Asia,
- Middle East

If a product in a Liebherr engine is not suitable for one or the desired regions, it will not be released for this purpose. In this case, the amount will not be refunded as Liebherr has carried out the process.

Timeline

After completing the external tests, submitting the registration data and transferring the registration fees to Liebherr, the approval and listing of the product should be made within 30 working days. In case of difficulties Liebherr can exeed this without reasons telling. The release to service is confirmed in writing by mail and online by listing on the Liebherr portal.

Validity and Renewal of a Release

A release is valid 2 years after the written approval of Liebherr. After this period, it automatically loses its validity and the applicant may no longer use the OEM release for his products.
The applicant will be informed of the early submission of an extension application. This period should be between 6 and 2 months before the expiry date of the release.
The applicant agrees also, reported in writing to Liebherr any change in the composition of the oil prior at least 3 months to the modification, as a change in the formulation also terminates the validity of the formulation and leads to a new approval.

Naming of a Liebherr Release

Lubricating oils which have undergone a Liebherr release test and have been released in writing by Liebherr may be listed by the lubricating oil manufacturers in data sheets or other publications as follows:

Liebherr approved LH-00-ENG -specification year ***performance level***

Withdrawal of the Release

Liebherr may withdraw a release already granted for important reasons. Reasons for this are:
- Abuse of the Liebherr brand
- Quality variations in the processing of the product (variance of the raw material quality, additive content)
- Change of the lubricating oil quality or the composition (base oil or additive) of the released engine oil
- Engine damage, which can be clearly assigned to a product.
- Application of Base Oil Interchange (BOI), Viscosity Grade Read Across (VGRA) and Minor Modification Rules in ATIEL / ATC Code of Practice, API 1509 and ACC Code of Practice

APPENDIX

1. Liebherr Machines Bulle SA engine oil specification LH-00-ENG

SPECIFICATION

Factory

LIEBHERR

Specification designation

REQUIREMENTS FOR THE ENGINE OIL

Spezifikation Ident No.

LH-00-ENG

Version-No.	Date
1.5a	08.07.2021

Inhalt :

LH-00-ENG

LIEBHERR

1. Tolerances and selection criteria (minimum requirement on the fresh oil)

Depending on the request, the corresponding engine oil in accordance with the following conditions must be selected.

Parameter	Unit	Tolerance LH-00-ENG	Tolerance LH-00-ENGLA	Method
Optical appearance		Clear	Clear	Visual
Viscosity min. temperature	mm^2/s	3500	3500	DIN 51562
Viscosity at operating temperature *.	mm^2/s	10.0 14.8	10.0 14.8	DIN 51562
VI-index		> 155	> 155	i.A. DIN ISO 2909
High Temp. High shear	cP	>3.5	>3.5	CEC L-36-A-90
Flash point	° C	> 220	> 220	DIN ISO 2592
TBN (total base number)	mg KOH/g	> 14	> 10	DIN ISO 3771
Shear stability over period of use	%	12%	12%	ASTM D6278
Evaporative losses (1 h at 250 °C)	%	Max 12%	up to 12%	CEC-L-040-93
Oxidation stability of DKA 192 h 160 ° C	%	< 30	< 30	CEC-L-48-A00
Ash (total) max.	g / 100 g	1.9	0.95	DIN 51575
Boron (B) max. *.	ppm	320	320	DIN 51399-1
Calcium (Ca) max. *.	ppm	4200	2400	DIN 51399-1
Phosphorus (P) max. *.	ppm	1200	800	DIN 51399-1
Zinc (Zn) max. *.	ppm	1200	600	DIN 51399-1
Magnesium (Mg) max. *.	ppm	50	50	DIN 51399-1
Barium (Ba) max. *.	ppm	80	80	DIN 51399-1
Molybdenum (Mo) max. *.	ppm	300	300	DIN 51399-1
Sulphur (S) max. *.	ppm	4000	2000	DIN 51399-1
Sodium (Na) max. *.	ppm	25	25	DIN 51399-1

Types of engines are different, but generally optimized to 98 ° C due to the operating temperature and requirement profiles

** Orientation values

- The engine oil must be inhibited against higher thermal load.
- Deposits in the motor must be avoided.
- The additives must be preserved over the usage period of the appliance to prevent damage. (TBN > 6 and soot in engine oil < 1%)
- The additives must be chosen so that the combustion gas influence can be compensated for and also compensate 3% of fuel without negative effect.
- Material compatibility Liebherr machines must be given.
- Mixability with conventional motor oils must be given.
- Recommended SAE J300 classes: 0W-40, 5W-30, 10W40
- Other viscosity classes are accepted, if the minimum specifications can be met.

The results of each test must be demonstrated in the case of damage and may be validated in an accredited laboratory.

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2. Applicable motor manufacturer standards

Due to the versatile applications in the components and machinery sector Liebherr can build not all engines themselves. Thus, also the following qualifications must be observed. A generally suitable for Liebherr diesel engine oil must meet the following standards.

	LH-00-ENG	LH-00-ENG LA
ACEA	E4 and E7	E6 and E9
API	CI-4; CI-4 plus	CJ-4 or CK-4
JASO	DH-1	DH-2
Mercedes Benz	MB 228.5	228.51 MB
MAN	3277	3477
Deutz	DQC III-18 or DQC IV-18	DQC III-18 LA or DQC IV-18 LA
John Deere	Qualification	Qualification
MTU	Category 3	Category 3.1
Cummins	CES 20077 or CES 20078	CES 20078, CES 20081 or CES 20086

Other standards which may be required in mixed fleets:

	LH-00-ENG	LH-00-ENG LA
Caterpillar	CAT ECF-2	CAT ECF-3
Volvo	VDS-3	VDS-4
EMA, ACEA, JAMA	Global DHD-1	---

The test results of the above mentioned standards must be presented in case of need to perform a full analysis when lubricant failure.

3. Liebherr OEM products and reference oil

Liebherr OEM engine oil	LH-marking	ID.-No. for 210 l drum
Liebherr Motoroil 10W-40	LH-00-ENG	10 33 02 46
Liebherr low ash Motoroil 10W-40	LH-00-ENG LA	10 32 61 11
Liebherr Motoroil 5W-30	LH-00-ENG	10 42 57 15
Liebherr low ash Motoroil 5W-30	LH-00-ENG LA	11 06 60 31

The relevant safety data sheets can be obtained at: http://www.Liebherr.com/ .

