Lubricants

WinGD Lubricants Guideline

DTAA001621

WIN GD

LUBRICANTS

Rev.	Creator	Approver	Approval Date	Change ID	Change Synopsis	E	C
B	mhu019	dst009	25.11.2025	CNAA011067	Document update	4	3
A	mhu019	dst009	29.10.2024	CNAA007045	... Drawing update	4	3
-	mhu019	mhu019	19.07.2024	CNAA005900	new Document	-	-

Prod.

Change History

Activity Code

LUBRICANTS

PC-Drawing

Dimension

Design Group	9722	Q-Code	- - -	Standard	WDS
A4	Document ID	DTAA001621		PC Page/s	1 / 22

List of Changes

Rev	Date	Made	Appd	Description
-	19.07.2024	jbi101	rma040	New guideline “Lubricants”, document number DTAA001621, replacing “Lubricants for WinGD engines -V9”
A	17.10.2024	jbi101	rma040	• Test method for FZG gear oil test added (table 2, page 17) • Minor visual improvements
B	25.11.2025	jbi101	rma040	Cylinder oils • Wording update on high residual BN (Chapter 2.3.2, page 11) • Added chapter 2.6 (Switching Cylinder Lubricants, page 13) System oils • Flash point: removed test method ASTM D92 (Table 2, page 17) • Particle count: added test method ASTM D7647 (Table 2, page 17) • Added clarification on particle count limits (Chapter 3.3.1, page18)

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1 General information

The WinGD guideline “Lubricants” provides comprehensive insights into the essential role of lubricants in ensuring optimal engine performance and longevity. It covers the fundamental properties of lubricants, their classification and selection criteria. Additionally, the guideline addresses the impact of operating conditions on lubricant performance and provides best practices for lubricant management and maintenance. The information provided in this guideline helps operators and engineers to make informed decisions about effective engine lubrication.
This guideline primarily focuses on cylinder oils and system oils which are essential for the operation of WinGD engines. Additionally, it provides a brief overview of other oils and lubricants required for optimal engine performance.

The following topics are covered within the WinGD guideline “Lubricants”:

- oil selection
- oil sampling, analysis and interpretation of results
- guideline for running-in of new components
- cylinder oil feed rate optimisation
- system oil limits and maintenance
- validated lubricants for WinGD engines.

Base Number
The Base Number (BN) is a measure of a lubricant’s ability to neutralise acids, indicating its alkalinity level. BN is measured in milligrams of potassium hydroxide per gram of lubricant (mg KOH/g) using ASTM D2896 test method. A suitable BN is crucial because it helps to protect engine components from corrosive wear caused by acidic byproducts of fuel combustion. Maintaining an appropriate BN ensures effective acid neutralisation, extending life of lubricants and components and maintaining engine performance and durability. The BN of the lubricant is not an index for detergency or for other properties of the cylinder oil.

NOTE: This guideline is intended for information purposes only. No liability, whether direct, indirect, special, incidental or consequential, is assumed with respect to the information contained in this document.

NOTE: The latest version of this guideline and all supporting & linked documents are available on the WinGD website:

WinGD Tribology Fuels & Lubricants Website
https://wingd.com/design-development/engine-technologies/tribology-fuels-lubricants

2 Cylinder oils

Cylinder oil is an essential component of the piston running system. It contributes significantly to achieving low wear rates and enabling long overhaul intervals.

The main functions of the cylinder oil are:

- lubrication of piston running components to decrease friction and wear
- keeping piston running components clean and free from deposits
- neutralisation of acidic combustion byproducts like sulphuric acid to prevent corrosion of piston running components.

The cylinder lubrication works according to the principle of lost lubrication. The recommended set feed rate range for the cylinder oil is between 0.6 g/kWh and 1.2 g/kWh.

Cylinder lubrication: WinGD recommendation

Only validated cylinder oils can be used on WinGD engines. An overview of currently validated cylinder oils can be found in Chapter 5.1. The kinematic viscosity of the validated cylinder oils is typically in the range of the SAE 50 viscosity grade. The alkalinity, represented by the Base Number (BN) of the cylinder oil, must be suitable for the fuel in use. To get good performance of the piston running components, WinGD recommends the following process:

1. Select a cylinder oil suitable for the engine type and fuel in use (see Chapter 2.1).
2. Set the initial feed rate to 0.9 g/kWh[1, 2].
3. Perform a cylinder oil drain oil analysis (see Chapter 2.2).
4. Interpret the analysis results based on the BN of the fresh cylinder oil in use:
   - For cylinder oils with BN<40, see Chapter 2.3.1.
   - For cylinder oils with BN between BN 40 and BN 100, see Chapter 2.3.2.
   - For cylinder oils with BN>100, see Chapter 2.3.3.
5. Adjust the feed rate according to the process described in Chapter 2.4.
6. WinGD recommends repeating some of the above steps on a regular basis:
   - At least once every week, repeat steps 3 to 5.
   - After a feed rate change, repeat steps 3 to 5.
   - After a fuel change, repeat steps 1 to 5.[2]
   - After a cylinder oil change, repeat steps 1 to 5.[2]

NOTE: It is recommended to store the data from the oil analyses.

[1] During running-in of new components, follow the process described in Chapter 2.7 first.
[2] In case of previous operating experience, like similar loads, fuel sulphur concentration ((±0.125% m/m) and cylinder oil BN, you can skip step 2 and directly set the feed rate to the previously used value.

2.1 Cylinder oil selection

Cylinder oil selection is heavily influenced by the type of fuel in use and its sulphur content. Higher sulphur fuels require cylinder oils with a higher Base Number (BN) to neutralise the increased acidic byproducts produced during combustion. Conversely, low-sulphur fuels require cylinder oils with a lower BN to avoid excessive alkalinity which can lead to deposits resulting in increased wear. The different BN ranges allowed depending on the fuel in use are shown in Figure 1.

