Engine cooling water specifications

Preliminary remarks

As is also the case with the fuel and lubricating oil, the engine cooling water must be carefully selected, handled and checked. If this is not the case, corrosion, erosion and cavitation may occur at the walls of the cooling system in contact with water and deposits may form. Deposits obstruct the transfer of heat and can cause thermal overloading of the cooled parts. The system must be treated with an anticorrosive agent before bringing it into operation for the first time. The concentrations prescribed by the engine manufacturer must always be observed during subsequent operation. The above especially applies if a chemical additive is added.

Requirements

Limit values

The properties of untreated cooling water must correspond to the following limit values:

Properties/Characteristic	Properties	Unit
Water type	Distillate or fresh water, free of foreign matter.	-
Total hardness	max. 10	°dH*
pH value	6.5 - 8	-
Chloride ion content	max. 50	mg/l**

Table 1: Cooling water - properties to be observed

*) 1°dH (German hardness) ≙ 10 mg CaO in 1 litre of water ≙ 17.9 mg $CaCO_3$/l

≙ 0.357 mval/l ≙ 0.179 mmol/l

**) 1 mg/l ≙ 1 ppm

Testing equipment

The MAN Diesel water testing equipment incorporates devices that determine the water properties referred to above in a straightforward manner. The manufacturers of anticorrosive agents also supply user-friendly testing equipment. For information on monitoring cooling water, refer to Work Card 000.07.

Additional information

Distillate

If distilled water (from a fresh water generator, for example) or fully desalinated water (from ion exchange or reverse osmosis) is available, this should ideally be used as the engine cooling water. These waters are free of lime and salts which means that deposits that could interfere with the transfer of heat to the cooling water, and therefore also reduce the cooling effect, cannot form. However, these waters are more corrosive than normal hard water as the thin film of lime scale that would otherwise provide temporary corrosion protection does not form on the walls. This is why distilled water must be handled particularly carefully and the concentration of the additive must be regularly checked.

Hardness

The total hardness of the water is the combined effect of the temporary and permanent hardness. The proportion of calcium and magnesium salts is of overriding importance. The temporary hardness is determined by the carbonate content of the calcium and magnesium salts. The permanent hardness

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is determined by the amount of remaining calcium and magnesium salts (sulphates). The temporary (carbonate) hardness is the critical factor that determines the extent of limescale deposit in the cooling system.

Water with a total hardness of > 10°dGH must be mixed with distilled water or softened. Subsequent hardening of extremely soft water is only necessary to prevent foaming if emulsifiable slushing oils are used.

Damage to the cooling water system

Corrosion

Corrosion is an electrochemical process that can widely be avoided by selecting the correct water quality and by carefully handling the water in the engine cooling system.

Flow cavitation

Flow cavitation can occur in areas in which high flow velocities and high turbulence is present. If the steam pressure is reached, steam bubbles form and subsequently collapse in high pressure zones which causes the destruction of materials in constricted areas.

Erosion

Erosion is a mechanical process accompanied by material abrasion and the destruction of protective films by solids that have been drawn in, particularly in areas with high flow velocities or strong turbulence.

Stress corrosion cracking

Stress corrosion cracking is a failure mechanism that occurs as a result of simultaneous dynamic and corrosive stress. This may lead to cracking and rapid crack propagation in water-cooled, mechanically-loaded components if the cooling water has not been treated correctly.

Processing of engine cooling water

Formation of a protective film

The purpose of treating the engine cooling water using anticorrosive agents is to produce a continuous protective film on the walls of cooling surfaces and therefore prevent the damage referred to above. In order for an anticorrosive agent to be 100 % effective, it is extremely important that untreated water satisfies the requirements in the Section *Requirements*.

Protective films can be formed by treating the cooling water with an anticorrosive chemical or an emulsifiable slushing oil.

Emulsifiable slushing oils are used less and less frequently as their use has been considerably restricted by environmental protection regulations, and because they are rarely available from suppliers for this and other reasons.

Treatment prior to initial commissioning of engine

Treatment with an anticorrosive agent should be carried out before the engine is brought into operation for the first time to prevent irreparable initial damage.