4. Alternative engine oils

Alternative oils must satisfy at least the requirement of LH-00-ENG of the chapters 1-2, must be chosen so that both the selection criteria can be met and lubrication properties are guaranteed as motor oil on the change interval.
Usually these are oils of the following viscosity classes (SAE J300):
SAE 5W-40, SAE 5W-30 and SAE 10W-40
But other viscosity classes may qualify if the above points are met.
The manufacturer of the engine oil must be in writing confirm the suitability of motor oil for the application the user before using and give the service life of the fluid, Liebherr is unable to evaluate the alternative oils without validation.

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Note:
The function and performance of engine oils that do not meet this specification, is not guaranteed by Liebherr. Liebherr is not liable for damage caused by wrong selected lubricants.

5. Additives and oil conditioners

Liebherr advises of additives or engine oil conditioner to use. Such additives affect the engine oil additives and must be used so selectively. A sporadic use can lead to damage or even failure of the motor.

6. Influence factors on the quality of the engine oil and oil change intervals

-Shortening influence factors are:

- Fuel qualities other than the required minimum standards (EN 590, ASTM 975 1-D/15,ASTM 975 2-D/15)
- Frequent cold starts
- Dust intensive usage
- High humidity with strong temperature changes

7. Determination of the replacement intervals

Note:
The change intervals described in the operating instructions / times have been with the recommended Liebherr Motoroil validated and tested with EN 590 diesel and correspond to the LH-00-ENG and LH-00-ENG LA Labelling!

The specific engine oil change intervals are to comply and to document, so that the function of the motor remains. Losses due to non-adherence change intervals or wrong engine oil are not covered by the warranty by Liebherr.
In the operational fluid analyses, LH-00-KIT, provids the necessary parameters and methods for oil analysis approved by Liebherr. On the basis of these values, it can be determined how long an engine oil under certain operating conditions can be used.
The warranty is still preserved, all media change, oil analysis, maintenance and machine operating data must be sustainable and documented after Liebherr standard.

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2. Requirements for oil approval categories

Oil Category	Minimum Standards	Viscosity	Chemical Analysis	Field Test	Volvo T-13
BASIC	ACEA E4 or ACEA E7 or API CI-4 Plus or DHD-1 or JASO DH-1	SAE 5W-30; SAE 10W-30; SAE 10W-40	Synthetic (Group 2 and/or 3 Base oils)	no	no
BASIC **for EATS**	ACEA E6 or ACEA E9 or API CJ-4 or JASO DH-2	SAE 5W-30; SAE 10W-30; SAE 10W-40	Synthetic (Group 2 and/or 3 Base oils)	no	no
STANDARD	**ACEA E4-16** or both ACEA E4 and ACEA E7	SAE 0W-30; SAE 5W-30; SAE; 5W-40; SAE 10W-40	Synthetic (Group 3 and/or 4) VI > 155 and long live additives	no	no
STANDARD **for EATS**	**ACEA E6-12** or both ACEA E6 and ACEA E9 or API CK-4	SAE 0W-30; SAE 5W-30; SAE 5W-40; SAE 10W-40	Synthetic (Group 3 and/or 4) VI > 155 and long live additives	no	no
PREMIUM	**ACEA E4-16** or both ACEA E4 and ACEA E7	SAE 0W-30; SAE 5W-30; SAE; 5W-40; SAE 10W-40	Synthetic (Group 3 and/or 4) VI > 155 and long live additives	yes	no
PREMIUM **for EATS**	**ACEA E6-12** or both ACEA E6 and ACEA E9 or API CK-4	SAE 0W-30; SAE 5W-30; SAE 5W-40; SAE 10W-40	Synthetic (Group 3 and/or 4) VI > 155 and long live additives	yes	yes

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3. Properties required in approval process

