NORKOOL®

Industrial Products

A Comparison of Ethylene Glycol and Propylene Glycol Heat Transfer Fluids

As coolants, corrosion inhibitors, and cleaners, NORKOOL® and NORCHEM™ Products set the standards in quality and performance, in unmatched technical expertise, and in industry-leading service.

With over 60 years experience in ethylene glycol, Union Carbide has an unparalleled record of meeting customer needs. In fact, NORKOOL Products are endorsed by many equipment manufacturers because of our continued dedication to solving coolant and cleaning needs in the field.

A total service package includes free sample analyses for trouble-free system performance. Our state-of-the-art automated laboratory provides the fastest, most accurate and comprehensive test program for heat transfer fluids available today. Our broad distribution network in the U.S. and Canada means product when and where you want it.

NORKOOL Coolants and NORCHEM Inhibitors—products that perform and save you money!

Introduction

Inhibited glycol solutions are widely used for engine cooling and other heat transfer applications in which low temperature (<32°F) protection is needed. Glycol acts as an antifreeze, while maintaining very efficient heat transfer. These inhibited glycol solutions, such as Union Carbide's NORKOOL® Industrial Coolants, contain a balanced corrosion inhibitor system to protect the common metals of construction. Glycol-based heat transfer fluids must be diluted prior to use to provide adequate freeze protection and enhanced heat transfer characteristics.

For engine cooling and other industrial applications, ethylene glycol (EG) is the glycol of choice; ethylene glycol-based coolants are normally preferred over propylene glycol (PG)-based coolants because of their more desirable physical properties, particularly at lower temperatures. However, where there is a reasonable expectation that the HTF may become a component of food or potable water, food-grade propylene glycol coolants must be used. PG-based industrial coolants contain non-food-grade corrosion inhibitors, which can be harmful if swallowed. Therefore, if contact with food is required, a food-grade PG coolant must be specified. However, these food-grade coolants will not provide the high standard of corrosion protection that industrial coolants provide.

A comparison of the properties of ethylene glycol versus propylene glycol and their relationship to heat transfer characteristics and applications follows.

UNION CARBIDE **Union Carbide Corporation** • 39 Old Ridgebury Road • Danbury, CT 06817-0001

Cavitation Protection

Cavitation corrosion of power cylinder liners is a phenomenon caused by the motion of the wet sleeve liner following the piston head rocking on the wrist pin and striking the liner. During the motion of the liner, an air bubble may form. When the bubble collapses or implodes, the energy from the implosion causes the liquid to impinge on the surface of the liner. This impingement has enough force to remove the protective corrosion inhibitor film or, in severe cases, gouge metal from the surface of the liner. Because this metal gouging, or corrosion, can be catastrophic due to perforations of the liner in high-speed engines, many methods for mitigating cavitation have been investigated.

Laboratory testing performed by suppliers of other commercially available fluids has shown some success in controlling cavitation through the use of industrial grade PG-based coolants that contain an inhibitor system similar to the inhibitors used in traditional ethylene glycol-based coolants. Despite apparent success during laboratory testing, field testing on the effectiveness of PG-based coolants has exhibited little success in mitigating cavitation. The corrosion inhibitors used in traditional coolants do not provide the protection required to prevent damage caused by the bubble implosion and fluid impingement. However, field testing has demonstrated that a different type of corrosion inhibitor, as found in EG-based NORKOOL® SLH Coolants and NORCHEM™ Inhibitors, protects against cavitation corrosion by forming a protective film that is much harder and more tightly adherent than the protective film formed by traditional inhibitors. Therefore, Union Carbide's NORKOOL/NORCHEM program of SLH coolants and inhibitors are much more effective in mitigating cavitation in high-speed engines than using a traditional PG-based coolant.

Freezing Point Characteristics

The ability of ethylene glycol and propylene glycol to lower the freezing point of water constitutes the most important physical property in coolant applications and the primary reason for using glycol-based heat transfer fluids. Pure uninhibited ethylene glycol has a freezing point of +9°F, whereas NORKOOL Industrial Coolants have a freezing point of –12.3°F. As water is added to these fluids, the freezing point decreases until about a 65% concentration of NORKOOL Coolant or ethylene glycol is reached. The addition of more water will then begin to increase the freezing point. The freezing points of these ethylene glycol fluids go through a minimum and thus give maximum freeze protection at a concentration of about 65% ethylene glycol.