⚠ CAUTION

Treatment of the cooling water

The engine must not be brought into operation without treating the cooling water first.

Additives for cooling water

Only the additives approved by MAN Diesel and listed in the tables under the section entitled *"Approved cooling water additives"* may be used.

Required approval

A cooling water additive may only be permitted for use if tested and approved as per the latest directives of the ICE Research Association (FVV) "Suitability test of internal combustion engine cooling fluid additives." The test report must be obtainable on request. The relevant tests can be carried out on request in Germany at the staatliche Materialprüfanstalt (Federal Institute for Materials Research and Testing), Abteilung Oberflächentechnik (Surface Technology Division), Grafenstraße 2 in D-64283 Darmstadt.

Once the cooling water additive has been tested by the FVV, the engine must be tested in the second step before the final approval is granted.

Only in closed circuits

Additives may only be used in closed circuits where no significant consumption occurs, apart from leaks or evaporation losses.

Chemical additives

Sodium nitrite and sodium borate based additives etc. have a proven track record. Galvanised iron pipes or zinc sacrificial anodes must not be used in cooling systems. This corrosion protection is not required due to the prescribed cooling water treatment and electrochemical potential reversal can occur due to the cooling water temperatures which are normally present in engines nowadays. If necessary, the pipes must be deplated.

Slushing oil

This additive is an emulsifiable mineral oil with added slushing ingredients. A thin film of oil forms on the walls of the cooling system. This prevents corrosion without interfering with the transfer of heat and also prevents limescale deposits on the walls of the cooling system.

The significance of emulsifiable corrosion-slushing oils is fading. Oil-based emulsions are rarely used nowadays for environmental protection reasons and also because stability problems are known to occur in emulsions.

Anti-freeze agents

If temperatures below the freezing point of water in the engine cannot be excluded, an anti-freeze solution that also prevents corrosion must be added to the cooling system or corresponding parts. Otherwise, the entire system must be heated. (Military specification: Sy-7025).

Sufficient corrosion protection can be provided by adding the products listed in the table entitled *"Anti-freeze solutions with slushing properties"* while observing the prescribed concentration. This concentration prevents freezing at temperatures down to -22 °C. However, the quantity of anti-freeze solution actually required always depends on the lowest temperatures that are to be expected at the place of use.

Anti- freezes are generally based on ethylene glycol. A suitable chemical anti-corrosive agent must be added if the concentration of the anti-freeze solution prescribed by the user for a specific application does not provide an appropriate level of corrosion protection, or if the concentration of anti-freeze solution used is lower due to less stringent frost protection requirements and does not provide an appropriate level of corrosion protection. For information on the compatibility of the anti-freeze solution with the anticorrosive agent and the required concentrations, contact the manufacturer. As regards the chemical additives indicated in the table *„Nitrite-Containing Chemical Additives“*, their compatibility with ethylene glycol-based antifreezes has been

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proved. Anti-freeze solutions may only be mixed with one another with the consent of the manufacturer, even if these solutions have the same composition.

Before an anti-freeze solution is used, the cooling system must be thoroughly cleaned.

If the cooling water contains an emulsifiable slushing oil, anti-freeze solution must not be added as otherwise the emulsion would break up and oil sludge would form in the cooling system.

Observe the applicable environmental protection regulations when disposing of cooling water containing additives. For more information, consult the additive supplier.

Biocides

If you cannot avoid using a biocide because the cooling water has been contaminated by bacteria, observe the following steps:

- You must ensure that the biocide to be used is suitable for the specific application.
- The biocide must be compatible with the sealing materials used in the cooling water system and must not react with these.
- The biocide and its decomposition products must not contain corrosion-promoting components. Biocides whose decomposition products contain chloride or sulphate ions are not permitted.
- Biocides that cause foaming of cooling water are not permitted.