PREMIUM

				LH-00-ENG Premium				LH-00-ENG Premium Low Ash			
Unit	Method	Help Text	Test Condition	Min Value	Max Value	Target Value	Allowed Values	Min Value	Max Value	Target Value	Allowed Values
mm2/s	DIN 51562 | EN ISO 3104 | ASTM D4052		0C								
mm2/s	DIN 51562 | EN ISO 3104 | ASTM D4052	Must Report	40C	0	1000			0	1000		
	DIN ISO 2909 | ASTM D2270	Must Report	-	155				155			
mPa.s	DIN 51377 | ASTM D5293	Must Report	-		6400				6400		
cP	CEC L-036-A-90	Must Report	-	3.3	3.9			3.3	3.9		
% (percent)	CEC L-40-93 | DIN51581-1 | ASTM D5800	Must Report	-		10				10		
mg KOH/g	DIN EN 12634 | ASTM D664		-								
mg KOH/g	DIN ISO 3771 | ASTM D2896	Must Report	-	14				10			
% (percent)	DIN EN 14103		-								
mg KOH/g	DIN 51559 | DIN EN ISO 3657 | ASTM D5558		-								
% w/w	DIN 51559 | DIN EN ISO 3657 | ASTM D5558		-								
% w/w	-		-								
% w/w	-		-								
ppm (parts-per-million)	DIN 51399 | ASTM D4951	Must Report	-	0	10000			0	10000		
ppm (parts-per-million)	DIN 51399 | ASTM D4951	Must Report	-	0	10000			0	10000		
ppm (parts-per-million)	DIN 51399 | ASTM D4951	Must Report	-	0	10000			0	10000		
ppm (parts-per-million)	DIN 51399 | ASTM D4951	Must Report	-	0	10000			0	10000		
ppm (parts-per-million)	DIN 51399 | ASTM D4951	Must Report	-	0	10000			0	10000		
ppm (parts-per-million)	DIN 51399 | ASTM D4951	Must Report	-	0	10000			0	10000		
ppm (parts-per-million)	DIN 51399 | ASTM D4951	Must Report	-	0	10000			0	10000		
ppm (parts-per-million)	DIN 51399 | ASTM D4951	Must Report	-	0	10000			0	10000		
ppm (parts-per-million)	DIN 51399 | ASTM D4951	Must Report	-	0	10000			0	10000		
ppm (parts-per-million)	DIN 51399 | ASTM D4951	Must Report	-	0	10000			0	1200		
ppm (parts-per-million)	DIN 51399 | ASTM D4951	Must Report	-	0	10000			0	10000		
min (minute)	CEC L-085-99	Must Report	-	110				110			
min (minute)	ASTM D2112 | ASTM D2272		-								
% (percent)	CEC L-48-A-00		Change in KV40								
% (percent)	CEC L-48-A-00		Change in KV100								
mg KOH/g	CEC L-48-A-00		Change in TAN								
	DIN 51354	Failure Load Stage	FZG A10/16.6R/130								
mg	DIN 51535	Must Report	Average of 3 tests		90				80		
ppm (parts-per-million)	ASTM D6594	Must Report	Copper Increase 135C		15				15		
ppm (parts-per-million)	ASTM D6594		Lead Increase 135C								
% w/w	DIN EN ISO 10370 | ASTM D4530		-								
	DIN 51811 | DIN EN ISO 2160 | ASTM D4048		Copper Strip Rating 135C								
	DIN ISO 7120 | ASTM D665		Steel Strip Rating with Pure Water 135C								
	DIN 51811 | DIN EN ISO 2160 | ASTM D4048		Aluminum Strip Rating 135C								
g/ml	DIN EN ISO 12185 | DIN 51757 | ASTM D4052		15C								
degC	DIN EN ISO 2592 | ASTM D92	Must Report	-	0	500			0	500		
degC	DIN ISO 3016 | ASTM D5985		-								
ml	ASTM D892 (without option A)		Sequence I								
ml	ASTM D892 (without option A)		Sequence II								
ml	ASTM D892 (without option A)		Sequence III								
ml	ASTM D6082		High Temperature								
MICRON	CEC L-099-08		OM646LA								
MICRON	CEC L-099-08		OM646LA								
MICRON	CEC L-099-08		OM646LA								
MICRON	CEC L-099-08		OM646LA								
% (percent)	CEC L-099-08		OM646LA								
MICRON	CEC L-099-08		OM646LA								
% (percent)	CEC L-099-08		OM646LA								
kg/test (kilograms per test)	CEC L-099-08		OM646LA								
MICRON	CEC L-51-A-97		OM602A								
% (percent)	CEC L-51-A-97		OM602A								
% (percent)	CEC L-51-A-97		OM602A								
MICRON	CEC L-51-A-97		OM602A								
kg/test (kilograms per test)	CEC L-51-A-97		OM602A								
Merit	CEC L-51-A-97		OM602A								
Merit	CEC L-51-A-97		OM602A								
% (percent)	ASTM 7156	Minimum TGA soot at 4.0 cSt increase a	Mack T-11								
% (percent)	ASTM 7156	Minimum TGA soot at 12.0 cSt increase	Mack T-11								
% (percent)	ASTM 7156	Minimum TGA soot at 15.0 cSt increase	Mack T-11								
% (percent)	CEC L-101-08	Must Report	OM501LA		1				1		
Merit	CEC L-101-08	Must Report	OM501LA	30				30			
kg/test (kilograms per test)	CEC L-101-08	Must Report	OM501LA		7				7		
Merit	CEC L-101-08	Must Report	OM501LA	0	100000			0	100000		
Demerit	CEC L-101-08	Must Report	OM501LA	0	100000			0	100000		
Demerit	CEC L-101-08	Must Report	OM501LA	0	100000			0	100000		
MICRON	CEC L-101-08	Must Report	OM501LA		2				2		
ASF	CEC L-101-08	Must Report	OM501LA			0				0	
% (percent)	CEC L-52-T-97		OM441LA								
Merit	CEC L-52-T-97		OM441LA								
% (percent)	CEC L-52-T-97	400 hours	OM441LA								
kg/test (kilograms per test)	CEC L-52-T-97		OM441LA								
Merit	CEC L-52-T-97		OM441LA								
Demerit	CEC L-52-T-97		OM441LA								
Demerit	CEC L-52-T-97		OM441LA								
MICRON	CEC L-52-T-97		OM441LA								
ASF	CEC L-52-T-97		OM441LA								
mg	ASTM D7468	At 3.9% Soot	Cummins ISM								
kPa	ASTM D7468		Cummins ISM								
Merit	ASTM D7468		Cummins ISM								
mg	ASTM D7468		Cummins ISM								
mg	ASTM D6975		Cummins M11EGR								
mg	ASTM D6975		Cummins M11EGR								
kPa	ASTM D6975	At 250 hours	Cummins M11EGR								
Merit	ASTM D6975		Cummins M11EGR								
mg	ASTM D6838		Cummins M11								
kPa	ASTM D6838		Cummins M11								
Merit	ASTM D6838		Cummins M11								
	ASTM D7422		Mack T-12								
MICRON	ASTM D7422		Mack T-12								
mg	ASTM D7422		Mack T-12								
ppm (parts-per-million)	ASTM D7422	At End-of-Test	Mack T-12								
ppm (parts-per-million)	ASTM D7422	250-300 hours	Mack T-12								
g/hr (grams per hour)	ASTM D7422	Phase II	Mack T-12								
