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GE Power Systems
Gas Turbine

Cooling Water Recommendations

for Combustion Gas Turbine Closed Cooling Systems

I. GENERAL

Properly treated closed cooling systems should provide reliable and trouble-free operation for the life of the gas turbine. A closed system is so named because the coolant is completely contained within the system and does not come into contact with the outside atmosphere.

Closed systems have a very low tolerance for corrosion and it is the goal of the treatment program to stop it as completely as possible. Metals encountered in GE Gas Turbine closed cooling systems are mild steel, copper, copper alloy, and stainless steel. There is no aluminum present.

It is possible to economically treat the closed cooling system with relatively high dosages of treatment products. Typical treatment for a closed system would include corrosion inhibitors for the various metals in the system, and a buffering agent to control pH. If the gas turbine will be exposed to below freezing temperatures, a compatible antifreeze must be added to the system.

II. WATER

Because of the wide variance in the properties of tap water throughout the country, and because of the relatively small quantity of coolant required by the gas turbine, the use of tap water in gas turbine cooling water systems is not recommended. Instead, ”pure” water should be used to prepare the coolant solution. Waters which fall into the classification of ”pure”, consist of distilled water, steam condensate, and deionized water.

III. ANTIFREEZE

Gas turbines installed in cold climates which have a closed cooling water system, require the use of ethylene glycol or propylene glycol antifreeze during winter months.

Most commercial antifreeze contains corrosion inhibitors. It is strongly recommended that a commercial antifreeze product that contains appropriate inhibitors be used rather than those without inhibitors. The inhibitor in one type of coolant (antifreeze or water) may not be compatible with another type of coolant and can form gums, as well as destroy the effectiveness of an inhibitor. When changing coolants (such as changing from one type of antifreeze or corrosion inhibitor to another) the cooling system should be drained and flushed thoroughly to protect against contamination of the coolant with incompatible solutions. The antifreeze vendor should be consulted for specific recommendations about the length of time between changes, the need for corrosion inhibitor additives, the dangers involved in adding antifreeze to another existing coolant; in addition to any other precautions he may suggest.

CAUTION

If the antifreeze concentration is too low or too high, there is danger of freeze-up in the winter that could damage the cooling system equipment. If the concentration of antifreeze is too high, it will reduce the cooling capacity of the system on very hot days during the summer, resulting in overheating of the lube system fluid, and possibly tripping the gas turbine on high lube oil temperature. It is important, therefore, that the glycol antifreeze concentration be maintained at exactly the recommended value consistent with expected minimum winter temperature at the respective gas turbine site. The table below gives the required glycol concentrations as a function of expected minimum winter temperature.

IV. ADDING ANTIFREEZE AND WATER

For the initial filling of the system, the water and concentrated antifreeze should not be added separately, directly to the system. The reason for this is because the exact amount of solution needed to fill the system is unknown, and if too much water were added before the antifreeze, it would require difficult adjustment to get the desired concentration of antifreeze into the system. It is recommended that the water and antifreeze be mixed in an external container (such as a drum) at the correct ratio, before adding the resulting solution to the system. Additional batches of solution should be prepared and added until the system is full. By measuring the total amount of solution added, an accurate determination of system volume is obtained. Knowing the total volume accurately, simplifies addition of treatment chemicals as explained below.

ANTIFREEZE SOLUTION STRENGTH

Expected Lowest Ambient (°F)			Vol. % Glycol (General Note–1)	
Unmargined (General Note–2)	5°F Margin (General Note–3)	GE Proposal (General Note–4)	Ethylene (Design Note–4)	Propylene (Design Note–1&2)
32	37	32	0	0
26	31	28	10	10
23	28	25		15
21	26	25	15	
19	24	22		20
16	21	20	20	
15	20	17		25
11	16	14	25	
9	14	10		30
4	9	7	30	
2	7	5		35
-3	2	0	35	
-6	-1	-4		40
-12	-7	-8	40	
-16	-11	-15		45
-22	-17	-20	45	
-28	-23	-27		50
-34	-29	-30	50	52
-42	-37	-36		55
-48	-43	-43	55	Not Recomended
-59	-54	-54	60	Not Recomended

For specifics on General Notes and Design Notes, refer to the current revision of GE Drawing #370A2260.

After the system has been in service for a period of time, coolant will inevitably be lost and will need to be replaced. Again, the antifreeze and water solution should be mixed externally and added in batchwise fashion.