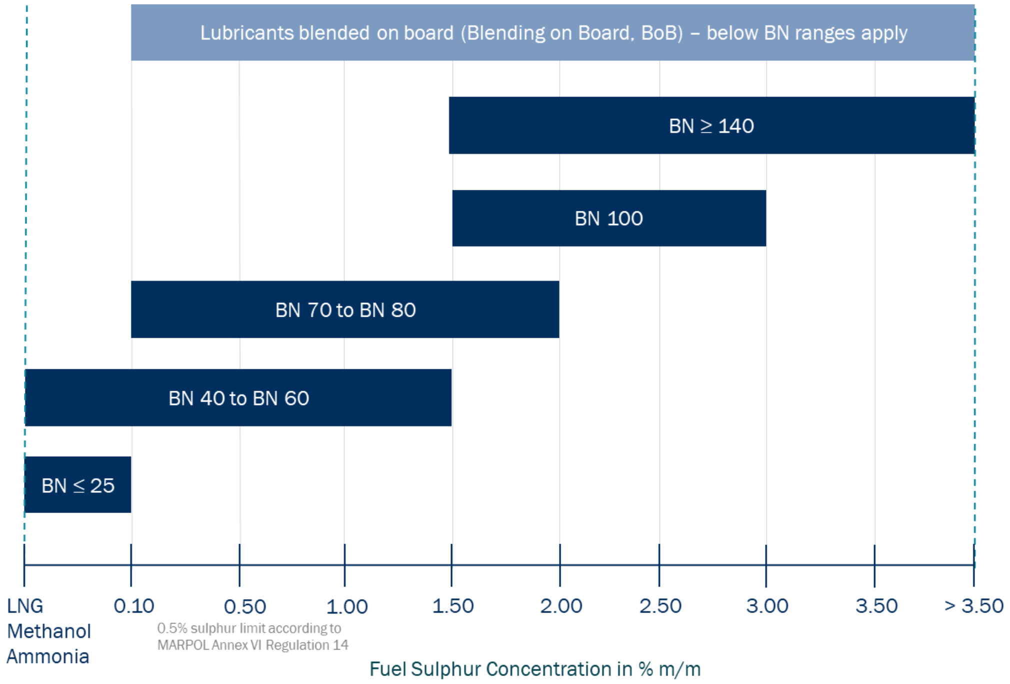

Figure 1 Selection of cylinder oil BN based on fuel in use

General guideline for cylinder lubricating oil selection

1. Choose a suitable BN range for cylinder lubricating oil based on the fuel in use.
2. Refer to the "List of validated cylinder lubricating oils" (Chapter 5.1) for cylinder oil selection.

Cylinder oil selection for LNG, methanol and ammonia

LNG, methanol and ammonia as fuel do not contain sulphur and possible acidic byproducts from their combustions can be considered weaker compared to sulphuric acid. Therefore, when operating on these fuels, no high BN lubricants are required. For a full list of validated lubricants that can be used for LNG, methanol and ammonia, see Chapter 5.1.

NOTE: Several X-DF engine types, burning alternative fuels, are still under development. Further information on lubrication of these engines will be released once the engines become commercially available.

Cylinder oil selection for biofuels

Regarding cylinder lubrication, biofuels and biofuel blends can be treated as liquid diesel fuels. Cylinder oil selection is based on the sulphur content of the biofuel or biofuel blend.

NOTE: For more information and guidelines on fuels for WinGD engines, refer to the WinGD Fuel Manual.

WinGD Fuel Manual
https://wingd.com/media/ijhk5xce/fuels.pdf

2.2 Cylinder oil sampling and analysis

The following chapter describes the cylinder oil sampling and analysis procedure. This procedure can be slightly different depending on the engine type and fuel in use. For more detailed information and safety instructions, please refer to the Instruction Manual of the engine.

NOTE: The engine must be in stable operation for 12 hours minimum before taking cylinder drain oil samples.

1. Sample pipe flushing:
   1.1. Close the ball valve (002, Figure 2) until enough oil is accumulated in the pipe. This typically takes 30 to 60 minutes and is strongly dependent on engine load and feed rate.
   1.2. Put a suitable container under the oil sample valve (001).
   1.3. Slowly open the oil sample valve (001) to flush out oil and possible dirt.
   1.4. Close the oil sample valve (001).
   1.5. Open the ball valve (002) to drain the remaining oil from the dirty oil pipe (003).
   1.6. Close the ball valve (002).
2. Drain oil sampling:
   2.1. Label the sample bottle with the cylinder number.
   2.2. Wait until enough oil is accumulated in the pipe. This typically takes 10 to 60 minutes and is strongly dependent on engine load and feed rate.
   2.3. Put the sample bottle under the oil sample valve (001).
   2.4. Slowly open the oil sample valve (001) to fill the sample bottle.
   2.5. Close the oil sample valve (001).
   2.6. Open the ball valve (002) to drain the oil in the dirty oil pipe (003).

NOTE: Step 1 followed by Step 2 must be repeated for each cylinder but can be done in parallel for all cylinders.

3. Fill out the oil analysis form with relevant engine data (e.g. operation conditions, fuel parameters, cylinder oil in use, feed rate).
4. On-board oil analysis tools: WinGD does not recommend specific tools to conduct on-board cylinder drain oil analysis. Tools can be freely chosen from any available supplier. However, the used tools must allow at minimum an analysis of the following parameters on-board:
   - residual BN
   - iron (Fe) concentration.

   Many oil suppliers offer their own tools and/or advanced services or recommend a specific supplier of on-board analysis tools. Therefore, WinGD recommends contacting the oil supplier for advice on which tools to be used for on-board cylinder drain oil analysis.
5. For interpretation of the oil analysis and recommendations based on the results, see Chapter 2.3 and Chapter 2.4.
6. Send the oil samples to a laboratory for an oil analysis.
7. Compare the oil analysis from the laboratory with the oil analysis from on-board. If the oil analyses are different, use the laboratory results (Step 5). In case of a continuous mismatch of results, contact your analysis tool supplier for advice or tool recalibration.

NOTE: On-board oil analysis is only used for immediate feedback. Always send samples for laboratory analysis to increase accuracy of the result.

