

Glycol Heat-Transfer Fluids

Ethylene Glycol versus Propylene Glycol

Water is probably the most efficient heat-transfer fluid known. If it did not freeze, water would be the ideal heat-transfer fluid for cooling applications. When freeze conditions exist (<35 F), ethylene glycol and propylene glycol can be added to water to provide freeze protection and burst protection. Both glycols have lower heat-transfer efficiencies than water and are more dense, resulting in higher volumetric flowrates or heat-exchange areas required to maintain the same temperature levels (see Tables 1 and 2). Higher flowrates lead to higher pressure drops, energy consumption, and equipment wear. As a result, it is important to accurately determine the minimal concentration of glycol needed to do the job in order to maintain system efficiency.

Between the two, ethylene glycol (C₂H₆O₂) is a better heat transfer fluid than propylene glycol (C₃H₈O₂). Propylene glycol is less toxic and is considered when toxicity is a concern.

Table 1 - Ethylene Glycol Versus Propylene Glycol Thermal Conductivities

Temperature (F)	Ethylene Glycol Thermal Conductivity [Btu/(hrft ²)(F/ft)] at 30% Volume	Propylene Glycol Thermal Conductivity [Btu/(hr ft ²)(F/ft)] at 30% Volume
10	0.238	0.235
20	0.243	0.239
30	0.247	0.243
40	0.251	0.247
50	0.255	0.251
60	0.259	0.254
70	0.263	0.258
80	0.266	0.261

Table 2 - Flow Increases Necessary to Achieve Same Heat Transfer as Pure Water

Percent Solution at 50F	Ethylene Glycol Volume Flow Increase vs. Water	Propylene Glycol Volume Flow Increase vs. Water
0	1.00	1.00
10	1.020	1.008
20	1.050	1.014
30	1.090	1.043
40	1.140	1.075
50	1.210	1.132

Water Quality: High quality water will help maintain system efficiency and prolong glycol fluid life. Recommended water characteristics include:

- ❑ Less than 50 ppm calcium (as CaCO₃),
- ❑ Less than 50 ppm magnesium (as CaCO₃),
- ❑ Less than 100 ppm total hardness (as CaCO₃),
- ❑ Less than 25 ppm chloride (as CaCO₃), and
- ❑ Less than 25 ppm sulfate (as CaCO₃).

Freeze Protection Versus Burst Protection: Water volume expands by 9% when frozen. Glycols depress water's freezing point providing protection to temperatures as low as -70 F to -100 F.

Freeze protection prevents ice crystal formation at the lowest temperature expected in the coolant circuit. This type of protection is necessary for year-round pumping. Continuous pumping will also prevent freezing but is costly and risky because of possible power failures.

Burst protection requires less glycol and allows some freezing to turn the coolant into a slush that is not easily pumped, but will not cause the pipe to burst. This method is used in closed circuits that are not operated in cold weather.

Corrosion: All glycols produce acids in the presence of air (oxidants). The acids can reduce pH and cause corrosion. When the system pH drops below 7, rust will form on any ferrous metal, and nonferrous metals start to corrode. For HVAC applications, glycols are formulated with passivating and buffering corrosion inhibitors to counteract acids formed by the oxidation of glycols.

System Monitoring: Glycols can typically be expected to last 12 years or longer, providing corrosion inhibitor strength is maintained. Inhibitor analysis is usually offered as a free service by glycol manufacturers.

Glycol fluid pH can be a good barometer for the condition of the glycol. Although the pH is primarily a function of the corrosion inhibitor and, therefore, will vary from product to product, a few rules of thumb are helpful in determining what constitutes proper pH.

Most concentrated inhibited glycols have a pH in the range of 9.0 to 9.5. A pH reading below 8.0 indicates that a significant portion of the inhibitor has been depleted and that more inhibitor needs to be added.

When the pH falls below 7.0, most manufacturers recommend replacing the fluid. A pH value of less than 7.0 indicates that oxidation of the glycol has occurred. The system should then be drained and flushed before severe damage occurs.

Should the system require cleansing after removing old or damaged antifreeze, flush the system with a heated 1% to 2% solution of trisodium phosphate for two to four hours then drain and rinse thoroughly.

Analysis: Inhibitor analysis is usually offered as a free service by glycol manufacturers with the assumption that you will buy any new glycol from them. They typically perform a GC analysis. To determine the type of glycol in your system, Bowser-Morner, Inc. will do an IR scan for \$50. Houghton Chemical Corporation sells glycol freeze protection testers and will do the analysis too (617-254-1010).

Mixing Glycols: Do not mix ethylene and propylene glycols in the same system.

Other Considerations: Automatic makeup water systems should be avoided to prevent undetected dilution or loss of glycol.

Do not use automotive-type glycols. These glycols are formulated with silicates which tend to gel, reducing heat-transfer efficiency.