V. CHANGING ANTIFREEZE AND/OR INHIBITORS

If the type of antifreeze or inhibitor used is changed, the following points should be kept in mind:

1. The system should be thoroughly flushed, and possibly even cleaned, before the new coolant is added. Follow the recommendations of the inhibitor supplier.

2. Follow the antifreeze/inhibitor suppliers recommendation for maintaining system chemistry. The pH should be monitored and maintained with an agent compatible with the antifreeze and inhibitor. Some inhibitors have a pH indicating dye which changes color if the pH is not proper. These dyes may be affected by the antifreeze used such that the color change is masked.

3. Do not add an inhibitor to a system containing a commercial antifreeze which has its own inhibitor package without ensuring the two are compatible. Specifically, some inhibitors are not compatible with the inhibitor packages used in commercial antifreeze manufactured outside of the United States.

4. Ensure that the antifreeze and inhibitor are compatible with system materials: carbon steel, copper, copper alloys and stainless steel.

VI. CORROSION INHIBITORS

At no time should the cooling system be operated without corrosion inhibitors in the coolant solution. If the coolant is a mixture of pure glycol and water, or just water alone, it is necessary to add a suitable corrosion inhibitor. Most commercially available antifreezes contain a sufficient quantity of inhibitor to protect the cooling system from corrosion when the mixture of water and ethylene glycol is made in accordance with the manufacturer’s instructions. Specific corrosion inhibitors cannot be recommended as the selection depends on economic factors, availability, and the environmental impact which may vary from locale to locale. However, there are generally two corrosion inhibitors for mild steel which are commonly used in closed cooling systems – molybdate and nitrite. The most commonly used corrosion inhibitor for copper and copper alloy is tolyltriazole but other azoles are sometimes used.

In the discussion which follows, several commercially available corrosion inhibitor packages are listed. They all contain nitrite, molybdate, or a blend of the two, tolyltriazole, and a buffering agent (typically sodium tetraborate). Ethylene glycol or propylene glycol (without inhibitors) is not included and must be purchased separately.

DEARBORN 540
Grace Dearborn
300 Genessee St.
Lake Zurich, IL 60047–2458

NALCO 8328
Nalco Chemical Co.
One Nalco Center
Naperville, Illinois 60563–1198

BETZ 66–P
Betz Laboratories
Somerton Road
Trevose, Penn 19047

DREWGARD 100
Drew Chemical Corp.
701 Jefferson Rd.
Parsippany, NJ 07054

CALGON CF or LCS–20
Calgon Corp.
P.O. Box 1346
Pittsburgh, PA 15230

NOTE

This list is not exclusive and other products may produce acceptable results. Since individual turbine customer conditions may vary and these manufacturers may change their product in the future, it is important to verify that the product chosen is appropriate.

These products are all compatible with ethylene and propylene glycol. Some problems have occurred with these inhibitors when used with commercial antifreeze available in countries outside of the United States, and therefore it is not recommended that these inhibitors be used with a commercial antifreeze without first determining the compatibility of the inhibitor package contained in the antifreeze.

A. Copper Alloy Corrosion Inhibitor

GE gas turbine closed cooling systems contain copper and copper alloy which must be treated with a suitable corrosion inhibitor. The discussion which follows will focus on tolyltriazole which is often referred to as TTA.

Commercial corrosion inhibitor products usually have TTA blended in, or it can be added separately. It is usually sold as a 50% solution of sodium tolyltriazole. TTA works by forming a microscopic film on the metal surface and a typical dosage for maintaining the film is 100 PPM.

B. Mild Steel Corrosion Iinhibitors

In the following discussion, general guidelines are given for treating the coolant with nitrite and molybdate corrosion inhibitors.

Sodium nitrite, which is described by the chemical formula $NaNO_2$, is an effective corrosion inhibitor for combustion gas turbine cooling water systems. The recommended dosage is 1000 PPM as NO_2.

Sodium molybdate dihydrate ($NaMoO_4 \bullet 2H_2O$) is another good corrosion inhibitor for closed systems. The recommended dosage is 250 PPM as Mo.

It is good practice to maintain the corrosion inhibitor concentration well above the minimum effective level to prevent pitting. If the pure water used as the coolant does not become contaminated, and if the recommended concentration of molybdate or nitrite is maintained, the inhibiting efficiency of the coolant will always be above the minimum effective level.

VII. PREPARING THE COOLANT

The following instructions explain how to calculate the amount of corrosion inhibitor product which needs to be added to a given volume of water to arrive at the desired dosage.