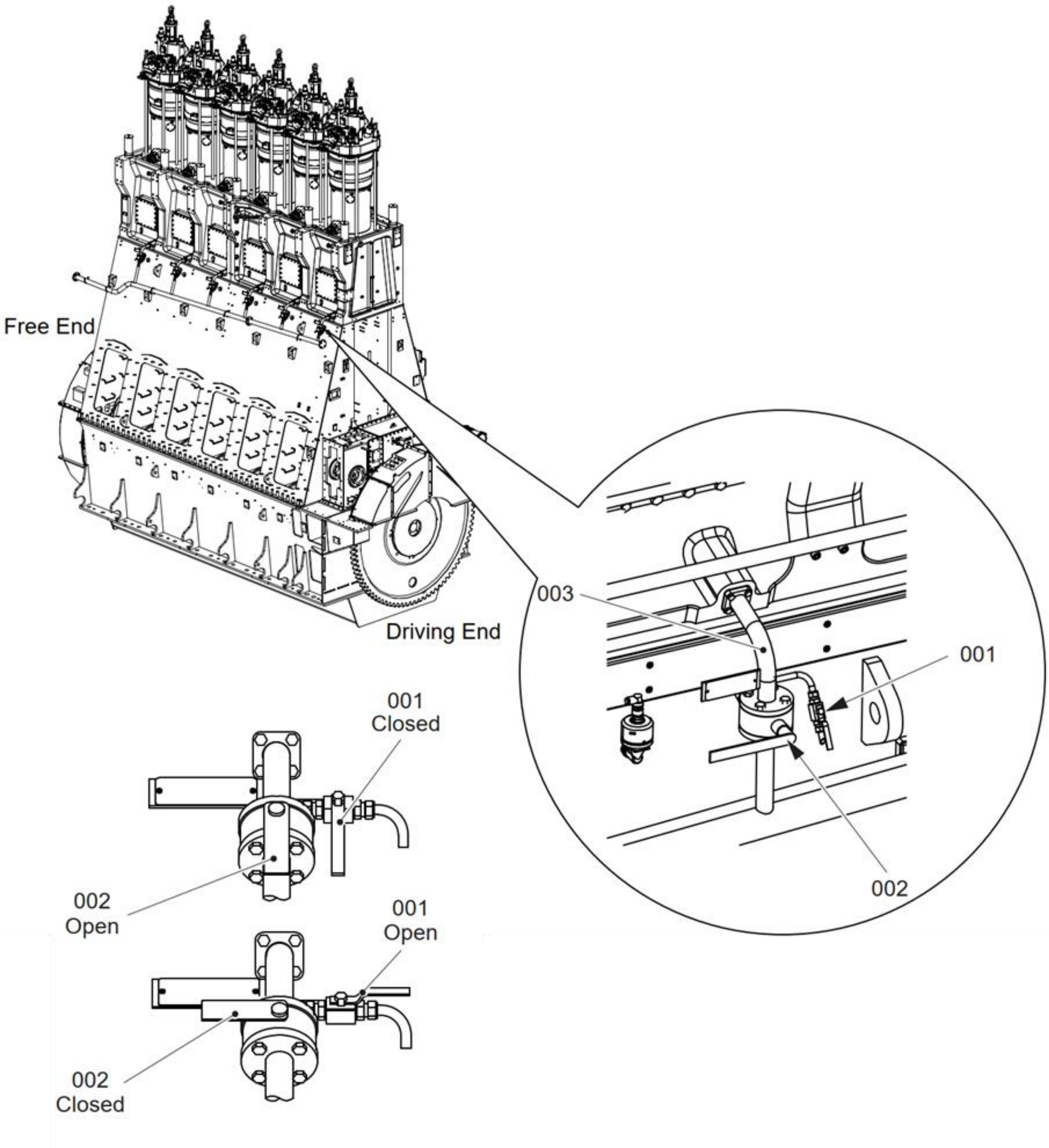

Figure 2: Location of ball valves (for used oil samples)

2.3 Interpretation of oil analysis results for cylinder oils

The interpretation of oil analysis results depends on the Base Number (BN) of the fresh cylinder oil in use. For cylinder lubricants with a BN<40, use the information provided in Chapter 2.3.1. When using a cylinder oil with a BN between 40 and 100 (including BN 40 and BN 100 cylinder oils), see Chapter 2.3.2. If cylinder oils with BN>100 are in use, use the information provided in Chapter 2.3.3.

NOTE: The recommended range of acceptable residual BN in the “Safe area” is based on the fresh BN range of the lubricant. This takes into account different requirements of the lubricants in terms of acid neutralisation ability. For different BN cylinder oils, different residual BN ranges can apply.

2.3.1 Interpretation of oil analysis for cylinder oils < BN 40

The applicable areas for the interpretation of the oil analysis when using cylinder oils with BN<40 are shown in Figure 3. This BN range includes, for example, all cylinder oils with BN 17 and BN 20.