Prerequisite for effective use of an anticorrosive agent

Clean cooling system

As contamination significantly reduces the effectiveness of the additive, the tanks, pipes, coolers and other parts outside the engine must be free of rust and other deposits before the engine is started up for the first time and after repairs are carried out on the pipe system. The entire system must therefore be cleaned with the engine switched off using a suitable cleaning agent (see Work Cards 000.03 and 000.08 by MAN Diesel).

Loose solid matter in particular must be removed by flushing the system thoroughly as otherwise erosion may occur in locations where the flow velocity is high.

The cleaning agents must not corrode the seals and materials of the cooling system. In most cases, the supplier of the cooling water additive will be able to carry out this work and, if this is not possible, will at least be able to provide suitable products to do this. If this work is carried out by the engine operator, he should use the services of a specialist supplier of cleaning agents. The cooling system must be flushed thoroughly following cleaning. Once this has been done, the engine cooling water must be treated immediately with anticorrosive agent. Once the engine has been brought back into operation, the cleaned system must be checked for leaks.

Regular checks of the cooling water condition and cooling water system

Treated cooling water may become contaminated when the engine is in operation, which causes the additive to loose some of its effectiveness. It is therefore advisable to regularly check the cooling system and the cooling

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water condition. To determine leakages in the lube oil system, it is advisable to carry out regular checks of water in the compensating tank. Indications of oil content in water are, e.g. discoloration or a visible oil film on the surface of the water sample.

The additive concentration must be checked at least once a week using the test kits specified by the manufacturer. The results must be documented.

NOTICE

Concentrations of chemical additives

The chemical additive concentrations shall not be less than the minimum concentrations indicated in the table *„Nitrite-containing chemical additives“*.

Excessively low concentrations can promote corrosion and must be avoided. If the concentration is slightly above the recommended concentration this will not result in damage. Concentrations that are more than twice the recommended concentration should be avoided.

Every 2 to 6 months send a cooling water sample to an independent laboratory or to the engine manufacturer for integrated analysis.

Emulsifiable anticorrosive agents must generally be replaced after abt. 12 months according to the supplier's instructions. When carrying this out, the entire cooling system must be flushed and, if necessary, cleaned. Once filled into the system, fresh water must be treated immediately.

If chemical additives or anti-freeze solutions are used, cooling water should be replaced after 3 years at the latest.

If there is a high concentration of solids (rust) in the system, the water must be completely replaced and entire system carefully cleaned.

Deposits in the cooling system may be caused by fluids that enter the cooling water, or the break up of emulsion, corrosion in the system and limescale deposits if the water is very hard. If the concentration of chloride ions has increased, this generally indicates that seawater has entered the system. The maximum specified concentration of 50 mg chloride ions per kg must not be exceeded as otherwise the risk of corrosion is too high. If exhaust gas enters the cooling water, this may lead to a sudden drop in the pH value or to an increase in the sulphate content.

Water losses must be compensated for by filling with untreated water that meets the quality requirements specified in the section Requirements. The concentration of the anticorrosive agent must subsequently be checked and adjusted if necessary.

Subsequent checks of cooling water are especially required if the cooling water had to be drained off in order to carry out repairs or maintenance.

Protective measures

Anticorrosive agents contain chemical compounds that can pose a risk to health or the environment if incorrectly used. Comply with the directions in the manufacturer's material safety data sheets.

Avoid prolonged direct contact with the skin. Wash hands thoroughly after use. If larger quantities spray and/or soak into clothing, remove and wash clothing before wearing it again.

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If chemicals come into contact with your eyes, rinse them immediately with plenty of water and seek medical advice.

Anticorrosive agents are generally harmful to the water cycle. Observe the relevant statutory requirements for disposal.

Auxiliary engines

If the same cooling water system used in a MAN Diesel & Turbo two-stroke main engine is used in a marine engine of type 16/24, 21/ 31, 23/30H, 27/38 or 28/32H, the cooling water recommendations for the main engine must be observed.

Analysis

We analyse cooling water for our customers in our chemical laboratory. A 0.5 l sample is required for the test.

