

Cooling water treatment and analysing

Information to Operators and Owners of concerned installations

For your information

Concerned engines / components

This bulletin is valid for following Wärtsilä engine types:

- Vasa 14, 14T, 14TK, 24TS
- Vasa 22ABC 22HF, 22MD, 22/26
- Vasa 32, 32LN
- Wärtsilä 20, 20DF
- Wärtsilä 32, 32DF, 32GD, 32LN GD
- Wärtsilä 34DF, 34LPG, 34SG
- Wärtsilä 46, 46GD, 46F
- Wärtsilä 50, 50DF, 50SG

Reference

19 Cooling water system

Introduction / Background

Correct cooling water treatment and follow-up of the cooling water condition are of utmost importance for keeping the cooling water systems of the engines in good condition.

Validity / Issue

Until further notice. Replacing issue 06 dated 25-Oct-2013.

Note

Main changes is in issue 7:

- Added information about alternative cooling water treatment system, Wärtsilä Water Conditioner Unit (WWCU).

Background

Correct cooling water treatment and follow-up of the cooling water condition are of utmost importance for keeping the cooling water systems of the engines in good condition. The corrosion processes that could occur due to a bad cooling water quality may under certain circumstances be local and by their nature proceed very rapidly. This may cause unexpected operating problems or engine failures even within relatively short periods of time, for example in the cylinder head exhaust valve seat pockets and other areas prone to corrosion (see further comments in the “Worth noticing” chapter below) in the cooling water systems of the engines.

Most of the cooling water additives which are approved by Wärtsilä are nitrite based (typically NaNO_2) and today the majority of the installations in operation are also using nitrite based additives. Although there is a trend towards more environmentally friendly alternatives. These operating instructions and recommendations are mainly intended for installations using nitrite based additives but certainly contain useful information also for users of other types of additives.

Purpose

To avoid unnecessary corrosion damages and operating problems in the cooling water systems of the engines.

Instructions & Recommendations

Raw water quality

The raw water quality for the cooling water circuits of an engine must meet the following specification:

Table 1, Raw water quality

Property	Unit	Limits for chemical use	Limits for WWCU ¹⁾ use	Test method reference
pH ¹⁾	-	6.5 - 8.5	6.5 - 8.5	ASTM D 1287 or D 1293
Hardness	°dH	Max. 10	Max. 10	ASTM D 1126
Chlorides ¹⁾	mg/l	Max. 80	Max. 40	ASTM D 512 or D 4327
Sulphates	mg/l	Max. 150	Max. 100	ASTM D 516 or D 4327

¹⁾ Wärtsilä Water Conditioner Unit

¹⁾ If a Reverse Osmosis (RO) process is used, min. limit for pH is 6.0 based on the RO process operational principle. The use of water originating from RO process further presumes that a max. content of 80 mg/l for chloride content is achieved.

Soft waters (like distilled, ion exchanged, reverse osmosis and rain water) with a total hardness close to 0 °dH (German degrees) have the ability to dissolve oxygen and carbon dioxide from the air, which quite rapidly lowers the pH levels and increases the corrosive effect of these waters.

Suitable amounts of calcium and magnesium compounds (= total hardness) participates in forming a thin, corrosion protective layer on the heat exchanging surfaces of the cooling water system. Correct additive dosage and careful follow up of the dosing levels are thus even more important with a very soft water compared to a normal quality tap/drinking water with a total hardness of 2 – 10 °dH.

The use of raw water qualities with a too high total hardness may on the other hand result in excessive deposit formations and reduced heat transfer properties. Water produced by one (1) stage reverse osmosis processes may sometimes contain too high chloride (and sulphates) contents, and are in those cases not suitable as cooling water. Two (2) stage RO processes usually achieve satisfactory chloride and sulphate levels.

Additive dosing

The cooling water additive dosage recommendations may vary, depending on additive type and manufacturer. The dosage recommendations for the cooling water additives approved by Wärtsilä are presented in Table 5. There exists no general dosage recommendation for the approved additives. Observe that these recommendations apply for normal raw/cooling water properties, see also the “Worth noticing” comments below. Generally a slight overdosing is better than under dosing, but an excessive additive (nitrite) dosage is not to be recommended economically, or technically. Large (> 2 – 3 times the maximum recommendation) overdosing may cause corrosion on copper, brass and other “soft alloys” in the system and possibly also problems with precipitation and deposit formations.

