CONVERTING A CLOSED-LOOP WATER SYSTEM TO A GLYCOL SYSTEM

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by

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INTRODUCTION

In most cases, the primary reason for converting a closed loop hot water heating or chilled water system to a glycol system is to prevent freeze/burst damage of equipment that is exposed to sub-freezing ambient temperatures. However, the potential for reduced maintenance costs could also justify this conversion in some situations. That is, monthly testing is not required for glycol systems—a benefit that may be especially important for remote locations, and seasonal drainage of chilled water coils is not required for glycol systems.

The reasons for **not** converting a closed loop hot water heating or chilled water system to a glycol system include the capital cost of the glycol—particularly for large systems, the reduced heat transfer for glycol, and the increased pump horsepower required for glycol.

However, if the capital cost can be justified and if the design of the existing closed loop water system has enough excess capacity to absorb the extra energy that a glycol system requires (i.e., the heating/cooling load can be comfortably met with the existing water system), the system preparation for this conversion, the operation & maintenance activities, and the required control tests for glycol systems are contained herein.

SYSTEM PREPARATION

System Cleaning

In order to improve the heat transfer efficiency and corrosion protection of the system, all lines and equipment of the system should be cleaned with a neutral pH cleaning solution, and the cleaning solution must be thoroughly flushed from the system prior to the glycol addition.

System Materials

The standard materials of construction (i.e., steel, cast iron, copper, brass, bronze, solder, and most plastics) that are found in closed loop water systems are also acceptable for use in glycol systems. However, aluminum and zinc materials should be avoided because the corrosion inhibitor in the glycol will not fully protect aluminum at temperatures greater than 150°F (65°C), and zinc will react with the corrosion inhibitor, thus depleting it and causing corrosion.

Fresh Make-up Water

The use of automatic fresh water make-up for glycol systems must be avoided in order to prevent undetected dilution of glycol in the system and possible contamination of the domestic water system with glycol.

Expansion tank

In heating systems, the direct contact of glycol with air will decompose the glycol to form glycolic acid, which in turn reacts with and depletes the corrosion inhibitor. Therefore, the expansion tank for a glycol heating system should be a bladder type.

Due to the higher density of glycol, the expansion tank for a glycol system must be capable of absorbing approximately 4% more volume than a water system in the same operating temperature range.

Type of Glycol

The types of glycol that are commercially available in bulk include automotive grade ethylene glycol & propylene glycol—the latter of which is also referred to as RV grade glycol, and industrial grade ethylene & propylene glycol. Industrial grades of ethylene glycol usually have product names that end with "therm" (e.g., "Dowtherm), whereas industrial grades of propylene glycol usually have product names that end in "frost" (e.g., "Dowfrost").

Automotive grade glycol and RV grade glycol must **not** be used in industrial glycol systems because these types of glycol contain corrosion inhibitors that are **not** compatible with the materials and operation of HVAC systems.

The acute oral toxicity of industrial grade propylene glycol is much lower than that of industrial grade ethylene glycol; therefore, industrial grade propylene glycol is the preferred choice for use in systems where **accidental** ingestion may occur (Note: intentional consumption of propylene & ethylene glycol in thirst quenching quantities must be avoided). However, because of its higher heat transfer efficiency, industrial grade ethylene glycol should be used in systems where oral toxicity is not a concern.

Concentration of Glycol

In order to provide adequate freeze protection and pumpability (i.e., a glycol concentration which is sufficient to prevent the formation of ice crystals at the lowest temperature experienced by the fluid) down to -34° C to -40° C, the acceptable glycol concentration range for cooling systems which are operational year round and for heating systems is 48-52 vol% for ethylene glycol systems and 50-54 vol% for propylene glycol systems.

As stated previously, the heat transfer rate for a glycol system is substantially less than for an equivalent water system. For example, the heat transfer rate for a heating system that contains 50 vol% ethylene glycol will be 54% less than an equivalent water system, and with an ethylene glycol concentration of 70 vol%, this difference increases to 67%. If 50 vol% propylene glycol is used, the heat transfer rate will be 60% less than an equivalent water system. Therefore, in order to maximise the heat transfer rate, excessive glycol concentrations should be avoided, and ethylene glycol is the preferred choice for glycol heating systems.

