

Effect of Water Type on On-site Dilution of Glycol-based Heat Transfer Fluids

Glycol-water heat transfer fluids are widely used across various industries including HVAC systems, industrial chillers, process heating and cooling applications, and data centers. The glycol concentration in these fluids provides critical benefits such as freeze protection at low temperatures, burst protection, an extended operating temperature range, high boiling point, and low vapor pressure. Customers often request inhibited propylene glycol, ethylene glycol or bio-based glycol concentrates for their closed loop systems which can then be diluted on-site to achieve the desired glycol concentration. There are several advantages to performing on-site dilution or blending of glycols:

- i. **Cost Savings:** By shipping concentrates instead of pre-diluted fluids, customers save on shipping costs, as they are not paying to transport water weight.
- ii. **Custom Concentrations:** Glycol concentrates can be diluted on-site to desired concentrations depending on the customer's need for specific thermo-physical properties such as freeze point, burst point and heat transfer efficiency.
- iii. **Storage Efficiency:** Storing concentrated glycol takes up less space compared to pre-mixed solution, which can be beneficial for facilities with limited storage areas.
- iv. **System Adaptation:** If system requirements change, the glycol concentration can be modified on-site using either an inhibited glycol concentrate (to increase the concentration) or water (to decrease the concentration).

Selection of the right type of water is crucial for maintaining system efficiency and longevity. ASTM D8039¹ outlines the quality of water needed for predilution (by manufacturer) as well as on-site dilution or blending (by end-user) of glycol-based heat transfer fluids used in HVAC applications. Some of the important criteria for water used for dilution can be summarized as follows in Table 1.

Table 1: Recommended water quality for dilution of glycol heat transfer fluids.

Water Quality	Prediluted	On-site Dilution
Total Solids	-	340
Total Hardness	20 ppm	170
Chloride	25 ppm	40
Sulfate	50 ppm	100
pH	5.5 to 8.5	5.5 to 9.0
Iron	1 ppm	-

The water properties in Table 1 such as total hardness, total dissolved solids (TDS), and certain ion concentration in the water have a big impact on the heat transfer systems.

Total hardness of water is the amount of dissolved calcium and magnesium present in the water and expressed as ppm of calcium carbonate. Soft water with total hardness < 60 ppm of calcium carbonate is ideal for predilution as it limits the chances of corrosion and scale buildup while higher hardness of the water (> 120 ppm of calcium carbonate) increases the chances of fouling and interaction with certain corrosion inhibitors. Kapustenko et. al. discussed fouling of heat exchangers in different types of water². Figure 1 shows an example of fouling of a plate and frame heat exchanger². Typically, a scale thickness of 0.01 inch can lead to a 10% drop in heat transfer efficiency³. Higher pumping power is then needed to compensate for the loss of efficiency and increasing energy usage. Total (Dissolved) Solids (TDS) is another parameter that should be monitored in different types of water. TDS is directly proportional to the electrical conductivity of the water. High TDS value means higher concentration of dissolved ions, which can cause scaling, corrosion deposits and clogging of pipes leading to shutdown times and maintenance. Presence of dissolved anions such as chloride (>100 ppm) and sulfate (~ 100 ppm) can increase the chances of localized corrosion such as pitting and crevice corrosion in copper, steel and aluminum⁴⁻⁶. Copper plumbing pipes are often affected by pitting corrosion in the presence of chloride and other contributing parameters⁷ leading to pinhole leaks in the piping. Figure 2 shows an example of copper pit under the pit cap/corrosion product⁷.

The following is an overview of various types of water: **deionized water**, **well water**, **potable water**, **distilled water**, and **RO water**, and their potential effect on closed-loop systems:

1. Deionized (DI) Water:

Deionized (DI) water is strongly recommended for performing any dilution or blending with glycol. DI water is also preferred by most of the heat transfer manufacturers or blenders when preparing the prediluted coolant. The deionization process by passing water through mixed bed ion exchange resin ensures that the DI water has very low electrical conductivity (< 1 $\mu\text{S}/\text{cm}$) and free of almost all types of dissolved ions (Table 1, prediluted column). DI water has TDS value almost zero with very low water hardness. When DI water is mixed with glycol and inhibitors it provides maximum corrosion protection without any loss of heat transfer efficiency. Use of DI water is essential for low conductivity electrical applications to prevent shorts and thermal runaways in case of accidental spills or leaks.