ETHYLENE GLYCOL

Typical Physical Properties of Aqueous Solutions

Volume %	Weight %	Freeze Point		Burst Protection		Boiling Point	
		F	C	F	C	F	C
0	0	32.0	0.0	32.0	0.0	212.0	100.0
10	11.1	24.2	-4.3	20.0	-5.0	212.6	100.2
20	22.0	14.9	-9.5	5.0	-15.0	215.1	101.7
25	27.3	9.3	-12.6	-5.0	-20.0	216.7	102.5
26	28.4	8.1	-13.3	-10.0	-20.0	217.0	102.7
27	29.5	6.9	-13.9	-10.0	-20.0	217.3	102.9
28	30.5	5.7	-14.6	-10.0	-25.0	217.6	103.1
29	31.6	4.4	-15.4	-15.0	-25.0	217.9	103.2
30	32.6	3.0	16.1	-15.0	-25.0	218.2	103.4
31	33.7	1.6	-16.9	-20.0	-25.0	218.5	103.6
32	34.7	0.2	-17.7	-20.0	-25.0	218.9	103.8
33	35.8	-1.2	-18.5	-20.0	-30.0	219.2	103.9
34	36.8	-2.8	-19.3	-25.0	-30.0	219.5	104.1
35	37.8	-4.3	-20.2	-30.0	-30.0	219.8	104.3
36	38.9	-6.0	-21.1	-35.0	-35.0	220.1	104.5
37	39.9	-7.6	-22.0	-40.0	-40.0	220.4	104.6
38	40.9	-9.4	-23.0	-45.0	-40.0	220.8	104.8
39	42.0	-11.2	-24.0	-55.0	-45.0	221.1	105.0
40	43.0	-13.1	-25.0	-65.0	-55.0	221.4	105.2
41	44.0	-15.0	-26.1	-75.0	-60.0	221.7	105.4
42	45.0	-17.0	-27.2	-90.0	-65.0	222.1	105.5
43	46.1	-19.1	-28.4	-100.0	-75.0	222.4	105.7
44	47.1	-21.3	-29.6	<-100	<-75	222.7	105.9
45	48.1	-23.5	-30.9	<-100	<-75	223.1	106.1
46	49.1	-25.9	-32.2	<-100	<-75	223.5	106.3
47	50.1	-28.3	-33.5	<-100	<-75	223.9	106.5
48	51.1	-30.8	-34.9	<-100	<-75	224.2	106.7
49	52.1	-33.5	-36.4	<-100	<-75	224.6	106.9
50	53.1	-36.2	-37.9	<-100	<-75	225.1	107.2
51	54.1	-39.1	-39.5	<-100	<-75	225.5	107.4
52	55.1	-42.0	-41.1	<-100	<-75	226.0	107.6
53	56.1	-45.1	-42.8	<-100	<-75	226.4	107.9
54	57.1	-48.3	-44.6	<-100	<-75	226.9	108.1
55	58.1	-51.6	-46.5	<-100	<-75	227.4	108.4
56	59.1	-55.1	-48.4	<-100	<-75	228.0	108.7
57	60.1	-58.7	-50.4	<-100	<-75	228.6	109.0
58	61.0	-62.4	-52.4	<-100	<-75	229.2	109.4
59	62.0	-66.3	-54.6	<-100	<-75	229.8	109.7
60	63.0	-70.3	-56.8	<-100	<-75	230.5	110.1
61	64.0	<-70	<-60	<-100	<-75	231.2	110.4
62	64.9	<-70	<-60	<-100	<-75	232.0	110.9
63	65.9	<-70	<-60	<-100	<-75	232.8	111.3
64	66.9	<-70	<-60	<-100	<-75	233.6	111.8
65	67.8	<-70	<-60	<-100	<-75	234.5	112.2
70	72.6	NA	NA	NA	NA	239.9	115.2
80	82.0	NA	NA	NA	NA	256.4	124.2
90	91.1	NA	NA	NA	NA	284.0	139.6
100	100.0	-12.3	-24.6	NA	NA	327.7	164.0

PROPYLENE GLYCOL**Typical Physical Properties of Aqueous Solutions**

Volume %	Weight %	Freeze Point		Burst Protection		Boiling Point	
		F	C	F	C	F	C
0	0.0	32.0	0.0	32.0	0.0	212.0	100.0
10	10.4	28.4	-2.0	20.0	-7.0		
16	16.5	22.3	-5.4	10.0	-12.0		
20	20.6	20.0	-6.6			214.0	100.1
21	21.6	19.0	-7.2				
22	22.6	18.0	-7.7	0	-18		
23	23.6	17.0	-8.3				
24	24.5	16.0	-8.8			215	100.6
25	25.5	15.0	-9.4				
26	26.5	14.0	-9.9				
27	27.4	13.0	-10.5				
28	28.4	12.0	-11.0				
29	29.4	11.0	-11.6	-10	-23	216	101.2
30	30.3	9.0	-12.7				
31	31.3	8.0	-13.2				
32	32.3	7.0	-13.8				
33	33.3	5.0	-14.9				
34	34.3	4.0	-15.4			217	101.75
35	35.3	2.0	-16.5	-20	-29		
36	36.2	1.0	-17.1				
37	37.2	-1.0	-18.2				
38	38.2	-3.0	-19.3			218	102.3
39	39.2	-4.0	-19.8	-30	-34		
40	40.2	-6.0	-20.9				
41	41.2	-8.0	-22.0	-40	-40	219	102.85
42	42.2	-10.0	-23.1	-50	-46		
43	43.2	-12.0	-24.2				
44	44.1	-14.0	-25.3	-60	-51	220	103.4
45	45.1	-16.0	-26.4				
46	46.1	-18.0	-27.5				
47	47.1	-20.0	-28.6			221	103.95
48	48.0	-22.0	-29.7				
49	49.0	-25.0	-31.4				
50	50.0	-27	-32.5			222	104.5
51	51.0	-29	-33.6				
52	52.0	-32	-35.2			223	105.05
53	53.0	-34	-36.3				
54	54.0	-36	-37.4			224	105.6
55	55.0	-39	-39.1				
56	56.0	-41	-40.2			225	106.15
57	57.0	-44	-41.8				
58	58.0	-47	-43.5			226	106.7
59	59.0	-50	-45.1				
60	60.0	-53	-46.8			227	107.25
61	61.0	NA	NA				
62	62.1	NA	NA			228	107.8
63	63.1	NA	NA				
64	64.1	NA	NA			229	108.35
65	65.1	NA	NA			230	108.9
100	100	-60	-51			323	162