Table 5 presents the currently approved cooling water treatment products, their suppliers of these and the dosage recommendations.

Worth noticing

Aggressive compounds and conditions

Sulphates, sulphides, halides and especially chlorides are extremely aggressive (corrosive) against iron. If there are high amounts of these aggressive ions present in the cooling water system the nitrite dosage should be increased accordingly. The recommendations vary slightly between different additive manufacturers but for increased chloride and sulphate contents the following formulas could be used as rules of thumb:

- Add 100 mg/l of nitrite (NO_2) / 10 mg/l of chlorides (Cl), for Cl > 50 mg/l.
- Add 100 mg/l of nitrite (NO_2) / 50 mg/l of sulphates (SO_4), for SO_4 > 150 mg/l.

It is strongly recommended to change the cooling water immediately if the chloride content of the water exceeds 200 mg/l and if the sulphate content exceeds 400 mg/l.

The nitrite oxidation curve in Figure 1 shows a schematic graph of the corrosion rate as a function of the nitrite dosage. Observe that the position of the curve peak on the x-axis (= dangerous condition for corrosion) is not stable, but will shift depending on several external conditions in the cooling water: temperature, pH, chlorides and sulphates contents, etc. That is, if the chloride content of the cooling water is increased the additive (nitrite) dosage also has to be increased in order to avoid the conditions of increased corrosion rate.

Nitrite oxidation curve

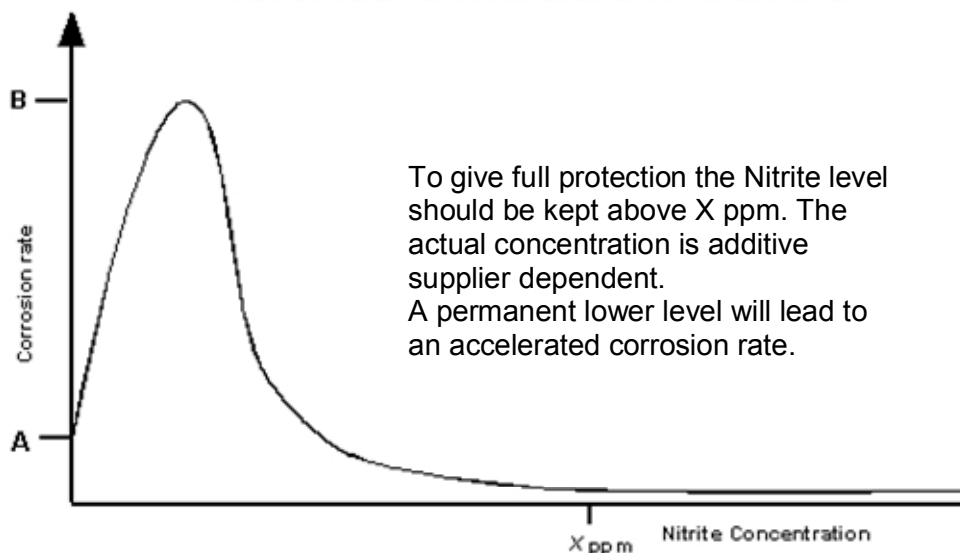


Figure 1, Corrosion rate as a function of the nitrite concentration

Chlorides and other corrosive ions additionally have the tendency to concentrate in cracks, under deposits etc. and may there reach considerably higher concentrations than in the "bulk phase". It is thus extremely important that all the surfaces of the system are cleaned properly before the corrosion protection additive is added to the system. Both fats/oils/greases and scale/rust should be properly removed. There are cleaning products available on the market that combines or can be combined to provide both degreasing and descaling properties, for example the environmentally friendly BioCleaner products provided by Wärtsilä.