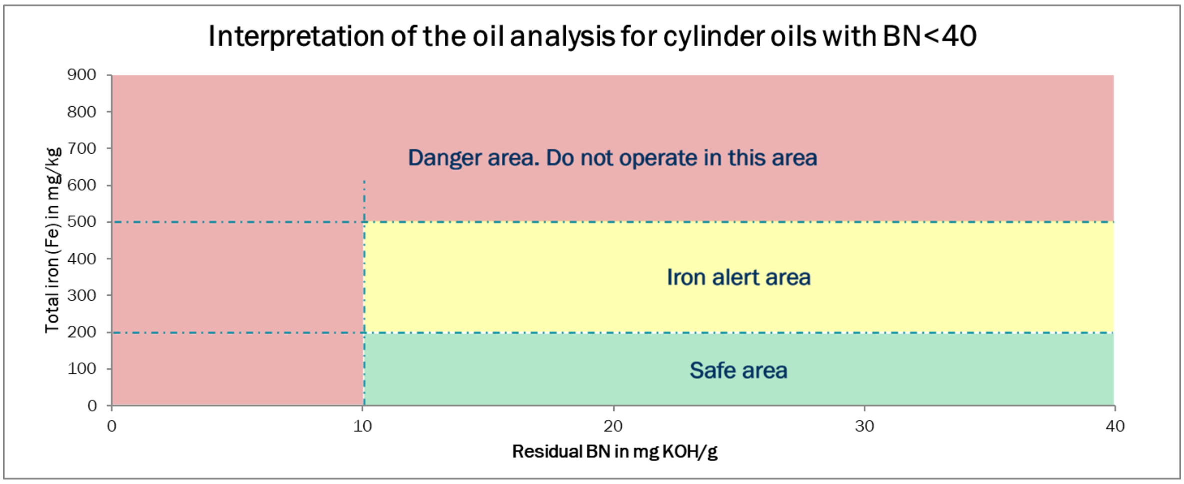

Figure 3 Interpretation of the oil analysis for cylinder oils < BN 40

Safe area

If the residual BN is 10 or higher and the iron (Fe) concentration is less than 200 mg/kg, the operation is considered safe.

Alert area

If the residual BN is 10 or higher and the iron (Fe) concentration is between 200 mg/kg and 500 mg/kg, damage of the piston running system can occur due to abrasive wear.

Danger area

If the residual BN is less than 10 and/or the iron (Fe) concentration is more than 500 mg/kg, excessive corrosion and/or abrasive wear can occur. Piston rings and cylinder liners can wear down quickly. The probability of scuffing is significantly increased when operating in such conditions. Do not operate the engine in these danger areas.

2.3.2 Interpretation of oil analysis for cylinder oils between BN 40 and BN 100

The applicable areas for the interpretation of the oil analysis when using cylinder oils between BN 40 and BN 100 are shown in Figure 4. This BN range includes, for example, all cylinder oils with BN 40, BN 50, BN 57, BN 70 and BN 100 as well as all cylinder oils in that BN range that are blended on board.

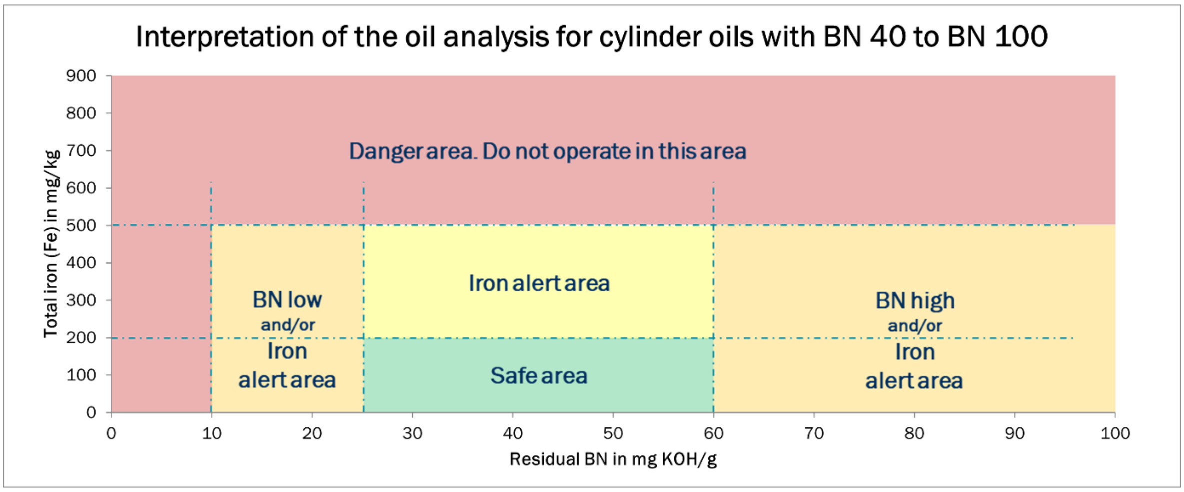

Figure 4 Interpretation of the oil analysis for cylinder oils between BN 40 and BN 100

Safe area

If the residual BN is between 25 and 60 and the iron (Fe) concentration is less than 200 mg/kg, the operation is considered safe.

Alert area

- The lower alert range for residual BN is between 10 and 25. In this area there is a risk of corrosion. Base additives in the cylinder oil can be insufficient to neutralise acidic products like sulphuric acid originating from fuel combustion.
- The upper alert range for residual BN is above 60. High residual BN can lead to excessive deposit formation, e.g. on the piston crown, particularly at high feed rates. Such deposits can lead to bore polishing and break down of the lubricant film and, thus, can cause damage to the piston running system.
- The alert range for the iron (Fe) concentration in the drain oil is between 200 mg/kg and 500 mg/kg. In this range there is an increased risk of abrasive or corrosive wear.

NOTE: Residual BN higher than fresh oil BN (e.g. 110%) is an indication of high thermal stress on the lubricant. Follow the recommendations on feed rate optimisation and consider using a lower BN lubricant to avoid excessive deposit formation and increased wear.

Danger area

If the residual BN is less than 10 and/or the iron (Fe) concentration is more than 500 mg/kg, excessive corrosion and/or abrasive wear can occur. Piston rings and cylinder liners can wear down quickly. The probability of scuffing is significantly increased when operating in such conditions. Do not operate the engine in these danger areas.

2.3.3 Interpretation of oil analysis for cylinder oils > BN 100

The applicable areas for the interpretation of the oil analysis when using cylinder oils with BN>100 are shown in Figure 5. This BN range includes, for example, all cylinder oils with BN 140 and BN 145 as well as all cylinder oils in that BN range that are blended on board.