In order to provide adequate burst protection (i.e., a glycol concentration which is high enough to prevent bursting of pipes and other mechanical damage), but not necessarily high enough to be pumpable down to less than -50° C, the acceptable ethylene glycol concentration range for cooling systems which are operational only during the summer months is 30-35 vol%. Similarly, the acceptable propylene glycol concentration range is 35-40 vol% for burst protection down to less than -40° C.

Although the heat transfer rate for a glycol cooling system is substantially less than for an equivalent water system, it is not as excessive as for a heating system because the glycol concentration is lower for cooling systems. For example, the heat transfer rate for a cooling system that contains 30 vol% ethylene glycol will be 40% less than an equivalent water system, and with an ethylene glycol concentration of 50 vol%, this difference increases to 60%. If 30 vol% propylene glycol is used, the heat transfer rate will be 51% less than an equivalent water system. Therefore, as stated for the heating systems, in order to maximise the heat transfer rate, excessive glycol concentrations should be avoided, and ethylene glycol is the preferred choice for glycol cooling systems. Glycol concentrations less than approximately 20 vol% must be avoided since glycol is a nutrient source for bacteria at these low concentrations.

Volume of Glycol

The following equation may be used to calculate the approximate amount of glycol that must be added to the system:

$G = V \times (CD-CP)/(100-CP)$

volume of fresh concentrated glycol to be added to the system	
	litres
V:	volume of the system, litres (determined by lithium test)
CD:	desired glycol concentration, vol%
CP:	present glycol concentration, vol%
	volum V: CD: CP:

Dilution Water

The water which is used to mix and/or dilute glycol must be of the highest possible quality (i.e., softened, demineralised, deionised, boiler condensate), otherwise the minerals in some domestic water supplies will deplete the inhibitor concentration in the glycol, thus making it corrosive. The following limits are recommended by the glycol supplier:

Chloride:	25 ppm, maximum
Sulphate:	25 ppm maximum
Calcium:	50 ppm maximum
Magnesium:	50 ppm maximum

OPERATION and MAINTENANCE

Once the system is filled with the glycol solution, the following operating and maintenance activities must be performed in order to minimise corrosion in the system:

1. Ensure that there is a positive pressure at the top of the system at all times by maintaining a minimum static system pressure according to the following equation by the addition of air to the expansion tank:

P = (H/2.31) + 5

- Where P: pressure at the circulating pumps with the circulating pumps shut off, psig;
 - H: elevation of the system piping above the circulating pumps, feet
- 2. Ensure that there is glycol solution in the expansion tank at all times;
- 3. Replace faulty automatic vents as required;
- 4. Replace the by-pass filter element with a fresh cartridge as required.

CONTROL TESTS

In order to ensure that the glycol solution in the system will provide adequate freeze/burst & corrosion protection, the following control tests must be performed:

- 1. Test & document the pH level of the glycol solution in the system at least once per year—it should be greater than 8.5;
- 2. Test & document the glycol concentration of the glycol solution in the system at least once per year—for ethylene glycol, it should be 48-52 vol% for heating & cooling systems that are operated year round, and 30-35 vol% for cooling systems that are operated only during the cooling season; for propylene glycol, it should be 50-54 vol% for heating & cooling systems that are operated year round, and 35-40 vol% for cooling systems that are operated only during the cooling season;
- Determine & document the corresponding freeze temperature of the glycol solution in the system at least once per year—it should be -34 to -40°C for heating & cooling systems that are operated year round & -16 to -19°C for cooling systems that are operated only during the cooling season;
- Determine & document the corresponding burst temperature of the glycol solution in the system at least once per year—for **ethylene glycol**, it should be less than -50°C; for **propylene glycol**, it should be less than -40°C;
- Determine & document the reserve alkalinity level of the glycol solution in the system at least once per year—add dipotassium hydrogen phosphate corrosion inhibitor solution as required in order to maintain a reserve alkalinity level, based on 100% glycol, greater than 9.0;
- Determine & document the iron & copper corrosion rates of the system if excessive corrosion is suspected—the iron corrosion rate should be less than 0.50 mpy, whereas the copper corrosion rate should be less than 0.20 mpy.