Additive characteristics

Nitrite based cooling water additives are so called anodic inhibitors and require proper dosing and maintenance in order to protect as intended. The nitrite of the additive is as such a salt and it will increase the electrical conductivity of the water. The conductivity is on the other hand one of the main parameters affecting the corrosion rate if a corrosion process gets started: the higher the conductivity the higher the corrosion rate. If the conditions (nitrite level, chlorides, pH, etc.) in the systems are such that the additive (nitrite based) is no longer able to protect the entire surface of the system there may occur a rapid, local (pitting) corrosion in the areas that are not protected. The corrosion rate at the attacked areas will even be much greater than it would be with no additive at all present in the system.

Sensitive areas for corrosion would typically be:

- In crevices and under deposits.
- Areas of very low flow (the inhibitor is not properly taken to the metal surface).
- Areas of turbulent flow, such as a change of pipe cross-section, where a proper protective film formation is more difficult to achieve.
- Areas that are typical problem areas for corrosion such as: welded sections, combinations of dissimilar metals, areas of increased mechanical stress, etc.

Powder form products

Nitrite based cooling water additives in powder form should be dissolved properly in water before adding to the system. In order to avoid possible dissolving problems resulting in under dosing, ensure sufficient mixing of the powder and the water in the maintenance tank.

Prolonged stops and mechanical design

During possible prolonged stops (> several months) of the engine it is recommended to apply proper circulation of the cooling water once in a while and to keep the additive (nitrite) dosage at least at the maximum recommended level and preferably at 1.5 times the normal dosage.

It is also worth noticing that the mechanical design of the cooling water system (venting pipes to the expansion tank, expansion tank, air separator, etc.) must be according to the recommendations and specifications in order to avoid corrosion (cavitation) and other operational problems.

Analysing and typical levels

It is recommended to perform cooling water analysis, for example with test kits provided by the additive manufacturer, once (1) a week. The additive concentration may decrease quite rapidly, especially in the beginning after the initial dosing of a new or thoroughly cleaned system. When the properties of the cooling water are found to be stabilised the analysis interval may, under normal conditions gradually be prolonged, for example to 2 – 4 weeks.

It is also recommended to perform a more complete cooling water analysis 2 – 4 times / year to check that the test kit analysis results are on a correct level and also to be able to make a more complete cooling water condition evaluation. When samples are taken and sent for analysis the sample bottles should be filled up totally to minimize the amount of air that is left in the bottle, a suitable sample amount is 1 litre. The cooling water samples should be taken from circulating water. Remember to flush sampling pipes and valves properly before taking the sample for analysis. The samples should also be kept cool and in a dark place during transportation and storage before the analysing. If special sample bottles are not available the best alternative is an empty, clean mineral water bottle, since these are most likely free from bacteria and other contaminants.

Water and cooling water samples should be analysed as soon as possible, preferably within a week, after sampling. Some of the properties/compounds (pH, sulphates and iron for example) of the water may react or precipitate in the sample bottle and result in false results.

Table 2 below shows typical/guidance values for the cooling water analysis that should be checked regularly (weekly). Observe that the values in Table 2 are not absolute “maximum or minimum allowed” levels. Sudden changes in the trends of the analysed properties should always be investigated and possible malfunctions and faults in the systems corrected.

Table 2, Regularly (weekly) controlled cooling water properties

Property	Typical level
pH	8 – 11
Nitrite (NO ₂)	500 – 2500 ^{*)} ppm
Chlorides (Cl)	< 40 mg/l
Sulphates (SO ₄)	< 100 mg/l

^{*)} Depending on additive type and manufacturer.

Table 3 presents typical/guidance values for the additional properties that should be performed during the more complete cooling water analysis, performed 2 – 4 times / year. Additional analysis may naturally be considered from case to case, if some special problems have occurred.

Table 3, Additional properties that should be checked 2 – 4 times / year

Property	Typical level
Iron (Fe)	< 1 mg/l ¹⁾
Nitrate (NO ₃)	< ≈ 200 mg/l ²⁾
Calcium (Ca)	The total hardness (Ca + Mg) < 10 °dH ³⁾
Magnesium (Mg)	
Copper (Cu)	< 1 mg/l

¹⁾ The iron levels may be higher in new or recently overhauled systems, due to presence of smaller amounts of machining and installation debris, etc. These “initially high” iron contents should however gradually decrease to the typical levels. Observe that the total iron contents should be analysed not dissolved iron.