Permissible cooling water additives

Nitrite-containing chemical additives

Manufacturer	Product designation	Initial dosing for 1,000 litres	Minimum concentration ppm		
			Product	Nitrite (NO_2)	Na-Nitrite ($NaNO_2$)
Drew Marine One Drew Plaza Boonton New Jersey 07005 USA	Liquidewt Maxigard	15 l 40 l	15,000 40,000	700 1,330	1,050 2,000
Wilhelmsen (Unitor) KJEMI-Service A.S. P.O.Box 49/Norway 3140 Borgheim	Rocor NB Liquid Dieselguard	21.5 l 4.8 kg	21,500 4,800	2,400 2,400	3,600 3,600
Nalfleet Marine Chemicals P.O.Box 11 Northwich Cheshire CW8DX, U.K.	Nalfleet EWT Liq (9-108) Nalfleet EWT 9-111 Nalcool 2000	3 l 10 l 30 l	3,000 10,000 30,000	1,000 1,000 1,000	1,500 1,500 1,500
Nalco	Nalcool 2000 TRAC 102 TRAC 118	30 l 30 l 3 l	30,000 30,000 3,000	1,000 1,000 1,000	1,500 1,500 1,500
Maritech AB P.O.Box 143 S-29122 Kristianstad	Marisol CW	12 l	12,000	2,000	3,000
Uniservice Via al Santuario di N.S. della Guardia 58/A 16162 Genova, Italy	N.C.L.T. Colorcooling	12 l 24 l	12,000 24,000	2,000 2,000	3,000 3,000
Marichem – Marigases 64 Sfaktirias Street 18545 Piraeus, Griechenland	D.C.W.T. - Non-Chromate	48 l	48,000	2,400	-

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Manufacturer	Product designation	Initial dosing for 1,000 litres	Minimum concentration ppm		
			Product	Nitrite (NO_2)	Na-Nitrite ($NaNO_2$)
Marine Care 3144 NA Maasluis The Netherlands	Caretreat 2	16 l	16,000	4,000	6,000
Vecom Schlenzigstraße 7 21107 Hamburg Deutschland	Cool Treat NCLT	16 l	16,000	4,000	6,000

Table 2: Nitrite-containing chemical additives

Nitrite-free additives (chemical additives)

Manufacturer	Product designation	Initial dosing for 1 000 litres	Minimum concentration
Arteco Technologiepark Zwijnaarde 2 B-9052 Gent, Belgium	Havoline XLI	75 l	7.5 %
Total Lubricants Paris, France	WT Supra	75 l	7.5 %
Q8 Oils	Q8 Corrosion Inhibitor Long-Life	75 l	7.5 %

Table 3: Chemical additives - nitrite free

Emulsifiable slushing oils

Manufacturer	Product (designation)
BP Marine, Breakspear Way, Hemel Hempstead, Herts HP2 4UL	Diatsol M Fedaro M
Castrol Int., Pipers Way, Swindon SN3 1RE, UK	Solvex WT 3
Deutsche Shell AG, Überseering 35, 22284 Hamburg, Germany	Oil 9156

Table 4: Emulsifiable slushing oils

Anti-freeze solutions with slushing properties

Manufacturer	Product designation	Minimum concentration
BASF Carl-Bosch-Str. 67063 Ludwigshafen, Rhein Deutschland	Glysantin G 48 Glysantin 9313 Glysantin G 05	35%
Castrol Int. Pipers Way Swindon SN3 1RE, UK	Antifreeze NF, SF	
BP, Britannic Tower Moor Lane, London EC2Y 9B, UK	Anti-frost X2270A	

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Manufacturer	Product designation	Minimum concentration
Deutsche Shell AG Überseering 35 22284 Hamburg Deutschland	Glycoshell	
Mobil Oil AG Steinstraße 5 20095 Hamburg Deutschalnd	Frostschutz 500	
Arteco, Technologiepark Zwijnaarde 2 B-9052 Gent, Belgium	Havoline XLC	
Total Lubricants Paris, France	Glacelf Auto Supra Total Organifreeze	

Table 5: Anti-freeze solutions with slushing properties

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Cooling water inspecting

Summary

Acquire and check typical values of the operating media to prevent or limit damage.