	ASTM D6987		Mack T-10								
MICRON	ASTM D6987		Mack T-10								
mg	ASTM D6987		Mack T-10								
ppm (parts-per-million)	ASTM D6987	At End-of-Test	Mack T-10								
ppm (parts-per-million)	ASTM D6987	250-300 hours	Mack T-10								
g/hr (grams per hour)	ASTM D6987	Phase II	Mack T-10								
MICRON	LH-MD2-PR1		Liebherr D964 Mix Idle vs HD								
MICRON	LH-MD2-PR1		Liebherr D964 Mix Idle vs HD								
mg	LH-MD2-PR1		Liebherr D964 Mix Idle vs HD								
ppm (parts-per-million)	LH-MD2-PR1		Liebherr D964 Mix Idle vs HD								
ppm (parts-per-million)	LH-MD2-PR1	At End-of-Test	Liebherr D964 Mix Idle vs HD								
mg	LH-MD2-PR1		Liebherr D964 Mix Idle vs HD								
g/hr (grams per hour)	LH-MD2-PR1		Liebherr D964 Mix Idle vs HD								
dB	LH-MD2-PR1	At 1500 rpm	Liebherr D964 Mix Idle vs HD								
Merit	CEC L-104-16		OM646LA Bio-Diesel								
ASF	CEC L-104-16		OM646LA Bio-Diesel								
Merit	CEC L-104-16		OM646LA Bio-Diesel								
A/cm	ASTM D8048	Must Report	Volvo T-13						80		
% w/w	DIN 51575 | ASTM D874		-		1.9				1.9		
	DIN 51451	Must Submit Report in *.csv* Format	-								
	ACEA E4 2016 or ACEA E4&E7 2016	Must Submit Approval Letter in *.pdf* f	-			WAHR				WAHR	
	CI-4 or CI-4 Plus	Must Submit Approval Letter in *.pdf* f	-			WAHR				WAHR	
	DH-1	Must Submit Approval Letter in *.pdf* f	-			WAHR				WAHR	
	MB 228.5	Must Submit Approval Letter in *.pdf* f	-			WAHR				WAHR	
	3277	Must Submit Approval Letter in *.pdf* f	-			WAHR				WAHR	
	DQC-III-18 or DQC IV-18	Must Submit Approval Letter in *.pdf* f	-			WAHR				WAHR	
	Category 3	Must Submit Approval Letter in *.pdf* f	-			WAHR				WAHR	
	CES 20077 or CES 20078	Must Submit Approval Letter in *.pdf* f	-			WAHR				WAHR	
	CAT ECF-2	Optional Approval Letter in *.pdf* form	-			WAHR				WAHR	
	VDS-3	Optional Approval Letter in *.pdf* form	-			WAHR				WAHR	
	Global DHD-1	Optional Approval Letter in *.pdf* form	-			WAHR					
	Liebherr Approved Machine and Site	Must Submit Final Field Trial Report	2 Test Machines x 2000 hours								
	-	Submit File in *.pdf* Format	-								
mm2/s	DIN 51562 | EN ISO 3104 | ASTM D4052	Must Report	100C	10	14.5			10	14.5		
	ASTM D5967	Relative Viscosity at 4.8% soot	Mack T-8E								
% (percent)	ASTM D8048	Must Report	Volvo T-13						50		
% (percent)	CEC L-112-16		ACEA RE6 Material								
% (percent)	CEC L-112-16		ACEA RE6 Material								
% (percent)	CEC L-112-16		ACEA RE7 Material								
% (percent)	CEC L-112-16		ACEA RE6 Material								
% (percent)	CEC L-112-16		ACEA RE7 Material								
% (percent)	CEC L-112-16		ACEA RE7 Material								
% (percent)	CEC L-112-16		ACEA RE8 Material								
% (percent)	CEC L-112-16		ACEA RE8 Material								
% (percent)	CEC L-112-16		ACEA RE8 Material								
% (percent)	CEC L-112-16		ACEA RE9 Material								
% (percent)	CEC L-112-16		ACEA RE9 Material								
% (percent)	CEC L-112-16		ACEA RE9 Material								
% (percent)	CEC L-14-A-93 | ASTM D6278	Must Report	After 30 cycles at 150C		14				14		
% (percent)	CEC L-14-A-93 | ASTM D6278		After 30 cycles at 100C								
% (percent)	CEC L-14-A-93 | ASTM D6278		After 90 cycles at 100C								
% (percent)	CEC L-14-A-93 | ASTM D6278	Must Report	After 90 cycles at 150C		14				14		
	Base Oil #1		(mandatory)								
% w/w	Base Oil #1		(mandatory)								
	Base Oil #2		(mandatory)								
% w/w	Base Oil #2		(mandatory)								
	Base Oil #3	Mandatory (if formulation contains 3 b	(if needed)								
% w/w	Base Oil #3	Mandatory (if formulation contains 3 b	(if needed)								
	Base Oil #1	Select Base Oil Group	(mandatory)				Gr-III | Gr-III+ | Gr-IV				Gr-III | Gr-III+ | Gr-IV
	Per SAE J300		(mandatory)				5W-30 | 10W-40 | 10W-30				5W-30 | 10W-40
	Base Oil #2	Select Base Oil Group	(mandatory)				Gr-III | Gr-III+ | Gr-IV				Gr-III | Gr-III+ | Gr-IV
	Base Oil #3	Mandatory (if formulation contains 3 b	(if needed)				Gr-III | Gr-III+ | Gr-IV				Gr-III | Gr-III+ | Gr-IV
	-	Attach base oil details (name, manufa	(optional)								
	-	Attach additive package details (name	(mandatory)								
cSt (centistokes)	ASTM D445-18	Kinematic Viscosity at 100C	100C								
cSt (centistokes)	ASTM D445-18	Kinematic Viscosity at 40C	40C								
	ASTM E2412-10(2018)	Fourier transform infrared results, .csv	FTIR Test								
ppm (parts-per-million)	ASTM D5185-18		ICP								
ppm (parts-per-million)	ASTM D5185-18		ICP								
ppm (parts-per-million)	ASTM D5185-18		ICP								
ppm (parts-per-million)	ASTM D5185-18		ICP								
ppm (parts-per-million)	ASTM D5185-18		ICP								
ppm (parts-per-million)	ASTM D5185-18		ICP								
ppm (parts-per-million)	ASTM D5185-18		ICP								
ppm (parts-per-million)	ASTM D5185-18		ICP								
ppm (parts-per-million)	ASTM D5185-18		ICP								
ppm (parts-per-million)	ASTM D5185-18		ICP								
ppm (parts-per-million)	ASTM D5185-18		ICP								
ppm (parts-per-million)	ASTM D5185-18		ICP								
ppm (parts-per-million)	ASTM D5185-18		ICP								
ppm (parts-per-million)	ASTM D5185-18		ICP								
ppm (parts-per-million)	ASTM D5185-18		ICP								
ppm (parts-per-million)	ASTM D5185-18		ICP								
ppm (parts-per-million)	ASTM D5185-18		ICP								
ppm (parts-per-million)	ASTM D5185-18		ICP								
ppm (parts-per-million)	ASTM D5185-18		ICP								
ppm (parts-per-million)	ASTM D5185-18		ICP								
ppm (parts-per-million)	ASTM D5185-18		ICP								
ppm (parts-per-million)	ASTM D5185-18		ICP								

