THE GLYCOL MANUAL

For use by the Practical Mechanical Contractor

Covering both Ethylene Glycol and Propylene Glycol

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Overview

In the HVAC and Mechanical Construction world, glycols are used primarily to protect heating and cooling systems from freezing. The two glycols most commonly used in these applications are Ethylene Glycol and Propylene Glycol.

Glycols are used in a variety of applications in many other parts of industry. There are seven types of "simple structure" glycols. After Ethylene and Propylene, they are Diethylene, Triethylene, Tetraethylene, Dipropylene, and Tripropylene Glycol.

These five, however, are not generally used in HVAC applications. They are not used due to their extremely poor heat transfer properties. Therefore, we will not be concerned with them for purposes of this manual.

This manual will focus on the properties of interest for Ethylene and Propylene Glycol with respect to HVAC applications.

Introduction

The two most important properties are the specific heat (a measure of the efficiency of heat transfer) and the freezing point depression.

We will discuss the differences between Ethylene and Propylene and explains when one or the other should be used in a particular application.

Of particular importance to proper usage in heat transfer applications is the additives (normally called inhibitors) that can be used in glycol. An area is devoted to this topic.

System maintenance is also of particular concern in these applications – you'll find information on proper system maintenance.

Specific Heat

The specific heat of a substance is a measure of how much heat is required to raise a given amount of the substance 1º in temperature. Today this is generally measured in cal/g/ºC (calories per gram per degree Centigrade), although BTU/lb/ºF (British Thermal Units per pound per degree Fahrenheit) are still used in many areas.

Water is defined to have a specific heat of 1 cal/g/ºC. All other substances are then measured versus water.

If the specific heat is less than 1 cal/g/ºC then that substance has the ability to hold less heat than water. Values larger than 1 cal/g/ºC indicate that the substance can hold more heat than water.

Unfortunately, the specific heats of Ethylene and Propylene Glycol are both lower than 1 cal/g/ºC. The exact value varies with temperature, but is always less than 1.

So, the glycols have the ability to hold less heat (energy) per gram than water. Thus, they cannot transfer as much heat as water without a greater increase in temperature.

When transferring heat efficiently is the goal, this property of the glycols is bad. **As the amount of glycol used in the system is increased, the ability to transfer heat is decreased.**

Of the seven glycols, Ethylene and Propylene have the highest specific heat. This is one of the reasons these two are selected for use in heating and cooling applications.

Freeze Point Depression

We all know that water freezes at 32ºF. It is a common experience that when the temperatures are cold in the winter, water freezes (snow, ice on the roads, etc.)

One of the many interesting phenomenon in nature is that when you add/mix things with water, the freezing point drops from 32ºF to some temperature that is lower. How much lower depends on what is added and how much of it is added.

When glycol is mixed with water, the freeze point also drops. The amount of the depression (drop in freeze point) is dependant on two factors:

1) The type of glycol used
2) The concentration, or percent of glycol

Both Ethylene and Propylene glycol lower the freezing point of water. Please refer to the tables to determine the new "freezing point" based on the amount and type of glycol.

Freezing point was put in quotes above, because glycol:water solutions don't have a well defined freezing point. When an ethylene glycol:water solution approaches its "freezing point" it supercools instead of freezing. Propylene glycol:water solutions form a semi-fluid glass-like solid.

The freezing point is the temperature at which the glycol:water solution will no longer flow properly.

Because the glycol solutions don't have a well-defined freeze point, another temperature, the burst point, is defined for the solutions.

As water freezes, it expands and the pipe that contains it can burst. With glycol solutions, this expansion (to the point of breaking pipes) occurs at a temperature lower than the freeze point.

The burst point is the temperature at which the piping in the system will burst due to expansion of the solution.

Ethylene Glycol Properties

Ethylene glycol's chemical formula is $C_2H_6O_2$. It is a clear viscous liquid at ambient temperature.

Ethylene glycol is poisonous to people and small animals if it is ingested. Therefore it should not be swallowed in any quantity.

For this reason, ethylene glycol is not generally used in heat transfer systems where a leak could lead to environmental contamination.

Propylene Glycol Properties

Propylene glycol's chemical formula is $C_3H_8O_2$. Like ethylene it is also a clear viscous liquid at normal temperatures.

The heat transfer capability of propylene glycol is less than ethylene glycol. Also, more propylene glycol is required to achieve the same freeze point. For example to achieve a freeze point of 0°F, requires 36% propylene glycol, but only 32% ethylene glycol).

However, propylene glycol is a G.R.A.S. compound. That is, it is Generally Regarded As Safe. Next time you shower, look to see if propylene glycol is listed as an ingredient…or check out the label of your cough syrup, make-up, sun screen lotion, packaged food…

Propylene glycol is used in heat transfer systems where:

1. freeze protection is required
2. a fluid that is "safe" to consume is desired.