The fresh water used to fill the cooling water circuits must satisfy the specifications. The cooling water in the system must be checked regularly in accordance with the maintenance schedule.
The following work/steps is/are necessary:
Acquisition of typical values for the operating fluid,
evaluation of the operating fluid and checking the concentration of the anti-corrosive agent.

Tools/equipment required

Equipment for checking the fresh water quality

The following equipment can be used:

- The MAN Diesel & Turbo water testing kit, or similar testing kit, with all necessary instruments and chemicals that determine the water hardness, pH value and chloride content (obtainable from MAN Diesel & Turbo or Mar-Tec Marine, Hamburg)

Equipment for testing the concentration of additives

When using chemical additives:

- Testing equipment in accordance with the supplier's recommendations. Testing kits from the supplier also include equipment that can be used to determine the fresh water quality.

Testing the typical values of water

Short specification

Typical value/property	Water for filling and refilling (without additive)	Circulating water (with additive)
Water type	Fresh water, free of foreign matter	Treated cooling water
Total hardness	≤ 10°dGH [1)]	≤ 10°dGH [1)]
pH value	6.5 - 8 at 20 °C	≥ 7.5 at 20 °C
Chloride ion content	≤ 50 mg/l	≤ 50 mg/l [2)]

Table 1: Quality specifications for cooling water (abbreviated version)

[1)] dGH German hardness

1°dGh = 10 mg/l CaO
= 17.9 mg/l $CaCO_3$
= 0.179 mmol/L

[2)] 1mg/l = 1 ppm

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Testing the concentration of anticorrosive agents

Short specification

Anticorrosive agent	Concentration
Chemical additives	according to the quality specification in Volume 010.005 Engine - Operating Instructions, Chapter 3, Sheet 3.3.7
Anti-freeze agents	according to the quality specification in Volume 010.005 Engine - Operating Instructions, Chapter 3, Sheet 3.3.7

Table 2: Concentration of the cooling water additive

Testing the concentration of chemical additives

The concentration should be tested every week, and/or according to the maintenance schedule, using the testing instruments, reagents and instructions of the relevant supplier.

Chemical slushing oils can only provide effective protection if the right concentration is precisely maintained. This is why the concentrations recommended by MAN Diesel & Turbo (quality specifications in Volume 010.005 Engine – Operating Instructions, Chapter 3, Page 3.3.7) must be complied with in all cases. These recommended concentrations may be other than those specified by the manufacturer.

Testing the concentration of anti-freeze agents

The concentration must be checked in accordance with the manufacturer's instructions or the test can be outsourced to a suitable laboratory. If in doubt, consult MAN Diesel & Turbo.

Regular water samplings

Small quantities of lubricating oil in cooling water can be found by visual check during regular water sampling from the expansion tank.

Testing

We test cooling water for customers in our laboratory. To carry out the test, we will need a representative sample of abt. 0.5 l.

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Cooling water system
Cleaning

Summary

Remove contamination/residue from operating fluid systems, ensure/re-establish operating reliability.

Cooling water systems containing deposits or contamination prevent effective cooling of parts. Contamination and deposits must be regularly eliminated.
This comprises the following:
Cleaning the system and, if required,
removal of limescale deposits,
flushing the system.

Cleaning

The cooling water system must be checked for contamination at regular intervals. Cleaning is required if the degree of contamination is high. This work should ideally be carried out by a specialist who can provide the right cleaning agents for the type of deposits and materials in the cooling circuit. The cleaning should only be carried out by the engine operator if this cannot be done by a specialist.

Oil sludge

Oil sludge from lubricating oil that has entered the cooling system or a high concentration of anticorrosive agents can be removed by flushing the system with fresh water to which some cleaning agent has been added. Suitable cleaning agents are listed alphabetically in the table entitled "*Cleaning agents for removing oil sludge*". Products by other manufacturers can be used providing they have similar properties. The manufacturer's instructions for use must be strictly observed.