STANDARD

LH-00-ENG Standard				LH-00-ENG Standard					LH-00-ENG Standard Low Ash			
Property Name	Unit	Method	Help Text	Test Condition	Min Value	Max Value	Target Value	Allowed Values	Min Value	Max Value	Target Value	Allowed Values
Kinematic Viscosity	mm2/s	DIN 51562 | EN ISO 3104 | ASTM D4052		0C								
Kinematic Viscosity	mm2/s	DIN 51562 | EN ISO 3104 | ASTM D4052	Must Report	40C	0	1000			0	1000		
Viscosity Index		DIN ISO 2909 | ASTM D2270	Must Report	-					155			
Low Temperature Cranking Viscosity	mPa.s	DIN 51377 | ASTM D5293	Must Report	-		6400				6400		
High Temperature High Shear Viscosity	cP	CEC L-036-A-90	Must Report	-	3.3	3.9			3.3	3.9		
Evaporative Loss Noack	% (percent)	CEC L-40-93 | DIN51581-1 | ASTM D5800	Must Report	-		10				10		
Total Acid Number (TAN)	mg KOH/g	DIN EN 12634 | ASTM D664		-								
Total Base Number (TBN)	mg KOH/g	DIN ISO 3771 | ASTM D2896	Must Report	-	14				10			
Fatty Acid Methyl Esters (FAME)	% (percent)	DIN EN 14103		-								
Saponification Value of Fats and Oils	mg KOH/g	DIN 51559 | DIN EN ISO 3657 | ASTM D5558		-								
Oxid Ash	% w/w	DIN 51559 | DIN EN ISO 3657 | ASTM D5558		-								
Calculated Oxid Ash with Element Analyses	% w/w	-		-								
Calculated Sulphated Ash with Element Analyses	% w/w	-		-								
Calcium	ppm (parts-per-million)	DIN 51399 | ASTM D4951	Must Report	-	0	10000			0	10000		
Potassium	ppm (parts-per-million)	DIN 51399 | ASTM D4951	Must Report	-	0	10000			0	10000		
Sodium	ppm (parts-per-million)	DIN 51399 | ASTM D4951	Must Report	-	0	10000			0	10000		
Barium	ppm (parts-per-million)	DIN 51399 | ASTM D4951	Must Report	-	0	10000			0	10000		
Magnesium	ppm (parts-per-million)	DIN 51399 | ASTM D4951	Must Report	-	0	10000			0	10000		
Zinc	ppm (parts-per-million)	DIN 51399 | ASTM D4951	Must Report	-	0	10000			0	10000		
Molybdenum	ppm (parts-per-million)	DIN 51399 | ASTM D4951	Must Report	-	0	10000			0	10000		
Boron	ppm (parts-per-million)	DIN 51399 | ASTM D4951	Must Report	-	0	10000			0	10000		
Silicon	ppm (parts-per-million)	DIN 51399 | ASTM D4951	Must Report	-	0	10000			0	10000		
Phosphorus	ppm (parts-per-million)	DIN 51399 | ASTM D4951	Must Report	-	0	10000			0	1200		
Sulphur	ppm (parts-per-million)	DIN 51399 | ASTM D4951	Must Report	-	0	10000			0	10000		
Oxidation Induction Time (PDSC)	min (minute)	CEC L-085-99	Must Report	-	110				110			
Oxidation RPVOT	min (minute)	ASTM D2112 | ASTM D2272		-								
DKA Oxidation Stability	% (percent)	CEC L-48-A-00		Change in KV40								
DKA Oxidation Stability	% (percent)	CEC L-48-A-00		Change in KV100								
DKA Oxidation Stability (TAN)	mg KOH/g	CEC L-48-A-00		Change in TAN								
FZG Gear Scuffing		DIN 51354	Failure Load Stage	FZG A10/16.6R/130								
Turbocharger Deposit Test	mg	DIN 51535	Must Report	Average of 3 tests		90				80		
Copper Corrosion	ppm (parts-per-million)	ASTM D6594	Must Report	Copper Increase 135C		15				15		
Lead Corrosion	ppm (parts-per-million)	ASTM D6594		Lead Increase 135C								
Determination of Carbon Residue	% w/w	DIN EN ISO 10370 | ASTM D4530		-								
Copper Corrosion (strip rating)		DIN 51811 | DIN EN ISO 2160 | ASTM D4048		Copper Strip Rating 135C								
Steel Corrosion (strip rating)		DIN ISO 7120 | ASTM D665		Steel Strip Rating with Pure Water 135C								
Aluminum Corrosion (strip rating)		DIN 51811 | DIN EN ISO 2160 | ASTM D4048		Aluminum Strip Rating 135C								
Density	g/ml	DIN EN ISO 12185 | DIN 51757 | ASTM D4052		15C								
Flash Point (COC)	degC	DIN EN ISO 2592 | ASTM D92	Must Report	-	0	500			0	500		
Pour Point	degC	DIN ISO 3016 | ASTM D5985		-								
Foaming Tendency	ml	ASTM D892 (without option A)		Sequence I								
Foaming Tendency	ml	ASTM D892 (without option A)		Sequence II								
Foaming Tendency	ml	ASTM D892 (without option A)		Sequence III								
Foaming Tendency	ml	ASTM D6082		High Temperature								
Cam Wear, Outlet	MICRON	CEC L-099-08		OM646LA								
Cam Wear, Inlet	MICRON	CEC L-099-08		OM646LA								
Cylinder Wear	MICRON	CEC L-099-08		OM646LA								
Tappet Wear, Inlet	MICRON	CEC L-099-08		OM646LA								
Bore Polishing	% (percent)	CEC L-099-08		OM646LA								
Tappet Wear, Outlet	MICRON	CEC L-099-08		OM646LA								
Viscosity Increase at 100C	% (percent)	CEC L-099-08		OM646LA								
Oil Consumption	kg/test (kilograms per test)	CEC L-099-08		OM646LA								
Cam Wear	MICRON	CEC L-51-A-97		OM602A								
Viscosity Increase at 40C	% (percent)	CEC L-51-A-97		OM602A								
Bore Polishing	% (percent)	CEC L-51-A-97		OM602A								
Cylinder Wear	MICRON	CEC L-51-A-97		OM602A								
Oil Consumption	kg/test (kilograms per test)	CEC L-51-A-97		OM602A								
Piston Cleanliness	Merit	CEC L-51-A-97		OM602A								
Sludge	Merit	CEC L-51-A-97		OM602A								
Soot Concentration	% (percent)	ASTM 7156	Minimum TGA soot a	Mack T-11								
Soot Concentration	% (percent)	ASTM 7156	Minimum TGA soot a	Mack T-11								
Soot Concentration	% (percent)	ASTM 7156	Minimum TGA soot a	Mack T-11								
Bore Polishing	% (percent)	CEC L-101-08	Must Report	OM501LA		1				1		
Piston Cleanliness	Merit	CEC L-101-08	Must Report	OM501LA	30				30			
Oil Consumption	kg/test (kilograms per test)	CEC L-101-08	Must Report	OM501LA		7				7		
Sludge	Merit	CEC L-101-08	Must Report	OM501LA	0	100000			0	100000		
Visual Wear	Demerit	CEC L-101-08	Must Report	OM501LA	0	100000			0	100000		
Total Deposits	Demerit	CEC L-101-08	Must Report	OM501LA	0	100000			0	100000		
Cylinder Wear	MICRON	CEC L-101-08	Must Report	OM501LA		2				2		
Piston Ring Sticking	ASF	CEC L-101-08	Must Report	OM501LA			0				0	
Bore Polishing	% (percent)	CEC L-52-T-97		OM441LA								
Piston Cleanliness	Merit	CEC L-52-T-97		OM441LA								
Boost Pressure Loss	% (percent)	CEC L-52-T-97	400 hours	OM441LA								
Oil Consumption	kg/test (kilograms per test)	CEC L-52-T-97		OM441LA								
Sludge	Merit	CEC L-52-T-97		OM441LA								
Visual Wear	Demerit	CEC L-52-T-97		OM441LA								
Total Deposits	Demerit	CEC L-52-T-97		OM441LA								
Cylinder Wear	MICRON	CEC L-52-T-97		OM441LA								
Piston Ring Sticking	ASF	CEC L-52-T-97		OM441LA								
Rocker Pad Average Weight Loss	mg	ASTM D7468	At 3.9% Soot	Cummins ISM								
Oil Filter Differential Pressure	kPa	ASTM D7468		Cummins ISM								
Sludge	Merit	ASTM D7468		Cummins ISM								
Adjusting Screw Weight Loss	mg	ASTM D7468		Cummins ISM								
Rocker Pad Average Weight Loss	mg	ASTM D6975		Cummins M11EGR								
Top Ring Average Weight Loss	mg	ASTM D6975		Cummins M11EGR								
Oil Filter Differential Pressure	kPa	ASTM D6975	At 250 hours	Cummins M11EGR								
Sludge	Merit	ASTM D6975		Cummins M11EGR								
Rocker Pad Average Weight Loss	mg	ASTM D6838		Cummins M11								