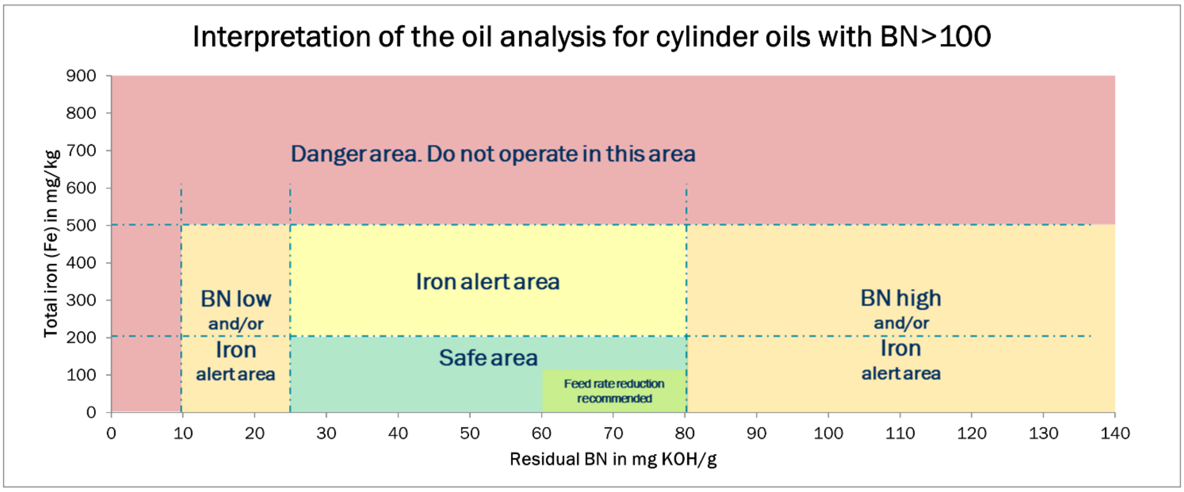

Figure 5 Interpretation of the oil analysis for cylinder oils > BN 100

Safe area

If the residual BN is between 25 and 80 and the iron (Fe) concentration is less than 200 mg/kg, the operation is considered safe.

NOTE: If the residual BN is between 60 and 80 and the iron (Fe) concentration is less than 100 mg/kg, it is highly recommended to keep the feed rate as low as possible to avoid deposit formation and wear.

Alert area

- The lower alert range for residual BN is between 10 and 25. In this area there is a risk of corrosion. Base additives in the cylinder oil can be insufficient to neutralise the sulphuric acid originating from fuel combustion.
- The upper alert range for residual BN is above 80. High residual BN can lead to excessive deposit formation, e.g. on the piston crown, particularly at high feed rates. Such deposits can lead to bore polishing and break down of the lubricant film and, thus, can cause damage to the piston running system.
- The alert range for the iron (Fe) concentration in the drain oil is between 200 mg/kg and 500 mg/kg. In this range there is an increased risk of abrasive or corrosive wear.

Danger area

If the residual BN is less than 10 and/or the iron (Fe) concentration is more than 500 mg/kg, excessive corrosion and/or abrasive wear can occur. Piston rings and cylinder liners can wear down quickly. The probability of scuffing is significantly increased when operating in such conditions. Do not operate the engine in these danger areas.

2.4 Feed rate optimisation

Based on the oil analysis the feed rate must be adjusted as follows:

1. If the analysis shows operation in the **Safe area**:
    a. Reduce the feed rate in steps of 0.05 g/kWh until a minimum feed rate of 0.6 g/kWh.
    b. Alternatively, keep the current feed rate.

NOTE: Reduction of the feed rate supports lowering the overall cylinder oil consumption. WinGD recommends reducing the feed rate (as described in option 1a.) as long as repeated oil analyses and visual inspections confirm safe engine operation. By following this recommendation, operational costs and environmental impact of the cylinder lubrication system can be minimised.

2. If the analysis shows operation in the **Alert area**:
    a. Adjust the feed rate to get into the Safe area. A change of cylinder oil BN can be required.
    b. Alternatively, the current feed rate can be kept unchanged. Monitor the situation by regular cylinder drain oil analysis and piston underside inspection.

3. If the analysis shows operation in the **Danger area**:
    a. Adjust the feed rate to get out of the Danger area.
    b. If the residual BN is too high, consider using a lower BN cylinder oil.
    c. If the residual BN is too low, consider using a higher BN cylinder oil.

NOTE: WinGD provides a tool for easier interpretation of the oil analysis and providing guidance regarding feed rate optimisation and cylinder oil BN selection. The tool can be downloaded from the WinGD website.

Table 1 Tool for interpretation of oil analysis

WinGD piston underside drain oil analysis tool - V3
https://wingd.com/media/pmgnkbov/wingd-piston-underside-drain-oil-analysis-tool-v3.xlsx

2.5 Effective feed rate

The cylinder lubricating feed rate is set in the engine control system and, therefore, referred to as set feed rate. The set feed rate is the specific cylinder lubricating feed rate for the engine operating at 100% R1 load. At part load operation and, depending on engine rating, even at 100% CMCR, a correction factor is applied to ensure enough cylinder oil is supplied. Thus, the effective feed rate is usually slightly higher than the set feed rate.

2.6 Switching Cylinder Lubricants

Switching to a different cylinder lubricant poses no concerns if the product is validated (see chapter 5.1) and suitable for the intended operation. Refer to the engine's instruction manual (IM) for detailed switching procedures and consult your oil supplier for a statement regarding compatibility. As a general recommendation, day tanks should be emptied as good as possible before switching, in order to avoid mixing different lubricant types, even when declared compatible.

2.7 Running-in of new components

After an overhaul with installation of new piston running components, WinGD recommends the running-in process given below. Proper running-in is crucial for the piston running system as it helps to achieve good surface contacts, to reduce initial wear and to ensure optimal long-term performance and reliability.

During running-in, the cylinder oil feed rate must be temporarily increased. As new components are running in, the feed rate can be stepwise reduced over a time of 72 operation hours. Inspections of the newly installed piston running components after 24 hours and after 72 hours of engine operation are recommended. The entire running-in process is visualised in Figure 6. Apart from vessel specific default protocols, no special loading up or load limitations are required during running-in of new components.