2. Well/Ground Water

Well Water is generally not recommended for dilution or blending with glycol due to their abundant mineral content leading to high water hardness, typically > 180 ppm calcium carbonate⁸ and TDS > 1,000 ppm⁹. Groundwater sourced from a well, is typically rich dissolved minerals (such as calcium, magnesium, and iron) and other impurities depending on the geology of the area. U.S. Environmental Protection Agency (USEPA) has set a maximum limit of 250 ppm of chloride for drinking, a small percent (2.5%) of the wells (in urban area) exceeds that concentration due to various contaminants¹⁰. All these minerals and ions can cause corrosion and fouling in the HVAC systems along with adverse reactions with the inhibitor package causing clogging of pipes. Due to the ease of availability in rural areas and low prices, customers sometimes might have to settle for Well Water for dilution purposes. It is recommended to do a quality check on this water and consult with your heat transfer fluid manufacturer before using

this water. Purification methods such as particulate filtration, deionization and/or water softening methods are strongly recommended before using Well Water.

3. Potable/Tap Water/City Water

Though recommended for drinking, Potable Water should not be the first choice for glycol blending and dilution. Potable water is treated to remove harmful contaminants, but it contains dissolved ions such as chloride and calcium which are responsible for pitting corrosion and scaling of the pipes. Along with the natural sources, the surface/potable water is also affected by the deicing salt runaways leading to wide variation in the chloride concentrations (average concentrations 100 to 200 ppm chloride)¹⁰. Typically, the hardness of Potable Water is > 100 ppm¹⁰ and TDS between 200 to 400 ppm¹¹. Like Well Water, the quality of the Potable Water can vary with region, and it is necessary to do a water quality check and possibly purification before using Potable Water for heat transfer applications.

4. Distilled Water

Distilled Water can be used for blending and dilution of glycol-based heat transfer applications. Distilled Water is produced by boiling water into steam and condensing that steam back into liquid water. The distillation process removes both organic and non-organic dissolved contaminants, so the properties of the distilled water are comparable to that of DI water as shown in Table 1, prediluted column. The distillation process ensures high purity of the distilled water and when this type of water is present in a closed loop system, chances of corrosion, scaling and fouling are significantly reduced. When compared to DI Water, Distilled Water is more expensive due to the energy intensive distillation process.

5. Reverse Osmosis (RO) Water

RO Water is another type of high purity, processed water that can be used for on-site blending of glycol with water quality very simi. RO or Reverse Osmosis water is produced by passing the water through a semi-permeable membrane (such as carbon filter) which only allows the water molecules to go through and blocks contaminants, and dissolved ions. One advantage of RO Water is that it can be produced readily from various types of water sources including municipal water, sea water, brackish water, boiler feed water, wastewater etc. The RO water specifications can match with those in Table 1, prediluted but it is dependent on the type of the feed water used. When compared to the widely used deionization process, an RO system requires more capital and maintenance. The corrosion and heat transfer benefits of the RO water are similar to DI Water, but it comes to the customer at a higher cost.

Summary

In summary, selection of the right type of water is critical for the optimal performance of a heat transfer system as it reduces scaling, fouling, pitting and other types of corrosion. Scaling and fouling also affects heat transfer efficiency adversely and might require frequent costly maintenance of the system. DI water is strongly recommended for blending inhibited glycol

concentrates. Distilled and RO water can be good alternatives to DI water at an added expense. Since the quality of the Groundwater and Potable Water vary from region to region and these types of water sources often have high dissolved mineral and ion concentration, please consult with your heat transfer manufacturer before using them for blending.

References:

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Figures:

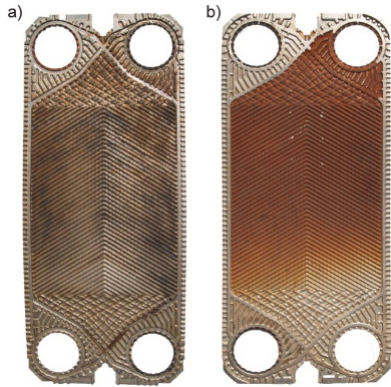


Figure 1: Fouling of Plate and Frame Heat Exchanger by water [Ref 2].

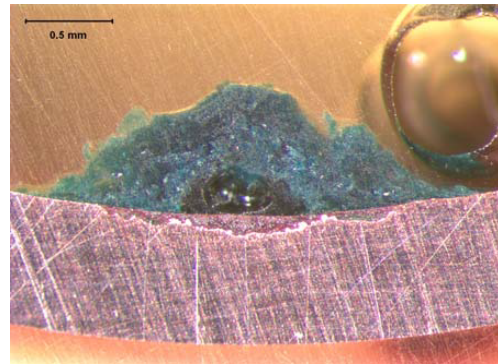


Figure 2: Copper pit formation under corrosion cap in presence of water-glycol mixtures [ref 4]