Oil Filter Differential Pressure	kPa	ASTM D6838		Cummins M11								
Sludge	Merit	ASTM D6838		Cummins M11								
Merit		ASTM D7422		Mack T-12								
Liner Wear Average	MICRON	ASTM D7422		Mack T-12								
Top Ring Average Weight Loss	mg	ASTM D7422		Mack T-12								
Lead Concentration	ppm (parts-per-million)	ASTM D7422	At End-of-Test	Mack T-12								
Lead Delta	ppm (parts-per-million)	ASTM D7422	250-300 hours	Mack T-12								
Oil Consumption	g/hr (grams per hour)	ASTM D7422	Phase II	Mack T-12								
Merit		ASTM D6987		Mack T-10								
Liner Wear Average	MICRON	ASTM D6987		Mack T-10								
Top Ring Average Weight Loss	mg	ASTM D6987		Mack T-10								
Lead Concentration	ppm (parts-per-million)	ASTM D6987	At End-of-Test	Mack T-10								
Lead Delta	ppm (parts-per-million)	ASTM D6987	250-300 hours	Mack T-10								
Oil Consumption	g/hr (grams per hour)	ASTM D6987	Phase II	Mack T-10								
Valve Wear	MICRON	LH-MD2-PR1		Liebherr D964 Mixidle vs HD								
Liner Wear Average	MICRON	LH-MD2-PR1		Liebherr D964 Mixidle vs HD								
Top Ring Average Weight Loss	mg	LH-MD2-PR1		Liebherr D964 Mixidle vs HD								
Copper Concentration	ppm (parts-per-million)	LH-MD2-PR1		Liebherr D964 Mixidle vs HD								
Lead Concentration	ppm (parts-per-million)	LH-MD2-PR1	At End-of-Test	Liebherr D964 Mixidle vs HD								
Ash, NOx, Emission at Exhaust	mg	LH-MD2-PR1		Liebherr D964 Mixidle vs HD								
Oil Consumption	g/hr (grams per hour)	LH-MD2-PR1		Liebherr D964 Mixidle vs HD								
Noise	dB	LH-MD2-PR1	At 1500 rpm	Liebherr D964 Mixidle vs HD								
Piston Cleanliness	Merit	CEC L-104-16		OM646LA Bio-Diesel								
Piston Ring Sticking	ASF	CEC L-104-16		OM646LA Bio-Diesel								
Sludge	Merit	CEC L-104-16		OM646LA Bio-Diesel								
Oxidation Stability	A/cm	ASTM D8048	Must Report	Volvo T-13								
Sulphated Ash	% w/w	DIN 51575 | ASTM D874				1.9				1.9		
FTIR		DIN 51451	Must Submit Report	-								
ACEA		ACEA E4 2016 or ACEA E6E7 2016	Must Submit Approv	-			WAHR				WAHR	
API		CI-4 or CI-4 Plus	Must Submit Approv	-			WAHR				WAHR	
JASO		DH-1	Must Submit Approv	-			WAHR				WAHR	
Mercedes Benz		MB 228.5	Must Submit Approv	-			WAHR				WAHR	
MAN			3277 Must Submit Approv	-			WAHR				WAHR	
Deutz		DQC III-18 or DQC IV-18	Must Submit Approv	-			WAHR				WAHR	
MTU		Category 3	Must Submit Approv	-			WAHR				WAHR	
Cummins		CES 20077 or CES 20078	Must Submit Approv	-			WAHR				WAHR	
Caterpillar		CAT ECF-2	Optional Approval Lc	-			WAHR				WAHR	
Volvo		VDS-3	Optional Approval Lc	-			WAHR				WAHR	
EMA, ACEA, JAMA		Global DHD-1	Optional Approval Lc	-			WAHR				WAHR	
Simulated Distillation		-	Submit File in *.pdf*	-								
Kinematic Viscosity	mm2/s	DIN 51562 | EN ISO 3104 | ASTM D4052	Must Report	100C	10	14.5			10	14.5		
Relative Viscosity		ASTM D5967	Relative Viscosity at	Mack T-8E								
Viscosity Increase at 40C	% (percent)	ASTM D8048	Must Report	Volvo T-13								
Elastomer Compatibility	% (percent)	CEC L-112-16		ACEA RE6 Material								
Elastomer Compatibility	% (percent)	CEC L-112-16		ACEA RE6 Material								
Elastomer Compatibility	% (percent)	CEC L-112-16		ACEA RE7 Material								
Elastomer Compatibility	% (percent)	CEC L-112-16		ACEA RE6 Material								
Elastomer Compatibility	% (percent)	CEC L-112-16		ACEA RE7 Material								
Elastomer Compatibility	% (percent)	CEC L-112-16		ACEA RE7 Material								
Elastomer Compatibility	% (percent)	CEC L-112-16		ACEA RE8 Material								
Elastomer Compatibility	% (percent)	CEC L-112-16		ACEA RE8 Material								
Elastomer Compatibility	% (percent)	CEC L-112-16		ACEA RE8 Material								
Elastomer Compatibility	% (percent)	CEC L-112-16		ACEA RE9 Material								
Elastomer Compatibility	% (percent)	CEC L-112-16		ACEA RE9 Material								
Shear Stability | Viscosity- delta	% (percent)	CEC L-14-A-93 | ASTM D6278	Must Report	After 30 cyles at 150C		14				14		
Shear Stability | Viscosity- delta	% (percent)	CEC L-14-A-93 | ASTM D6278		After 30 cyles at 100C								
Shear Stability | Viscosity- delta	% (percent)	CEC L-14-A-93 | ASTM D6278		After 90 cyles at 100C								
Shear Stability | Viscosity- delta	% (percent)	CEC L-14-A-93 | ASTM D6278	Must Report	After 90 cyles at 150C		14				14		
Base Oil Product Name				(mandatory)								
Base Oil Percentage	% w/w	Base Oil #1		(mandatory)								
Base Oil Product Name		Base Oil #2		(mandatory)								
Base Oil Percentage	% w/w	Base Oil #2		(mandatory)								
Base Oil Product Name		Base Oil #3	Mandatory (if formul	(if needed)								
Base Oil Percentage	% w/w	Base Oil #3	Mandatory (if formul	(if needed)								
Base Oil Group		Base Oil #1	Select Base Oil Grou	(mandatory)				Gr-III | Gr-III+ | Gr-IV				Gr-III | Gr-III+ | Gr-IV
Viscosity Grade		Per SAE J300		(mandatory)				5W-30 | 10W-40 | 10W-30				0W-30 | 5W-30 | 10W-40 | 10W-30
Base Oil Group		Base Oil #2	Select Base Oil Grou	(mandatory)				Gr-III | Gr-III+ | Gr-IV				Gr-III | Gr-III+ | Gr-IV
Base Oil Group		Base Oil #3	Mandatory (if formul	(if needed)				Gr-III | Gr-III+ | Gr-IV				Gr-III | Gr-III+ | Gr-IV
Base Oil Table		-	Attach base oil data	(optional)								
Additive Package Table		-	Attach additive pack	(mandatory)								
Kinematic Viscosity	cSt (centistokes)	ASTM D445-18	Kinematic Viscosity	100C								
Kinematic Viscosity	cSt (centistokes)	ASTM D445-18	Kinematic Viscosity	40C								
FTIR		ASTM E2412-10(2018)	Fourier transform ir	FTIR Test								
Aluminium	ppm (parts-per-million)	ASTM D5185-18		ICP								
Barium	ppm (parts-per-million)	ASTM D5185-18		ICP								
Boron	ppm (parts-per-million)	ASTM D5185-18		ICP								
Calcium	ppm (parts-per-million)	ASTM D5185-18		ICP								
Chromium	ppm (parts-per-million)	ASTM D5185-18		ICP								
Copper	ppm (parts-per-million)	ASTM D5185-18		ICP								
Iron	ppm (parts-per-million)	ASTM D5185-18		ICP								
Lead	ppm (parts-per-million)	ASTM D5185-18		ICP								
Magnesium	ppm (parts-per-million)	ASTM D5185-18		ICP								
Manganese	ppm (parts-per-million)	ASTM D5185-18		ICP								
Molybdenum	ppm (parts-per-million)	ASTM D5185-18		ICP								
Nickel	ppm (parts-per-million)	ASTM D5185-18		ICP								
Phosphorus	ppm (parts-per-million)	ASTM D5185-18		ICP								
Potassium	ppm (parts-per-million)	ASTM D5185-18		ICP								
Silicon	ppm (parts-per-million)	ASTM D5185-18		ICP								
Silver	ppm (parts-per-million)	ASTM D5185-18		ICP								
Sodium	ppm (parts-per-million)	ASTM D5185-18		ICP								
Sulfur	ppm (parts-per-million)	ASTM D5185-18		ICP								
Tin	ppm (parts-per-million)	ASTM D5185-18		ICP								
Titanium	ppm (parts-per-million)	ASTM D5185-18		ICP								
Vanadium	ppm (parts-per-million)	ASTM D5185-18		ICP								
Zinc	ppm (parts-per-million)	ASTM D5185-18		ICP								