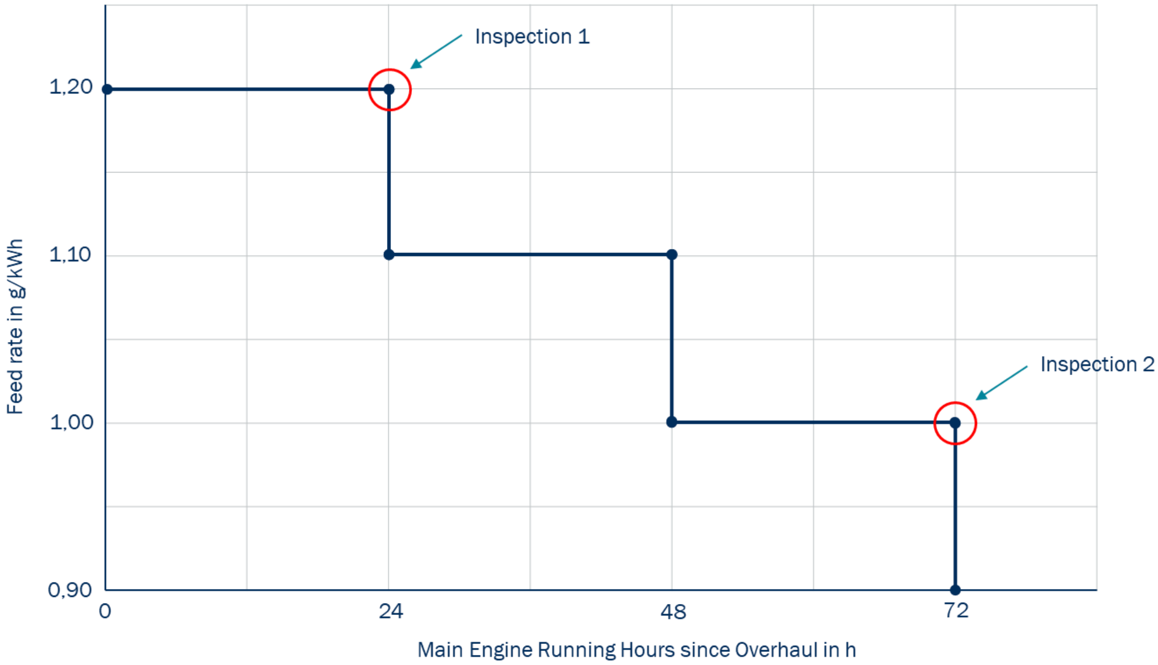

Figure 6 Feed rate adjustments for running-in

1. Set the cylinder oil feed rate to 1.2 g/kWh for all cylinders with newly installed components.
2. Operate the engine for 24 hours.
3. Inspect the piston running components for any damages.[1]
4. Set the feed rate to 1.1 g/kWh.[2]
5. Operate the engine for 24 hours.
6. Set the feed rate to 1.0 g/kWh.[2]
7. Operate the engine for 24 hours.
8. Inspect the piston running components for any damages.[1]
9. Set the feed rate to 0.9 g/kWh. [2, 3] End of running-in process.

[1] If any damage occurs during an inspection, find the cause and repair the fault. Restart the running-in process with Step 1.

[2] If the original feed rate before installation of the new components was higher than this value, the feed rate must not be reduced below the original feed rate for the duration of the running-in process. You can adjust the feed rate according to the procedures described in Chapters 2 to 2.4 after the running-in process is completed.

[3] At the end of the running-in process you can directly set the feed rate back to the original value (if below 0.9 g/kWh) used before the installation of the new components.

3 System oils

System oil is an essential component for system lubrication, the hydraulic system and for component cooling. It contributes to stable engine operation, clean components and enables long overhaul intervals.

The main functions of the system oil are:

- lubrication of bearings, the crosshead and other powertrain components
- cooling of pistons, vibration dampers and other components
- keeping powertrain components and the piston cooling system clean and free from deposits
- system oil used as hydraulic fluid in the servo oil system.

In contrast to cylinder oil, system oil is circulated and used over a longer period. Therefore, certain limits apply to system oil to prevent excessive ageing and loss of performance of the lubricant over time. For system oil limits, see Chapter 3.3

System oil: WinGD recommendation

Only validated system oils can be used on WinGD engines. An overview of currently validated system oils can be found in Chapter 5.1. The kinematic viscosity of the validated system oils is typically in the range of the SAE 30 viscosity grade. The alkalinity, represented by the Base Number (BN) of the system oil, is independent of the fuel in use. Validated system oils have a minimum BN of 5 mg KOH/g. To enable and maintain good performance of the system oil, WinGD recommends the following process:

1. Select a validated system oil (see Chapter 5.1).
2. Take a system oil sample and send it to a laboratory for analysis[1] (see Chapter 3.2).
3. Interpret the analysis results based on the system oil limits, (see Chapter 3.3 and Chapter 0).
4. Do system oil maintenance (see Chapter 3.5).
5. WinGD recommends repeating steps 2 to 4 on a regular basis:
   - every 3000 hours of engine operation or every 6 months[2] for regular system oil analysis, and
   - an additional FZG gear oil test and particle count analysis (see Chapter 3.3) every 6000 hours of engine operation or every 12 months[2].

NOTE: It is recommended to store the data from the oil analyses.

3.1 System oil selection

The selection of system oil is independent from the fuel in use and its sulphur content. System oils can be freely chosen from the list of validated engine oils (see Chapter 5.1). The BN of fresh system oils is typically between BN 5 and BN 9 to neutralise acidic byproducts that can enter the system oil e.g. from the scavenge air space or originate from system oil degradation (e.g. oxidation). It is not needed to choose a certain system oil BN based on engine type, fuel in use or operating conditions. Thus, system oil can be chosen based on available supply, commercial aspects etc.

NOTE: Before mixing different system oils, contact your oil supplier for advice on compatibility.

[1] For regular system oil analysis, a sample volume of 100 ml is required. For the additional combined FZG gear oil test and particle count analysis, an additional sample volume of 5 l is required.
[2] Whichever occurs first.

3.2 System oil sampling and analysis

The following chapter describes the system oil sampling and analysis procedure. This procedure can be slightly different depending on engine type and fuel in use. For more detailed information and safety instructions, please refer to the Instruction Manual of the engine.