Propylene glycol, on the other hand, does not exhibit this decreasing and increasing freezing point curve. As propylene glycol is added to water, the freezing point decreases continuously until a 60% solution is achieved. Propylene glycol solutions containing 60-100% glycol will dramatically increase in viscosity at low temperatures until they become glass-like solids. no specific freezing point can be measured on these solutions. Due to these freezing point characteristics, as well as other heat transfer properties, the most desirable concentration of either ethylene glycol or propylene glycol in heat transfer fluids ranges from 25-60% glycol.

Burst Protection

In addition to providing freeze point depression, glycol solutions give added protection against bursting. Upon freezing, water expands about 9% and thus may rupture piping and cause catastrophic system failure. The addition of glycol to the water significantly reduces the amount of expansion the solution undergoes upon freezing, and therefore reduces the likelihood of bursting.

Table 1 provides guidelines for freeze and burst protection for ethylene and propylene glycols. Freeze protection should be chosen when cold weather operation is anticipated; burst protection concentrations can be used in systems that are not operational during the winter months. Table 1 shows that on the average, 2-4% more propylene glycol is required in most cases to achieve the protection level given by ethylene glycol, due to ethylene glycol's superior ability to depress the freezing point of a glycol solution.

Table 1 • Freeze and Burst Protection of Ethylene and Propylene Glycols*

	Freeze Protection		Burst Protection	
Desired Protection, °F	% Ethylene Glycol	% Propylene Glycol	% Ethylene Glycol	% Propylene Glycol
20	16	19	11	10
10	25	29	16	16
0	33	36	21	22
–10	40	42	26	29
–20	45	46	31	35
–30	49	51	36	39
–40	53	55	37	41
–50	56	58	38	42
–60	—	—	40	44

* Measured on a typical sample

Viscosity

Viscosity is one of the most important properties of heat transfer fluids because of its influence on heat transfer characteristics and the ability to pump the fluid at low temperatures. Aqueous glycol solutions are more viscous than water, and their viscosities increase with increasing glycol concentration and decreasing temperature. Ethylene glycol solutions are normally considered pumpable down to their freezing points. However, where continuous operation at low temperatures is expected, an increase in pumping horsepower may be required. Propylene glycol is considerably more viscous than ethylene glycol at low temperatures, and thus its use in industrial systems operating at temperatures of 0°F or below should be carefully reviewed with respect to pumping requirements.

Temperature, °F	Viscosity of 60% Solutions, cP		
	Ethylene Glycol	Propylene Glycol	Difference
0	30	103	3 x EC
–20	63	400	6 x EC
–40	170	1500	9 x EC

In addition to these low-temperature pumping considerations, the higher viscosity of propylene glycol over the entire operating temperature range translates to lower heat transfer. Heat transfer is inversely related to the viscosity of the fluid. The increased viscosity results in a thicker surface film, and this film causes a decrease in heat transfer and cooling capacity. For turbocharged engines, this could result in detonation in the combustion chamber and necessitates a reduction in the load on the engine to counteract the reduction in cooling capacity and to prevent detonation. Thus, the higher viscosity of propylene glycol as compared to ethylene glycol causes the system to lose efficiency.

Overall Heat Transfer Coefficient

The heat transfer efficiency of a system is usually defined by the overall heat transfer coefficient — the higher the heat transfer coefficient, the greater the efficiency of the system. The overall factor, μ, is dependent on the thermal conductivity of the materials of construction in the area of heat transfer, the resistance to heat transfer of the component being heated or cooled and the resistance to heat transfer of the fluid doing the heating or cooling (i.e., the water or glycol solution). For the glycol solution, this resistance to transfer the heat can be defined as the heat transfer coefficient, h. The heat transfer coefficient is directly proportional to the thermal conductivity (k, the specific heat (Cp), and the density of the fluid (r), and is inversely proportional to the viscosity.