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4. Engine Field Validation process for engine oil approval (*Premium*)

General information

Liebherr diesel engines are high-performance units, which have to be technically accordingly treated and maintained. These include the lubricants, contributing a significant portion to the function, security, efficiency and reliability. Wrong motor oils can lead to damage, loss up to the total damage of the engine. For this reason, Liebherr seeks contact with oil producers to ensure optimum motor function and life together with this and the user.

Within approval process *PREMIUM* label approval must show passed field test for diesel engines.

Engine oil MUST NOT exceed limits of below standing table within test time of 2.000 hours. Oil change before end of test time is prohibited and will restart oil validation field test..

Selection of the engine

Introducing a qualification opportunity of a engine is the oil manufacturer/customer or Liebherr. The final selection of the test engine is carried out by the Development Department of Liebherr Machines Bulle SA for operational fluids.

Ideally, a new engine with a maximum maturity of 1,000 hours of operation and a minimum of two engines will be selected for the qualification.

Prototype engines (before SOP) are not allowed for oil validation.

Fuel quality

The fuel quality during the test run must correspond to the specification of the Liebherr Fuel Specification LH-00-FUEL. Usable fuels are just premium diesel blends.

Deployment and documentation of the engine oil to qualifying

The engine oil manufacturer or supplier provides the engine oil in sufficient quantity and documented quality for the duration of the testing. The engine oil documentation must be supplied in advance. In addition, the result of a resent analysis of fresh oil sample and a 1 L engine oil has to be submitted to Liebherr.

Engine operating data

For the field test, following engine operating data must be recorded in order to see how and under what conditions the engine is operated and loaded and thus allow a final decision about the release of the engine oil:

A) Continuous measured engine operating data:
   Engine operating data have to be tracked continuously and data should be stored on:
   a) COMAP server
   b) LMB share point

B) Additional measurements (optional)
   To be performed manually when an oil sample is taken or if the measurement value is available by plant:
   1. Exhaust gas temperature
   2. Crankcase pressure (e.g. possible with U-pipe)

Test preparation

The delivery of the engine is usually without engine oil. Remaining shares of the first filling out the engine test run at the factory must be removed. In the case of delivery including a motor oil filling, it is to be removed (1 l samples of the drained oil is taken) before testing and filled afterward with the engine oil to be tested. In this case, another oil change is done after 100 hours of operation. The minimum motor filling quantity is used as "Flushing oil". Changing the oil is carried out in the hot state.

Oil Sampling Procedure

Oil samples can be taken from the Oil sampling valve provided on the engine by Liebherr and sampling generally occurs in the following cycle:

After initial filling

1. Sample after 100 h
2. Sample after 250 h
3. Sample after 500 h
4. Further samples every 250 h

All oil sample analysis is performed by the oil manufacturer in an accredited laboratory (ISO 17025). The determined data are analyzed together and have to be agreed by Liebherr.
Initial timing of sampling must not be reduced if two following samples are non-stable in values. At least two up following samples must show similar values. Deviation from limits will indicate ODI (oil drain interval).