²⁾ Constantly/rapidly increasing nitrate (NO₃) levels, especially in combination with simultaneously decreasing nitrite (NO₂) levels, indicate presence of possible bacterial/microbial activity in the systems. Bacterial contamination may come for example from salt water or some other dirty water contamination of the system.

³⁾ A total hardness of 10 °dH (German degrees) ↔ 178 mg/l (as CaCO₃) and Mg = 4.3 mg/l ↔ 1 °dH and Ca = 7.1 mg/l ↔ 1 °dH.

Alternative cooling water treatment additives and treatment systems

The Havoline XLi, Q8 Corrosion Inhibitor Long Life, WT Supra and Cooltreat AL are more environmentally friendly alternatives to the traditional, nitrite based cooling water additives.

As an alternative to the validated cooling water additives, the Wärtsilä Water Conditioner Unit (WWCU) can also be used to treat cooling water of engines' closed water circuits. WWCU is based on the Enwamatic EMM cooling water treatment system, but includes a number of new features based on Wärtsilä design. The WWCU protects the engine from corrosion without any chemicals. It acts as a side stream filtration and water treatment unit and includes the following functions: corrosion protection, scale control, filtration, control of bacterial growth and air separation. The stricter raw water quality requirements compared to what is specified when cooling water additives are used shall be taken into account, see Table 1. Due to a severe corrosion risk WWCU cannot be used in the cooling water systems containing aluminium or aluminium alloys as a construction material.

The WWCU can be a sensible alternative for the installations in which environmentally friendly solutions are appreciated.

The assembly, installation, operation and maintenance instructions of Wärtsilä shall always be followed. The contact details are included in the following table.

Table 4, Contact details, WWCU

Distributor	Manufacturer	Treatment system
Wärtsilä Finland Oyj Services Tarhaajantie 2 FI-65380 Vaasa Finland	Enwa AS PO Box 257 Forus N-4066 Stavanger Norway	Wärtsilä Water Conditioner Unit (WWCU)

Use of glycol

If a freezing risk exists, glycol needs to be added to cooling water. Since glycol alone does not protect the engine and cooling water system against corrosion, additionally an approved cooling water additive must always be used. All approved cooling water additives are compatible with glycol.

Ready-to-use mixtures containing both glycol and corrosion inhibitors are not allowed to use, since those are normally designed to be used as strong (30 –) 50% / 50% mixtures. However, in Wärtsilä engines normally a much lower glycol amount is adequate to protect the cooling water system against freezing. But when decreasing the glycol amount, simultaneously also the concentration of corrosion inhibitors will decrease to too low level resulting in an increased risk of corrosion.

The amount of glycol in closed cooling water system shall always be minimized since heat transfer of water containing glycol has deteriorated significantly. The engine may therefore be subject to additional output derating when using glycol in the cooling water.

There are commercially available two types of glycol qualities, monopropylene glycol (MPG) and monoethyleneglycol (MEG). So called industrial qualities of both glycol types can be used, but MPG is considered to be a more environmental alternative.

Mixing of different cooling water additives

Different cooling water additives shall not be mixed with each other, but if it is desired to start to use another cooling water additive, the one being used shall be drained from the system before filling with another product. If the cooling water system is dirty, it shall be flushed with good quality water or if needed use additionally chemicals to remove possible deposits, like grease, oil, rust, etc. Though many cooling water additives are chemically compatible with each other, those can contain e.g. polymers starting to loosen existing deposits from cooling water system, which can then drift in the system and attach to engine component surfaces, e.g. cylinder head and cause there detrimental effects in terms of heat transfer decline, clogging of small diameter water channels and deposit formation leading to corrosion.

