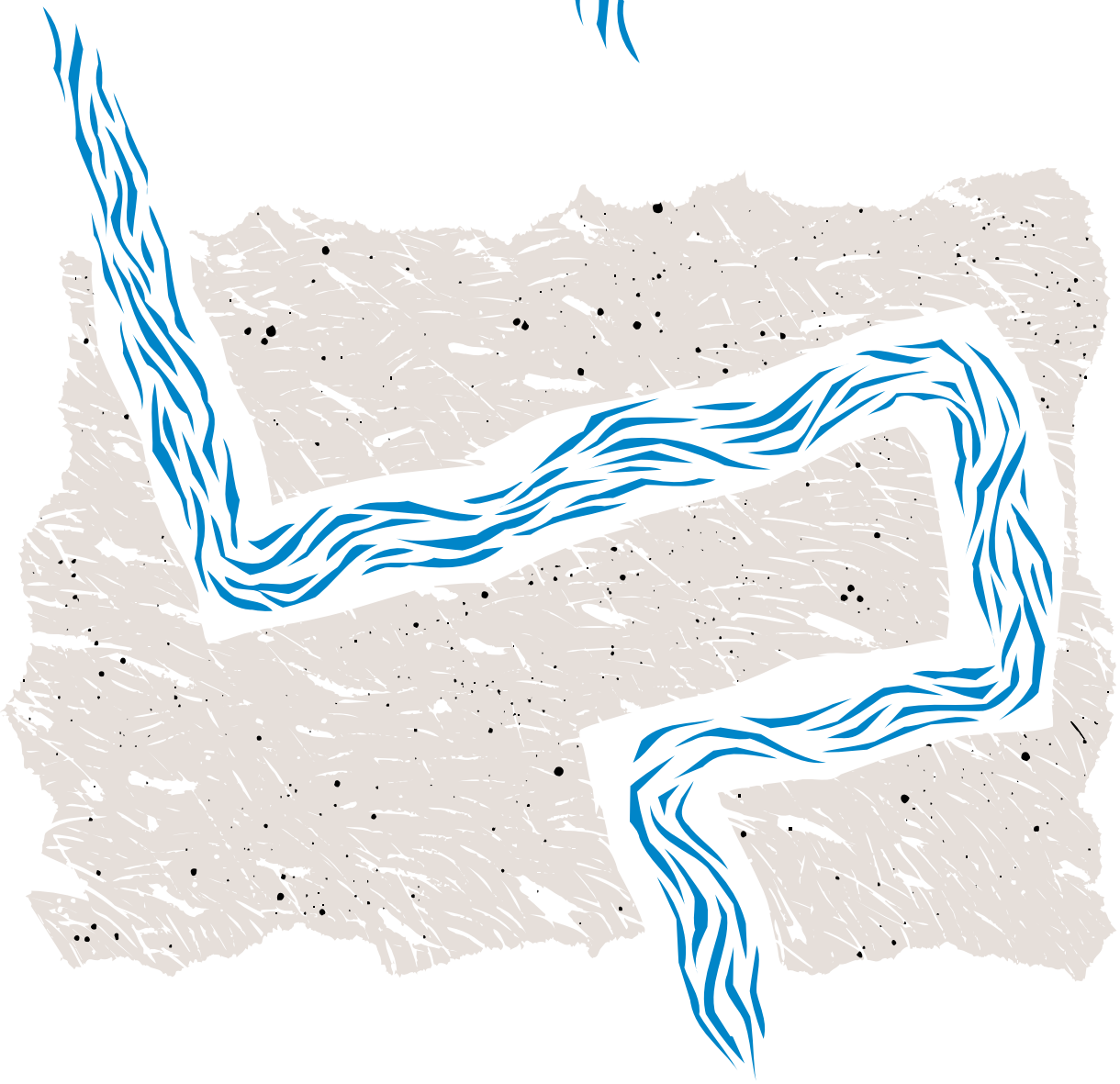
Engineering and Operating Guide

for DOWFROST and DOWFROST HD
Inhibited Propylene Glycol-based Heat Transfer Fluids



D O W F R O S T

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INTRODUCTION

This guide provides basic product performance information, engineering data, and operating guidelines for DOWFROST* inhibited propylene glycol-based heat transfer fluids. Included in the guide are: a brief introduction to DOWFROST fluids, typical product specifications, system design and preparation guidelines, glycol concentration and dilution water quality information, plus detailed engineering data including density, viscosity, specific heat and thermal conductivity. If you would like additional product information or specific engineering or operating assistance, call Dow toll free at 1-800-447-4369.