Most breweries, dairies, food-processing facilities utilize propylene glycol. It is used in most snow-melt systems to avoid environmental contamination by ethylene glycol should a leak develop.

Because of the differing heat transfer characteristics of propylene and ethylene glycol (and the changes in viscocity and heat transfer ability of different percentage solutions) **systems should be maintained with the type and amount of glycol that they were designed to contain.**

Additives (Inhibitors)

Glycol and water are not the only compounds in a “glycol-filled system.” Inhibitors are added to the raw (ethylene or propylene) glycol when it is going to be used in heat transfer systems.

Two types of inhibitors are used (only one type is used in food-processing applications). One is added to help prevent the glycol from breaking down in the system. The other is to help protect the system from corrosion.

When heated, both ethylene and propylene glycol will decompose (by oxidation) and form by-products that are damaging to piping systems. **The first type of inhibitor prevents glycol decomposition by buffering the solution.**

It keeps the pH of the solution in the system up around 8.8-10. In this range, both ethylene and propylene glycol are “happy.” The decomposition of the glycol is slowed to a stand-still and any decomposition products are prevented from damaging the system.

Without this type of inhibitor in the proper amount, the glycol will decompose very quickly and the pH of the solution will become acidic. This causes general corrosion of the piping in the system and creates a foul-smelling mess. Soon after this process begins, leaks develop in the system.

Dipotassium Phosphate and Boron are industry recognized as two chemicals that are acceptable for use in preventing the decomposition of the glycol.

In the properly buffered pH range, mild steel will exhibit very little corrosion. So any mild steel or black iron piping in the system does not require any further protection. However, **the second type of inhibitor is added to prevent corrosion** of copper components of systems.

Dyes (often pink, green, or yellow) can also be added to the glycol upon request to that owners can easily tell the difference between the glycol solution and water systems.

System Care

Heat transfer systems that contain glycol:water solutions can give the owner/service contractor many years of worry-free operation. This will only be the case if a few easy steps are taken to assure the glycol is properly cared for. “An ounce of prevention is worth a pound of cure,” or a ton of cure as the case may be.

Preventative maintenance for these systems with respect to the glycol solution should be aimed to achieve:

1. Assurance of proper freeze protection.
2. Prevent decomposition of the glycol.
3. Prevent system corrosion.
4. Prevent system erosion.

The first three of these can be achieved by having the solution analyzed by a qualified laboratory on an annual basis. Systems with problems should be sampled on a more frequent basis until the problems are resolved.

A good laboratory report of the test results and an accompanying interpretation sheet will provide information about freeze/burst point, inhibitor level, and warn of signs of system corrosion.

System erosion can be minimized by the installation of a side-stream cartridge filter. A unit of this type will remove the particles in the system that are causing erosion – scraping away of the inside of pipes and pump impellers.

For existing systems it is often too late to start right, but proper care beginning today can help prolong the system’s longevity and increase it’s efficiency.

For information on how to get started right or more information on how to properly maintain existing systems, contact Enerco Corporation. 317 N. Bridge St. Grand Ledge MI 48837 toll-free phone: (800) 292-5908 fax: (517) 627-6405 email: admin@enercocorp.com

Ethylene Glycol Table

% (v/v) Ethylene Glycol	% (v/v) E-8006	Freeze Point °F	Burst Point °F
47.5	50	-29	-60
45.6	48	-24	-60
43.7	46	-20	-60
41.8	44	-15	-60
39.9	42	-12	-60
38.0	40	-9	-60
36.1	38	-6	-60
34.2	36	-3	-60
32.3	34	0	-60
30.4	32	+3	-60
28.5	30	+5	-20
26.6	28	+8	-15
24.7	26	+10	-10
22.8	24	+13	-5
20.9	22	+15	0
19.0	20	+17	+4
17.1	18	+19	+8
15.2	16	+21	+12
13.3	14	+22	+15
11.4	12	+24	+18
9.5	10	+26	+21
7.6	8	+27	+23
5.7	6	+28	+25
3.8	4	+30	+28
1.9	2	+31	+30
0	0	+32	+32

Propylene Glycol Table

% (v/v) Propylene Glycol	% (v/v) E-8406	Freeze Point °F	Burst Point °F
47.5	50	-22	-60
45.6	48	-18	-60
43.7	46	-14	-60
41.8	44	-10	-60
39.9	42	-7	-60
38.0	40	-3	-60
36.1	38	0	-60
34.2	36	+3	-60
32.3	34	+6	-30
30.4	32	+8	-25
28.5	30	+10	-20
26.6	28	+12	-10
24.7	26	+14	-5
22.8	24	+16	0
20.9	22	+18	+5
19.0	20	+20	+10
17.1	18	+22	+10
15.2	16	+24	+15
13.3	14	+26	+20
11.4	12	+27	+20
9.5	10	+28	+25
7.6	8	+28	+25
5.7	6	+29	+28
3.8	4	+30	+30
1.9	2	+31	+31
0	0	+32	+32