$$h = \frac{k^{0.67} Cp^{0.33} p^{0.8}}{\mu 0.47}$$

Therefore, a higher thermal conductivity, specific heat, and density, and lower viscosity will give the best heat transfer. Ethylene glycol has a higher thermal conductivity, a higher density, and a lower viscosity than propylene glycol, but propylene glycol has the higher specific heat. The relative heat transfer coefficients can be calculated using the following data:

Properties at 100°F, 50% Solution	Ethylene Glycol	Propylene Glycol
Thermal Conductivity, k Btu/(hr)(ft)(°F)	0.25	0.22
Specific Heat, Cp Btu/(lb)(°F)	0.815	0.865
Viscosity, cP	2.3	3.0
Specific Gravity	1.056	1.026
Relative Heat Transfer Coefficient	0.2537	0.2105

The larger relative heat transfer coefficient of ethylene glycol indicates that EC will provide slightly better heat transfer than PC at the same conditions.

Support Services

For product information or customer service contact:

Union Carbide Corporation
Houston Customer Center
10235 West Little York Road, Suite 300
Houston, TX 77040
800-568-4000 or 713-849-7000

For technical assistance, contact:

Union Carbide Heat Transfer Laboratory
3200 Kanawha Turnpike, Building 770
South Charleston, WV 25303
800-UCC-HTFS or 800-822-4837

Product Safety

When considering the use of any Union Carbide Products in a particular application, you should review our latest Material Safety Data Sheets and ensure that the use you intend can be accomplished safely. For Material Safety Data Sheets and other product safety information, contact the Union Carbide Sales office nearest you. Before handling any other products mentioned in the text, you should obtain available product safety information and take necessary steps to ensure safety of use.

No chemical should be used as or in a food, drug, medical device, or cosmetic, or in a product or process in which it may contact a food, drug, medical device, or cosmetic until the user has determined the suitability and legality of the use. Since government regulations and use conditions are subject to change, it is the user's responsibility to determine that this information is appropriate and suitable under current, applicable laws and regulations.

Union Carbide requests that the customer read, understand, and comply with the information contained in this publication and the current Material Safety Data Sheet(s). The customer should furnish the information in this publication to its employees, contractors, and customers, or any other users of the product(s), and request that they do the same.

Emergency Service

Union Carbide maintains an around-the-clock emergency service for its products. The Chemical Manufacturers Association (CHEMTREC), Transport Canada (CANUTEC), and the Chemical Emergency Agency Service maintain around-the-clock emergency service for all chemical products:

Location	*Union Carbide Products*	*All Chemical Products*
Mainland United States and Puerto Rico	Phone Union Carbide HELP: (800) UCC-HELP (toll-free), which numerically is (800) 822-4357	Phone CHEMTREC: (800) 424-9300 (toll-free)
Alaska and Hawaii	Phone Mainland United States: (304) 744-3487 (collect)	Phone CHEMTREC: (800) 424-9300 (toll-free)
Canada	Phone Union Carbide: (514) 640-6400 (collect)	Phone CANUTEC: (613) 996-6666 (collect)
Europe, Middle East, and Africa	Phone Antwerp AIDE Centre at Union Carbide Benelux NV: (32) 14-58-4545 or the nearest Poison Control Center	Phone CHEMTREC (United States): (202) 483-7616 (collect) (United Kingdom and Ireland) Phone Chemical Emergency Service, Harwell, England: 0235-83-48 00
Latin America, Asia/Pacific, and any other location worldwide	Phone United States: (304) 744-3487 (collect)	Phone CHEMTREC (United States): (202) 483-7616 (collect)

At sea, radio U.S. Coast Guard, who can directly contact Union Carbide HELP. . . (800) 822-4357 (toll-free) or CHEMTREC. . .(800) 424-9300 (toll-free).

DO NOT WAIT. Phone if in doubt. You will be referred to a specialist for advice.

Union Carbide Corporation • 39 Old Ridgebury Road • Danbury, CT 06817-0001

UC-945
1/96-2M

P5-2649
Printed in U.S.A.