Where to use DOWFROST propylene glycol-based fluids

Solutions of DOWFROST propylene glycol-based fluids are widely used for secondary cooling and heating applications, for freeze and burst protection of pipes, and for various deicing, defrosting, and dehumidifying applications. They contain specially formulated packages of industrial inhibitors that help prevent corrosion. Specific applications for these fluids include:

- HVAC system freeze/burst/ corrosion protection
- Immersion freezing
- Cooling liquid foods
- Packaging carbonated beverages
- Fermentation cooling
- Refrigeration coil defrosting
- Cold room dehumidifying
- Conveyor roller defrosting
- Process cooling
- Process heating
- Waste heat recovery
- Air preheating
- Solar heating
- Sidewalk snow melting systems
- Refrigeration warehouse floor heating

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Choosing between propylene glycol and ethylene glycol fluids

In addition to DOWFROST propylene glycol-based fluids, DOWTHERM* ethylene glycol-based fluids are also available. There are two major differences between propylene and ethylene glycol fluids: viscosity and toxicity. Ethylene glycol-based fluids are less viscous than propylene glycol-based fluids. Therefore, they generally provide superior heat transfer efficiency and better low temperature performance and are preferred for most heat transfer applications. However, in applications where toxicity is a concern, propylene glycol fluids are used because of their low acute oral toxicity vs. the moderate acute oral toxicity of ethylene glycols. Examples include applications where contact with drinking water is possible, food processing applications where accidental contact with food or beverage products could occur, and applications in localities where propylene glycol use is mandated by law. For additional toxicity information, see the discussion on page 42 of this brochure and request Material Safety Data (MSD) sheets, available from Dow.

This guide provides information about DOWFROST propylene glycol-based fluids only. For additional information about DOWTHERM ethylene glycol-based fluids, call 1-800-447-4369 and request Form No. 180-1190, "Engineering and Operating Guide for DOWTHERM SR-1 and DOWTHERM 4000 Inhibited Ethylene Glycol-based Heat Transfer Fluids."

Dow offers you a choice of propylene glycol-based fluids

There are two Dow propylene glycol-based fluids:

DOWFROST: An industrially inhibited fluid with an operating range of -50°F to 250°F (-46°C to 121°C).

DOWFROST HD: An industrially inhibited fluid with an operating range of -50°F to 325°F (-46°C to 163°C).

Compared to DOWFROST fluid, DOWFROST HD fluid has a higher maximum operating temperature, higher reserve alkalinity, and greater thermal stability. While DOWFROST fluid is considered the standard propylene glycol-based fluid for most applications, DOWFROST HD fluid is specified to extend fluid life where service temperatures are higher and the likelihood of thermal degradation is greater. It is sometimes also used in less demanding applications because the heavy duty inhibitors last longer, and maintenance requirements can be reduced. DOWFROST HD is particularly well-suited for HVAC applications because its inhibitor package offers additional corrosion protection for systems containing copper components.

Both fluids are low in acute oral toxicity, making them suitable for use where incidental contact with drinking water is possible. However, DOWFROST fluid is recommended for use in food processing applications regulated by either the Food and Drug Administration (FDA) or the United States Department of Agriculture (USDA). The ingredients in DOWFROST fluid have been cleared by the FDA for use as food additives. DOWFROST fluid is also listed as chemically acceptable by the USDA for certain food processing applications. See page 8 for additional product regulatory information.

Complete supporting services including free fluid analysis

DOWFROST propylene glycol-based heat transfer fluids are backed by a comprehensive package of Dow supporting services. Dow technical service personnel can provide you with fluid related information to better enable you to design, operate, and maintain your thermal fluids system for maximum productivity and economy.

For systems containing 250 gallons (950 liters) of DOWFROST fluid or more, Dow offers free fluid analysis. Typically performed on an annual basis, the analysis includes determination of current fluid inhibitor and glycol levels, plus Dow's recommendations for maintaining proper corrosion protection and thermal performance capabilities. Dow also provides assistance to operators of smaller systems so they can conduct their own, on-site fluid analyses. See page 16 for more information.

Basic Product Descriptions: DOWFROST and DOWFROST HD Heat Transfer Fluids

DOWFROST fluid is a formulation of 95.5 percent propylene glycol, dipotassium phosphate and water. The fluid is colorless (water white). DOWFROST fluid has an operating temperature range of -50°F to 250°F (-46°C to 121°C) and solutions in water provide freeze protection to below -60°F (-51°C) and burst protection to below -100°F (-73°C).