Category	PARAMETER	UNIT	MIN VALUE	MAX VALUE	RECOMMENDED TEST METHOD
Wear	Fe	ppm	0	100	ASTM D5185, ASTM D4951
Wear	Cr	ppm	0	5	ASTM D5185, ASTM D4951
Wear	Co	ppm			ASTM D5185, ASTM D4951
Wear	Sn	ppm	0	20	ASTM D5185, ASTM D4951
Wear	Al	ppm	0	10	ASTM D5185, ASTM D4951
Wear	Ni	ppm	0	5	ASTM D5185, ASTM D4951
Wear	Cu	ppm	0	120	ASTM D5185, ASTM D4951
Wear	Pb	ppm	0	100	ASTM D5185, ASTM D4951
Wear	Mo	ppm			ASTM D5185, ASTM D4951
Wear	PQ-Index		n.d.	25	PARKER/Kittiwake-ANALEX PQ
contamination	Si	ppm		20	ASTM D5185, ASTM D4951
contamination	K	ppm		20	ASTM D5185, ASTM D4951
contamination	Na	ppm		Fresh oil + 20	ASTM D5185, ASTM D4951
contamination	water	m%		0.1	ASTM D95
contamination	IR-Glycol	ppm		n.d.	ASTM E2412
contamination	Soot	%		1.0	ASTM E1131
oil additivation	Solid contamination	mg			ASTM D4055
physical oil health	Viscosity at 40°C	mm^2/s	Max 15% deviation from fresh oil		ASTM D445
physical oil health	Viscosity 100°C	mm^2/s			ASTM D445
physical oil health	Viscosity index	-	Tbd.	Tbd.	ASTM D2270
physical oil health	Oxidation	A/cm		20	ASTM D7414
physical oil health	Nitration	A/cm		20	ASTM D7624
physical oil health	Sulfation	A/cm		30	ASTM D7415
physical oil health	Dispersancy	%	98	100	ASTM D7899
oil additivation	Oil Elements: Ca, Mg,B,Zn,P,Ba,S,Cl…	ppm	Max 10% deviation from fresh oil		ASTM D5185, ASTM D4951
special test	BN	mg KOH/g	50% from Fresh oil		ASTM D4739
special test	AN	mg KOH/g		5	ASTM D664
special test	i-pH-Wert	-	3.5		Metrohm

Lube Oil Consumption documentation:
Lubricating oil consumption is important and part of the test run. Thus, a documentation is part of the technical release without which the release cannot be granted. The operator of the engine makes sure to properly document the oil consumption and to provide this data Liebherr in digital form on the project SharePoint.

Component inspection
Following components must be inspected by endoscope according to the interval in the table below. This inspection by endoscope is performed to monitor the visual condition of the engine during the field test and to secure that no abnormal engine behavior is identified. These tests have to be done by qualified service partners (Liebherr decision) or Liebherr themselves.

Component	Focus	250h	500h	1000h	2000h
Cylinder head and valves	Deposits	✓	✓	✓	✓
Cylinder liner	Wear	✓	✓	✓	✓
Top of Piston	Deposits	✓	✓	✓	✓

Additionally, all replaced components must be send to Liebherr, including spare parts exchanged in the engine as well as the lube oil filter.

OPTION 1:
Based on oil analytics quality after each 2000 hours a component inspection with disassembly of the engine must be performed by Liebherr personal on site and by sending following parts for component inspection to Liebherr:

- 4 x Cylinder head with valves and ignition candles
- 4 x Cylinder liner
- 4 x Piston and piston rings
- 4 x Main bearing and con rod bearing
- 4 x Con-rod
- Optional 1 x Turbocharger in case of non-stable endurance data

OPTION 2:
Complete engine change after a minimum of 2000 can be discussed.
Pass-/Fail-criteria of validation endurance run are:

- Continuous stable oil analytics
- No violation of limits in expected lifetime wear

Implementing the findings
The expansion of the components must be organized and paid by the lubricant manufacturer. With an endoscopic analysis a complete documentation has to be shared with Liebherr in digital form at the provided SharePoint.
If parts are extracted, then these are taken by qualified personnel (proof must be submitted) and are shipped properly packed to Liebherr in Bulle for the diagnosis.
Liebherr has the right to be present at the activities and examinations of the test run.
Organization and costs
The applicant organizes the coordination and logging of field tests. This is typically the lubricant manufacturer. The client carries the costs for the operation, the prescribed maintenance and the measurement documentation, as well as the oil documentation (refills, oil sampe taking, etc.). The applicant organizes the service tasks with a qualified and authorized service partner. These activities are to be told to Liebherr in a timely manner so that Liebherr may have the opportunity to participate in this event. The applicant bears the cost for these service activities and spear materials. The cost during the field test of the necessary oil analyses are taken over by the applicant as well. The component inspection is performed by Liebherr in Bulle on costs of requestor.
At the end all information's are collected in a final report and presented to Liebherr for confirmation and eventual release by requestor in proper layout.
Liability
The oil manufacturer / supplier assumes liability for the functioning of the engine oil to be qualified. The engine oil manufacturer guarantees that the product is free of defects and corresponds to the usual production quality. The engine oil supplier / manufacturer is liable for tribological damage. I.e. any damage, caused by tribological failure despite of proper application and compliance with the measures prescribed for the qualifying session, proven on the defective function of the engine oil, be liable to the oil manufacturer / supplier to the fullest extent. To do this, a separate contract for the clarification of the liability is exchanged between the operators of the engine and the oil producer / supplier. This tribological part of the warranty is recorded by the lubricant manufacturer in a qualifying contract. Damages caused by the oil validation, close by and after are insured by this contract.
Functional defects without tribological aspects (not engine oil relevant), are covered by the standard warranty of the engine.

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5. Draft of Liebherr Certificate for engine oil approval

LIEBHERR

Liebherr Fluid Approval System (LiFAS)

Liebherr Machines Bulle SA confirms according to valid specification an approval for operational fluids with this letter.

Specification

LIEBHERR OEM – FLUID APPROVAL

LH-00-FAS (Version 1.1b)
date 1.9.2022

For the product:

Oil code:

Of Requester:

LiFAS-Code:

Approval Date:

Expiration:

LiFAS has approved successfully certification and grants according to specification the product owner to inform meeting performance level

- ***Liebherr approved LH-00-ENG-22 PREMIUM/STANDARD***
- ***Liebherr approved LH-00-ENG LA-22 PREMIUM/STANDARD***