NOTE: Before taking samples, the oil pump must be running, and the system oil must be at operating temperature.

1. Sample pipe flushing:
   1.1. Put a suitable container under the system oil sample valve.
   1.2. Open the sample valve to flush out oil and possible dirt.
   1.3. Close the sample valve.

NOTE: Use the sampling point at the engine inlet for drain oil sampling. If the engine is equipped with a servo oil filter and the analysis shows unusual values, use the sampling point after the servo oil filter instead.

2. Drain oil sampling:
   2.1. Put a sample bottle under the system oil sample valve.
   2.2. Open the sample valve and fully fill the sample bottle.
   2.3. Close the sample valve.
   2.4. Close the sample bottle.
3. Label the sample bottle:
   - vessel name
   - engine type and serial number
   - sampling date
   - location of the sampling point
   - operating hours of the oil and main engine running hours
   - brand and type of the system oil in use.
4. Send the oil samples to a laboratory for an oil analysis.
5. Follow the process described on the previous page for interpretation of analysis results and proper system oil maintenance.

3.3 System oil limits

System oil is circulated and used over a longer period. Therefore, certain limits apply to system oil to prevent excessive ageing and loss of performance of the lubricant over time. System oil limits are listed in Table 2. Alert limits indicate potential impending problems and allow a certain amount of time to react. If condemnation limits are reached, immediate action is required to prevent the engine from damage. Use these limits as a guide. It is not possible to estimate the condition of the system oil by a single parameter. Analysis of different parameters usually allows to locate occurring issues.

Table 2 Alert and condemnation limits for system oil

Regular system oil analysis				
Parameter	**Alert limit**	**Condemnation limit**	**Unit**	**Test method**
Viscosity at 40 °C	min. 95	min. 90	mm²/s (cSt)	ASTM D 445
	max. 140	max. 150	mm²/s (cSt)	ASTM D 445
Flash point	min. 200	min. 180	°C	ASTM D 93
Total insoluble materials	max. 0.7	max. 1.0	mass-%	ASTM D 893b
Base Number	max. 12	max. 15	mg KOH/g	ASTM D 2896
Water content	max. 0.20	max. 0.30	mass-%	ASTM D 95 or ASTM D 1744
Strong Acid Number	0.0	0.0	mg KOH/g	ASTM D 664
Calcium	-	max. 6000	mg/kg (ppm)	ICP
Zinc	-	min. 100	mg/kg (ppm)	ICP
Phosphorus	-	min. 100	mg/kg (ppm)	ICP
FZG gear oil test				
Parameter	**Alert limit**	**Condemnation limit**	**Unit**	**Test method**
FZG gear oil test	Minimum failure load stage (FLS) 9	Minimum failure load stage (FLS) 8	-	A/8.3/90 (ISO 14635-1)
Particle count limits				
Parameter	**Alert limit**	**Condemnation limit**	**Unit**	**Test method**
Particles $R_4/R_6/R_{14}$	-	max. --/20/17	-	ASTM D7647 (ISO4407, ISO11500)
Large Particles >14 µm		see 3.3.1		ASTM D7647 (ISO4407, ISO11500)

NOTE: If FAME or FAME blends are used as fuel, there is a risk of system oil being contaminated with FAME. In addition to system oil limits mentioned above, it is advised to check for increased sludge formation in the oil system. An increase of sludge formation can indicate FAME contamination of the system oil.

NOTE: Particle counting shall preferably be performed according to ASTM D7647, which is specifically designed for accurate measurement in used, dark, or heavily additised oils. ISO 4407 and ISO 11500 are acceptable as alternative methods. If particle counts are close to specified limits or show unexpected changes, it is strongly recommended to confirm the results using ISO 4407, as it is the most accurate and discriminating method. Laboratories should ensure that sample handling and preparation steps are suited to the chosen method, especially when using ISO 11500.

3.3.1 Particle limits

Abrasive particles in the system oil can cause wear on several parts of the engine and in the hydraulic system. Therefore, the number of particles in the system oil is limited. In addition to the absolute number of particles, also the particle size can influence the system oil performance. Larger particles show higher impact compared to smaller particles. Thus, the allowed particle count depends on the size of the particles with bigger particles being more limited compared to smaller particles. For particle classes up to 14 µm, the ISO 4406 specification is used. The different particle classes and applied limits are shown in Table 2.

WinGD recommends the following limits for particle count in 100 ml system oil:

Small Particles:

ISO 4406 max. --/20/17

- Particles <6 µm: no limits
- Particles >6 µm (R_6): max. 1.000.000 particles (ISO 4406 class 20 maximum)
- Particles >14 µm (R_{14}): max. 130.000 particles (ISO 4406 class 17 maximum)

Medium and Large Particles:

In addition to ISO 4406 limits, larger particle counts must remain below the following thresholds:

- Particles >20 µm: max. 8000 particles
- Particles >50 µm: max. 130 particles
- Particles >100 µm: max. 3 particles

To accommodate different laboratory reporting capabilities, the following functionally equivalent thresholds are also accepted:

- Particles >21 µm: max. 8000 particles
- Particles >38 µm: max. 575 particles
- Particles >70 µm: max. 31 particles

NOTE: It is sufficient to meet either the original (>20 µm, >50 µm, >100 µm) or the alternative (>21 µm, >38 µm, >70 µm) thresholds. This flexibility is intended to simplify implementation without compromising control of wear-critical particles.

NOTE: Previously used specifications NAS 1638 and SAE AS 4059 are no longer applicable.

3.4 Interpretation of analysis results for system oils

Exceeding one or multiple limits given in Table 2 typically indicates an issue in the oil system. Depending on the parameter(s) that are exceeding limits, different types of damages can be observed. Some common issues are listed in this Chapter, but WinGD recommends contacting the system oil supplier if limits are exceeded for further advice.

The following countermeasures can help to get the system oil values back to normal conditions. However, WinGD recommends to also analyse the origin for exceeding system oil limits and, if necessary, repair occurring damages.