Table 5, Approved cooling water additives, suppliers and dosage recommendations (for normal conditions)

Product designation	Dosage per 1 m ³ of system capacity	Concentration of active corrosion inhibitor
Diaprosim RD11 (RD11M)	5 kg	1250 ppm as NO ₂
XL Corrosion Inhibitor Concentrate	50 - 100 litres	1.8 - 3.7 Brix° of active compounds measured with a supplier's refractometer
Drewgard 4109	16 - 30 litres	640 - 1200 ppm as NO ₂
Liquidewt	8 - 12 litres	470 - 700 ppm as NO ₂
Maxigard	16 - 30 litres	640 - 1200 ppm as NO ₂
Havoline XLI	50 - 100 litres	1.8 - 3.7 Brix° of active compounds measured with a supplier's refractometer
Corrshield NT 4293	10 litres	670 - 1000 ppm as NO ₂
Corrshield NT 4200	10 litres	670 - 1000 ppm as NO ₂
Pekar J	20 litres	30 ppm as Mo
Q8 Corrosion Inhibitor Long-Life	50 - 100 litres	1.8 - 3.7 Brix° of active compounds measured with a supplier's refractometer
Caretreat 2 Diesel	6 - 10 litres	1500 - 2500 ppm as NO ₂
Marisol CW	6 - 9 litres	1000 - 1500 ppm as NO ₂
TRAC102	32 - 48 litres	1000 - 1500 ppm as NO ₂
TRAC118	2.25 - 3.4 litres	670 - 1000 ppm as NO ₂
WT Supra	50 - 100 litres	1.8 - 3.7 Brix° of active compounds measured with a supplier's refractometer
Cool Treat NCLT (ex-Vecom CWT Diesel QC-2)	6 - 10 litres	1500 - 2500 ppm as NO ₂
Dieselguard NB	2.0 - 4.8 kg	1000 - 2400 ppm as NO ₂
Rocor NB Liquid	9.5 - 24 litres	1000 - 2400 ppm as NO ₂
Cooltreat AL	50 - 100 litres	1.8 - 3.7 Brix° of active compounds measured with a supplier's refractometer
Engine Water Treatment 9-108	2.25 - 3.4 litres	670 - 1000 ppm as NO ₂
Nalfleet 2000	32 - 48 litres	1000 - 1500 ppm as NO ₂

Note 1: For many products the recommended minimum and maximum limits are listed in the table above. Since the amount of active corrosion inhibitors, especially nitrites, is decreasing during the service of engines, the engine manufacturer recommends to start the dosage from the upper level of indicated range.

Note 2: The nitrite content of nitrite-based cooling water additives tends to decrease in use. The risk of local corrosion increases substantially when nitrite content goes below the recommended limit.

Note 3: Cooling water additive manufacturers can indicate the required nitrite content measured either as sodium nitrite, NaNO₂ or as nitrite, NO₂. 1 mg/l as NO₂ equals to 1.5 mg/l as NaNO₂.

Note 4: Nitrite based cooling water additives are not offering a good protection against corrosion for aluminium and its alloys and thus the use of such products can't recommended for cooling systems containing those construction materials.

Contacts

For questions about the content of this bulletin, or if you need Wärtsilä assistance, services, spare parts and/or tools, please contact your nearest Wärtsilä representative. If you don't have the contact details at hand, please follow the link "Contact us" – "24h Services" on the Wärtsilä webpage:

www.wartsila.com

© 2015 Wärtsilä Finland Oy – All rights reserved

No part of this publication may be reproduced or copied in any form or by any means (electronic, mechanical, graphic, photocopying, recording, taping or other information retrieval systems) without the prior written permission of the copyright holder. Wärtsilä Finland Oy makes no representation, warranty (express or implied) in this publication and assumes no responsibility for the correctness, errors or omissions for information contained herein. Information in this publication is subject to change without notice.

Unless otherwise expressly set forth, no recommendation contained in this document or any of its appendices is to be construed as provided due to a defect of the product, but merely as an improvement of the product and/or the maintenance procedures relating thereto. Any actions by the owner/operator as a result of the recommendations are not covered under any warranty provided by Wärtsilä and such actions will thus be at the owners/operators own cost and expense.

NO LIABILITY WHETHER DIRECT, INDIRECT, SPECIAL, INCIDENTAL OR CONSEQUENTIAL, IS ASSUMED WITH RESPECT TO THE INFORMATION CONTAINED HEREIN. THIS PUBLICATION IS CONFIDENTIAL AND INTENDED FOR INFORMATION PURPOSES ONLY.