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the ANALYST
THE VOICE OF THE WATER TREATMENT INDUSTRY
2003 Summer

Which to Use: Ethylene Glycol or Propylene Glycol

By Stephen M. Pescatore, Houghton Chemical Corporation

Definition of Inhibited Industrial Glycols
Heat transfer and antifreeze fluids containing a balanced inhibitor system to protect the common metals of construction. These fluids are typically diluted with water to provide for antifreeze and enhanced heat transfer properties.

Inhibited ethylene glycol solutions are normally preferred over propylene glycol solutions because of their more desirable physical properties, particularly at lower temperature. However, in certain applications involving possible contact of the coolant with foods or beverages, stipulation should be given to the use of propylene glycol. Propylene glycol appears on the list of substances "generally recognized as safe" for use in food or food processing applications as published by the FDA.

The ability of both ethylene and propylene glycol to lower the freezing point of water, together with their relatively low vapor pressure and high boiling points, constitute the most important physical properties of these compounds. Their aqueous solutions are, therefore, applicable over a wide temperature range from -60°F to +300°F depending, of course, upon the concentration and the type of system the product is used.

Certain features in connection with these properties may be noteworthy. It should be noted that pure ethylene glycol has a freezing point of about +9°F. Inhibited glycols usually contain a small proportion of water (2 - 4%) and hence would not be expected to freeze unless exposed to temperatures somewhat below 0°F. Propylene glycol is more difficult to crystallize; however, solutions containing 60 - 100% of this glycol will increase in viscosity until they become glass – like solids.

The freezing point vs. composition curve for aqueous ethylene glycol solutions indicates the occurrence of a eutectic, i.e., the point at which water and glycol crystallize together. On the dilute side of the eutectic, ice forms upon freezing while on the concentrated side, solid glycol separates from solution when the freezing point is reached.

The lowest possible freezing point occurs at the eutectic, but due primarily to their viscous nature, solutions of approximately 60 to 80 percent ethylene glycol, which includes the concentration of the eutectic mixture, have low and difficult-to- determine freezing points.

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Ethylene glycol is more effective than propylene glycol at depressing the freezing point of water, as seen below.

Desired Aqueous Solution Freezing Temperature, °F	Wt. % Ethylene Glycol Required	Wt. % Propylene Glycol Required
20	16	19
10	25	29
0	33	36
-10	40	43
-20	45	48
-30	49	52
-40	53	55
-50	56	58

The freezing point is understood to be that initial (equilibrium) temperature at which the first crystals appear.

Other glycols, such as triethylene glycol, also possess the ability to lower the freezing point of water, but they are not as efficient. For this reason they are not normally used as freezing point depressants; however, they are useful in other areas such as gas and air dehydration.

From the high temperature standpoint, unlike aqueous solutions of methanol or other low boiling alcohols, vapor compositions above boiling glycol solutions of normal dilutions (25 - 65 per cent) are significantly low in glycol content. Since evaporation losses could be appreciable in certain vented or open applications, care should be taken to avoid excessive concentration of the solution. In this connection the use of distilled, de-ionized, or condensate water as makeup will alleviate the buildup of undesirable matter which may be deleterious to the performance of the contained corrosion inhibitors.

Viscosity Comparison between Ethylene and Propylene Glycol (60%)	
Temperature	**Viscosity, 60% P.G.**
0° F	3 x E.G.
-20° F	6 x E.G.
-40° F	9 x E.G.

Viscosity is one of the most important characteristics of coolants because of its influence on the ability to be pumped and heat transfer capability. Aqueous glycols are more viscous than water alone and their viscosities become greater as the glycol content is increased and/or the temperature is lowered. Ethylene glycol solutions are normally considered as pumpable down to freezing points commonly encountered under ambient

conditions. However, where continuous operation at low temperature is anticipated, an increase in pump horsepower is generally allowed.

Propylene glycol solutions become considerably more viscous than ethylene glycol solutions at low temperatures; thus, their use in industrial systems operating in the range of 0ºF or below should be carefully evaluated with respect to pumping requirements.

One of the physical properties most frequently encountered or required in dealing with glycol solutions is that of specific gravity. Bearing a direct relationship to density, specific gravity data are essential in the calculation of a number of engineering expressions such as film coefficients of heat transfer, for example. But even in a more basic way specific gravity measurements are extremely useful in that one can approximate rather quickly the glycol concentration of a given solution.

Propylene glycol solutions on the other hand are not particularly well suited for the determination of glycol content by gravity measurement. Small changes in specific gravity measurement produce rather large changes in propylene glycol content. Obviously, unless extreme care is taken in the measurement, a significant error can be induced.

A simple and more reliable determination of propylene glycol content can be made by the use of an optical refractometer. Refractive index is the preferred laboratory method for both glycols, but the Karl Fischer method for determination of water content is also helpful, particularly for badly contaminated fluids.

The Environmental Protection Agency has listed ethylene glycol as a hazardous chemical. It has a reportable quantity (RQ) for spills of 5,000 pounds or more. Propylene glycol does not appear on the hazardous chemical list. Ironically, even though ethylene glycol is listed due to its toxicity, the environmental harm caused by the product contaminating an ecological area is less than propylene glycol because its decomposition rate is faster by half. Thereby having a far lower Biological Oxygen Demand (BOD) than propylene glycol.

In summary both products have pros and cons for their use. Where toxicity is an issue or there is an immediate environmental concern, propylene glycol should be the product of choice. If these concerns are not an issue then ethylene glycol should be considered because of its superior physical attributes.

About the Author

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Analyst – Summer 2003
Which to use: Ethylene Glycol or Propylene Glycol

1. **What is the generally accepted range of Temperature that ethylene and propylene glycol is effectively used?**
    a. -40 C to + 100 C
    b. 0 F to 160 F
    c. -60 F to +300 F
    d. -0 C to 300 C

2. **Propylene glycol is more difficult to crystallize than ethylene glycol, but solutions containing 60-100% of this glycol will increase in viscosity until they become glass like solids.**
    a. True
    b. False

3. **What is a "eutectic."**
    a. A point of maximum glycol concentration.
    b. A point at which water and glycol crystallize together.
    c. A point where glycol breaks down to acidify system water.
    d. A what?

4. **What is understood to be the initial (equilibrium) temperature at which the first crystals appear in a solution?**
    a. Slushing point
    b. Point of dynamic inhibition
    c. Freezing point
    d. Absolute zero

5. **The viscosity of a glycol solution _____ as the glycol content increases.**
    a. is reduced
    b. stays the same
    c. increases with temperature only
    d. increases

6. **Which statement is true concerning Propylene Glycol?**
    a. It is well suited for the determination of glycol content by gravimetric measurements.
    b. It is less viscous than ethylene glycol
    c. It should be used where toxicity is an issue.
    d. It is more effective than ethylene glycol at depressing the freeze point of water.

7. **The reportable quantity (RQ) for ethylene glycol spills is 5000 lbs. or more, what is the RQ for propylene glycol?**
    a. 10,000 lbs.
    b. 1,000 lbs.
    c. 10 lbs
    d. Doesn't not appear on the RQ list

8. **Which glycol, ethylene or propylene, is less environmentally harmful because it has a faster decomposition rate?**
    a. ethylene glycol
    b. propylene glycol

9. **Where toxicity is an issue or where there is immediate environmental concern, which glycol is considered a better choice.**
    a. ethylene glycol
    b. propylene glycol

10. **A more simple and reliable test procedure for determining propylene glycol content other than specific gravity would be?**
    a. film coefficients of heat transfer
    b. freeze point check
    c. optical refractometer
    d. the Karl Usinger method