Manufacturer	Product	Concentration	Duration of cleaning procedure/temperature
Drew	HDE - 777	4 - 5%	4 h at 50 – 60 °C
Nalfleet	MaxiClean 2	2 - 5%	4 h at 60 °C
Unitor	Aquabreak	0.05 – 0.5%	4 h at ambient temperature
Vecom	Ultrasonic Multi Cleaner	4%	12 h at 50 – 60 °C

Table 1: Cleaning agents for removing oil sludge

Lime and rust deposits

Lime and rust deposits can form if the water is especially hard or if the concentration of the anticorrosive agent is too low. A thin lime scale layer can be left on the surface as experience has shown that this protects against corrosion. However, limescale deposits with a thickness of more than 0.5 mm obstruct the transfer of heat and cause thermal overloading of the components being cooled.

Rust that has been flushed out may have an abrasive effect on other parts of the system, such as the sealing elements of the water pumps. Together with the elements that are responsible for water hardness, this forms what is known as ferrous sludge which tends to gather in areas where the flow velocity is low.

Products that remove limescale deposits are generally suitable for removing rust. Suitable cleaning agents are listed alphabetically in the table entitled "*Cleaning agents for removing lime scale and rust deposits"*. Products by

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other manufacturers can be used providing they have similar properties. The manufacturer's instructions for use must be strictly observed. Prior to cleaning, check whether the cleaning agent is suitable for the materials to be cleaned. The products listed in the table entitled *"Cleaning agents for removing lime scale and rust deposits"* are also suitable for stainless steel.

Manufacturer	Product	Concentration	Duration of cleaning procedure/temperature
Drew	SAF-Acid Descale-IT Ferroclean	5 - 10% 5 - 10% 10%	4 h at 60 - 70 °C 4 h at 60 - 70 °C 4 - 24 h at 60 - 70 °C
Nalfleet	Nalfleet 9 - 068	5%	4 h at 60 – 75 °C
Unitor	Descalex	5 - 10%	4 - 6 h at approx. 60 °C
Vecom	Descalant F	3 – 10%	Approx. 4 h at 50 – 60°C

Table 2: Cleaning agents for removing limescale and rust deposits

In emergencies only

Hydrochloric acid diluted in water or aminosulphonic acid may only be used in exceptional cases if a special cleaning agent that removes limescale deposits without causing problems is not available. Observe the following during application:

- Stainless steel heat exchangers must never be treated using diluted hydrochloric acid.
- Cooling systems containing non-ferrous metals (aluminium, red bronze, brass, etc.) must be treated with deactivated aminosulphonic acid. This acid should be added to water in a concentration of 3 - 5 %. The temperature of the solution should be 40 - 50 °C.
- Diluted hydrochloric acid may only be used to clean steel pipes. If hydrochloric acid is used as the cleaning agent, there is always a danger that acid will remain in the system, even when the system has been neutralised and flushed. This residual acid promotes pitting. We therefore recommend you have the cleaning carried out by a specialist.

The carbon dioxide bubbles that form when limescale deposits are dissolved can prevent the cleaning agent from reaching boiler scale. It is therefore absolutely necessary to circulate the water with the cleaning agent to flush away the gas bubbles and allow them to escape. The length of the cleaning process depends on the thickness and composition of the deposits. Values are provided for orientation in the table entitled *"Detergents for removing lime scale and rust deposits"*.

Following cleaning

The cooling system must be flushed several times once it has been cleaned using cleaning agents. Replace the water during this process. If acids are used to carry out the cleaning, neutralise the cooling system afterwards with suitable chemicals then flush. The system can then be refilled with water that has been prepared accordingly.

⚠ CAUTION

Only carry out the cleaning operation once the engine has cooled down

Start the cleaning operation only when the engine has cooled down. Hot engine components must not come into contact with cold water. Open the venting pipes before refilling the cooling water system. Blocked venting pipes prevent air from escaping which can lead to thermal overloading of the engine.

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CAUTION

Cleaning products can cause damage

The products to be used can endanger health and may be harmful to the environment.
Follow the manufacturer's handling instructions without fail.

The applicable regulations governing the disposal of cleaning agents or acids must be observed.

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