DOWFROST HD fluid is a formulation of 94.0 percent propylene glycol and a specially designed industrial package of corrosion inhibitors. The fluid is dyed fluorescent yellow to aid in leak detection. DOWFROST HD fluid has an operating temperature range of -50°F to 325°F (-46°C to 163°C) and solutions in water provide freeze protection to below -60°F (-51°C) and burst protection to below -100°F (-73°C).

Both fluids are practically odorless and are low in acute oral toxicity. They offer good heat transfer characteristics, good freeze and corrosion protection, and low volatility. These fluids are hygroscopic at low temperatures, which means they attract moisture from the surrounding atmosphere. Both fluids are also non-flammable in solutions up to 80 percent glycol in water. Table 1 highlights typical specifications of DOWFROST and DOWFROST HD heat transfer fluids. Table 2 provides electrical conductivity data for DOWFROST fluid. Table 3 provides freezing and boiling points for DOWFROST and DOWFROST HD.

Table 1—Typical Product Specifications†

	DOWFROST Heat Transfer Fluid	DOWFROST HD Heat Transfer Fluid
Composition (% by weight)		
Propylene Glycol	95.5	94.0
Inhibitors & Water	4.5	6.0
Color	Water White	Fluorescent Yellow
Specific Gravity (at 60/60°F)	1.046 – 1.056	1.053 – 1.063
pH of Solution (50% glycol)	9.5 – 10.5	9.0 – 10.7
Reserve Alkalinity (min.)	9.0 ml	16.0 ml

†*Typical properties, not to be construed as specifications. Complete sales specifications are available on request.*

Table 2—Electrical Conductivity of DOWFROST Fluid

Weight % Glycol	Temperature °C	Electrical Conductivity mhos/cm (S)
0	25	9.69×10^{-7}
12.5	25	2.19×10^{-3}
25.0	25	2.78×10^{-3}
50.0	25	2.06×10^{-3}
100.0	25	1.49×10^{-4}
0	0	9.69×10^{-7}
12.5	0	1.10×10^{-3}
25.0	0	1.25×10^{-3}
50.0	0	7.49×10^{-4}
100.0	0	3.90×10^{-5}

Table 3—Typical Freezing and Boiling Points of Aqueous Solutions of DOWFROST and DOWFROST HD†