- Increase the purification in the separator by adjusting the flow rate and/or the temperature.
- Treat the system oil in a renovating or settling tank.
- (Partially) replenish the system oil.

3.4.1 High Base Number

If the BN of the system oil exceeds the limit values given in Table 2, check all piston rod gland boxes and the piston rod conditions. Repair damaged gland boxes and replace worn sealing rings.

NOTE: Slight increase of the system oil BN is typically expected compared to the BN of fresh system oil in use. If the BN of the system oil is not increasing over time, this can indicate that the system oil consumption is low. A normal level of system oil consumption and replenishment is necessary to keep the system oil in good condition by regularly adding fresh system oil.

3.4.2 Low flash point

Decrease of the flash point below the limit values given in Table 2 indicates fuel contamination of the system oil. It is recommended to identify the origin of the contamination and to stop the leakage. Partially replenish the system oil to increase the flash point above the limits.

3.4.3 High particle count

If particle numbers increase above the limits shown in Chapter 3.3.1, the following procedures must be done:

- Check the centrifugal separator. Adjust the flow rate and/or the temperature to increase the efficiency of the centrifugal separator. Refer to the manuals of the manufacturer of the separator for additional advice.
- Check all piston rod gland boxes. Repair damaged gland boxes and replace worn sealing rings.
- For engines with servo oil filter: Check the servo oil filter. Repair damaged filters or replace the filter element.
- Do an elemental analysis of the particles. This analysis can indicate the origin of the particles and can be tracked back to certain damaged engine components. Repair the related components.
- Replenish the system oil. In most cases, a partial replenishment is sufficient, but some scenarios can require a complete exchange of the system oil.

Once the origin of the particle contamination is resolved and the system oil is (partially) replenished, it is recommended to do another system oil particle count analysis to ensure oil quality within the given limits. This prevents components from damage originating from abrasive particles.

3.5 System oil maintenance

WinGD recommends installing a self-cleaning centrifugal separator in the oil system to keep the system oil in good condition for a long period of time.

- There is a risk that (sea) water can enter the system oil and cause corrosion of engine parts. Water contamination can also cause bacterial contamination of the system oil, which causes decrease in lubrication performance and heavy corrosion of engine parts. Thus, solid contaminants (dirt) and water must be removed from the system oil as completely and as frequently as possible.
- The self-cleaning centrifugal separator is used as a purifier in bypass mode. The oil flows from the oil tank through the centrifugal separator. Set the oil flow through the centrifugal separator according to the recommendations of the centrifugal separator manufacturer. Unless the manufacturer of the centrifugal separator recommends differently, WinGD recommends oil temperature of 95 °C for this treatment.

3.6 Running-in of new or polished gear wheels

The FZG gear oil test indicates the lubrication and wear protection properties of the system oil. Especially if a new gear wheel has been installed, or if a gear wheel has been polished, it is important that the FZG load stage is at a satisfactory level. This is to prevent scuffing of the gear wheels during running-in. Therefore, WinGD recommends ensuring no alarm or condemnation limit (see Chapter 3.3) is exceeded before the running-in. As the FZG gear oil test is typically only done every 6000 hours of engine operation or approximately once a year, it can make sense to perform an additional FZG gear oil test before the running-in. This is especially recommended if the last FZG gear oil test was done more than 6 months ago, if the values of the previous tests showed alarm or close to alarm values, or if the vessel history indicates regular falling below FZG load stage limits. If the alert or condemnation value is exceeded, a partial replenishment of the system oil is recommended before running-in.

4 Other oils and lubricants

Several other oils and lubricants are required for operating WinGD engines.

Turbocharger

System oil is usually used for turbocharger lubrication. However, in some installations, a separate oil circuit is used. Refer to the recommendations in the turbocharger instruction manual.

Turning gear

Refer to the recommendations in the instruction manual of the turning gear manufacturer for advice on turning gear lubricant selection and maintenance.

Flywheel and pinion gear teeth

Recommended lubricants for flywheel and pinion gear teeth are listed in Chapter 5.2. These lubricants have been validated by WinGD. However, there can be additional suitable lubricants available. Contact your lubricant supplier for advice on possible products.

Environmentally Acceptable Lubricants

Environmentally Acceptable Lubricants (EALs) are required in several areas (e.g. U.S. waters) or ports to minimize the environmental impact. These lubricants are intended for all oil-to-sea interfaces, e.g. stern tubes, thrusters, rudders, stabilizers, variable pitch propellers, underwater ropes, machinery and underwater transmissions.

EALs are produced with base oils and additives that differ from those used for system oils and cylinder oils. Thus, EALs must not be mixed with system oils or cylinder oils. Contamination of EALs in system oil or cylinder oil can cause severe issues, like damages of some type of sealings, water emulsification or deposit formation in areas of high temperature.

5 Validated engine oils for WinGD engines

Use only lubricants that comply with the general WinGD lubricant specifications. Follow the recommendations for the use of these lubricants described in the “Operation” chapter of the Instruction Manual.

The lubricant supplier assumes all responsibility for the performance of the used lubricants to the exclusion of any liability of WinGD. The lubricant supplier and any other manufacturers and distributors of the relevant products must indemnify WinGD against all claims, damages and losses caused using their lubricants.

5.1 List of cylinder oils and system oils

Validated cylinder oils and system oils are listed in the document “Validated engine oils for WinGD engines”. This list is updated on a regular basis. Therefore, WinGD recommends to always use the latest version available online and accessible through the WinGD website as shown in Table 3.

Table 3 List of validated cylinder oils, blending on board additives and system oils

The up-to-date list of validated engine oils
https://wingd.com/media/watb1kkz/validated-engine-oils-for-wingd-engines_v17.pdf

5.2 List of lubricants for flywheel and pinion gear teeth

Validated lubricants for flywheel and pinion gear teeth are listed in Table 4.

Table 4 List of lubricants for flywheel and pinion gear teeth

Supplier	Brand
Lubrication Engineers Inc.	LE 5182 PYROSHIELD
Klüber Lubrication München KG	Klüberfluid C-F 3 ULTRA