1. Obtain the following information:

a. **System Volume**. The most accurate way of obtaining the system volume is to measure how much antifreeze/water solution is added as described previously. The next best way would be to use an estimate of the volume based on engineering data.

b. **Volumetric Product Dosage**. Obtain the amount of product needed per 1000 gallons of water from the table below.

VOLUMETRIC PRODUCT DOSAGE

Sodium Tolyltriazole (50% Liquid)	2 Pts/1000 Gals
Sodium Molybdate Dihydrate (100% Dry)	5 Lbs/1000 Gals
Sodium Nitrite (100% Dry)	13 Lbs/1000 Gals

2. Multiply the system volume (i.e. gallons of water to be treated from step 1a) by the volumetric product dosage (from step 1b) and divide by 1000. This is the amount of product which should be added to the system.

NOTE

If products of different strengths than those given above are obtained, the volumetric dosage must be proportionately adjusted.

When the corrosion inhibitors are added at the volumetric dosages given above, the following product residual dosages will result. These are the control values.

INHIBITOR RESIDUAL DOSAGES

Tolyltriazole (PPM as TTA)	100
Molybdate (PPM as Mo)	250
Nitrite (PPM as NO_2)	1000

When the system is filled initially, some of the inhibitors will be used up rapidly in the production of films on the metal surfaces and thus an adjustment of concentration may be necessary to bring the inhibitor residual up to the desired level.

VIII. BIOCIDE

In systems which use nitrite for corrosion inhibition, there is a risk of infestation by denitrifying bacteria. These organisms break down nitrite to nitrate – thereby reducing corrosion inhibition and increasing the likelihood of fouling. It is therefore imperative that bacteria be controlled by temperature or non–oxidizing biocide.

Temperatures inside gas turbine cooling systems will vary from one installation to another. If the temperature is in excess of 140°F, thermal disinfection will effectively prevent microbiological growth and no biocide will be needed.

In cooling systems which operate below 140°F and contain nitrite as part of the coolant solution, it is recommended that two different non–oxidizing biocides be added on alternate occasions whenever bacteria are detected in the system.

The biocides selected must be compatible with the coolant solution (ingredients, pH, etc.) and not be aggressive to system components. The use of chlorine gas, hypochlorite bleach, or bromine compounds should be avoided as they are not compatible with nitrite.

CAUTION

> Non-oxidizing biocides are dangerous substances and precautions must be taken not to inhale or come in contact with the product. Manufacturers instructions on safe handling should be followed at all times.

IX. BUFFER

The corrosion inhibitors described above have a recommended pH range of 8.5 to 10.0. If a pH adjustment is necessary, check to ensure the agent used is compatible with the inhibitor and antifreeze used. Sodium tetraborate (borax) is the usual buffer of choice and is compatible with nitrite, molybdate, tolyltriazole, and glycol antifreeze.

X. COOLANT PH VALUE

The final coolant solution should have a pH value between 8.5 and 10.0. It is recommended that the pH value of the final coolant solution be checked with a suitable pH meter, a number of which are available on the market. Other methods, such as pH paper indicators, can also be used.

XI. TESTING

For a newly installed gas turbine unit, the recommended inhibitor dosages as given earlier should be applied. Due to the high inhibitor demand during the initial passivation period, the first residual testing should be performed after 48 hours to prevent the inhibitor residuals from dropping below the maintenance dosages given earlier. After that, weekly tests for nitrate or molybdate are recommended. The TTA residual test is fairly complex, so rather than test for it, it is recommended that whenever chemicals are added, TTA should also be added at the above volumetric dosage.

A number of commercial test kits for nitrite and molybdate residuals are available from chemical and laboratory suppliers such as the HACH Company (Loveland, Colorado) and Taylor Technologies, Inc. (Sparks, Maryland).

Over time, the concentration of corrosion inhibitor in the cooling water will decrease as a result of small leaks in the system, addition of makeup water, and the consumption for film maintenance. Weekly tests should be made to insure that the corrosion inhibitor concentrations (molybdate and nitrite) in the cooling water do not fall below the maintenance dosages given earlier.

The antifreeze concentration should also be tested with a suitable hydrometer since it may be lost through leaks and must be replenished. As a rule, whenever makeup coolant is needed, a batch of water and antifreeze should be mixed at the proper ratio before adding to the system. Afterwards, the antifreeze concentration should be checked with a hydrometer at least weekly and after every addition of makeup water/antifreeze solution.

Total bacteria dip slides should be used to monitor microbiological organism count weekly. If any microbes are present on the dip slide, a lethal amount of biocide should be added to maintain sterility.

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