Freezing Point °F	Freezing Point °C	Wt % Propylene Glycol	Vol % Propylene Glycol	Vol % DOWFROST	Vol % DOWFROST HD	Boiling Point °F @ 760 mm Hg	Boiling Point °C @ 0.96 Barr	Degree Brix††	Refractive Index 22°C
32.0	0.0	0.0	0.0	0.0	0.0	212	100	0.0	1.3328
29.1	-1.6	5.0	4.8	5.0	5.1	212	100	4.8	1.3383
26.1	-3.3	10.0	9.6	10.0	10.2	212	100	8.4	1.3438
22.9	-5.1	15.0	14.5	15.1	15.4	212	100	12.9	1.3495
19.2	-7.1	20.0	19.4	20.3	20.6	213	101	15.4	1.3555
18.3	-7.6	21.0	20.4	21.3	21.7	213	101	16.0	1.3567
17.6	-8.0	22.0	21.4	22.4	22.8	213	101	16.7	1.3579
16.6	-8.6	23.0	22.4	23.4	23.8	213	101	17.4	1.3591
15.6	-9.1	24.0	23.4	24.5	24.9	213	101	18.4	1.3603
14.7	-9.6	25.0	24.4	25.5	26.0	214	101	19.0	1.3615
13.7	-10.2	26.0	25.3	26.5	26.9	214	101	19.6	1.3627
12.6	-10.8	27.0	26.4	27.6	28.1	214	101	20.2	1.3639
11.5	-11.4	28.0	27.4	28.6	29.1	215	102	20.8	1.3651
10.4	-12.0	29.0	28.4	29.7	30.2	215	102	21.4	1.3663
9.2	-12.7	30.0	29.4	30.7	31.3	216	102	22.0	1.3675
7.9	-13.4	31.0	30.4	31.8	32.3	216	102	22.7	1.3687
6.6	-14.1	32.0	31.4	32.8	33.4	216	102	23.6	1.3698
5.3	-14.8	33.0	32.4	33.9	34.5	216	102	24.4	1.3710
3.9	-15.6	34.0	33.5	35.0	35.6	216	102	25.3	1.3621
2.4	-16.4	35.0	34.4	36.0	36.6	217	103	26.1	1.3733
0.8	-17.3	36.0	35.5	37.1	37.8	217	103	26.9	1.3744
-0.8	-18.2	37.0	36.5	38.2	38.8	217	103	27.5	1.3756
-2.4	-19.1	38.0	37.5	39.2	39.9	218	103	28.0	1.3767
-4.2	-20.1	39.0	38.5	40.3	41.0	218	103	28.5	1.3779
-6.0	-21.1	40.0	39.6	41.4	42.1	219	104	29.1	1.3790
-7.8	-22.1	41.0	40.6	42.4	43.2	219	104	29.6	1.3802
-9.8	-23.2	42.0	41.6	43.5	44.3	219	104	30.2	1.3813
-11.8	-24.3	43.0	42.6	44.5	45.3	219	104	30.7	1.3825
-13.9	-25.5	44.0	43.7	45.7	46.5	219	104	31.3	1.3836
-16.1	-26.7	45.0	44.7	46.7	47.6	220	104	31.8	1.3847
-18.3	-27.9	46.0	45.7	47.8	48.6	220	104	32.4	1.3858
-20.7	-29.3	47.0	46.8	48.9	49.8	220	104	33.0	1.3870
-23.1	-30.6	48.0	47.8	50.0	50.9	221	105	33.5	1.3881
-25.7	-32.1	49.0	48.9	51.1	52.0	221	105	34.1	1.3892
-28.3	-33.5	50.0	49.9	52.2	53.1	222	106	34.7	1.3903
-31.0	-35.0	51.0	50.9	53.2	54.1	222	106	35.5	1.3914
-33.8	-36.6	52.0	51.9	54.3	55.2	222	106	35.9	1.3924
-36.7	-38.2	53.0	53.0	55.4	56.4	223	106	36.6	1.3935
-39.7	-39.8	54.0	54.0	56.5	57.4	223	106	37.2	1.3945
-42.8	-41.6	55.0	55.0	57.5	58.5	223	106	38.0	1.3956
-46.0	-43.3	56.0	56.0	58.5	59.6	223	106	38.5	1.3966
-49.3	-45.2	57.0	57.0	59.6	60.6	224	107	39.0	1.3977
-52.7	-47.1	58.0	58.0	60.6	61.7	224	107	39.6	1.3987
-56.2	-49.0	59.0	59.0	61.7	62.8	224	107	40.1	1.3998
-59.9	-51.1	60.0	60.0	62.7	63.8	225	107	40.6	1.4008
b	b	65.0	65.0	68.0	69.1	227	108	42.1	1.4058
b	b	70.0	70.0	73.2	74.5	230	110	44.1	1.4104
b	b	75.0	75.0	78.4	79.8	237	114	46.1	1.4150
b	b	80.0	80.0	83.6	85.1	245	118	48.0	1.4193
b	b	85.0	85.0	88.9	90.4	257	125	50.0	1.4235
b	b	90.0	90.0	94.1	95.7	270	132	51.4	1.4275
b	b	95.0	95.0	99.3	a	310	154	52.8	1.4315

[a] *Propylene glycol concentrations greater than 94% are not attainable with DOWFROST HD fluid.*

[b] *Freezing points are below -60°F (-51°C).*

† *Typical properties, not to be construed as specifications.*

†† *Degree Brix is a measure of the sugar concentration in a fluid and is important in fermentation and syrups applications. Although there is no sugar present in DOWFROST heat transfer fluids, the glycol affects the refractive index of the fluid in a similar fashion.*

NOTE: Generally, for an extended margin of protection, you should select a temperature in this table that is at least 5° F (3°C) lower than the expected lowest ambient temperature. Inhibitor levels in glycol solutions less than 25–30% may not provide adequate corrosion protection. Solutions of glycol less than 25% may be at risk for bacterial contamination.

Regulatory Status of DOWFROST Fluid

DOWFROST inhibited propylene glycol-based fluid is listed as chemically acceptable by the U.S. Department of Agriculture (USDA) for both defrosting refrigeration coils and for immersion freezing of wrapped meats, poultry and meat products in food processing plants operated under federal inspection. The FDA clears only individual ingredients, not proprietary products (trademarks). The two ingredients in DOWFROST fluid are generally recognized by the FDA as safe food additives under parts 182 and 184 of the Food Additive Regulations. The regulation for propylene glycol is 21 CFR 184.1666; for dipotassium phosphate, 182.6285. The propylene glycol and dipotassium phosphate in DOWFROST fluid meet the requirements of these regulations. Grade A dairies and meat packing establishments sometimes require a letter certifying the appropriate use and quality of DOWFROST fluid. Such a letter, along with copies of the acceptance letter from the USDA and a statement of FDA compliance, will be provided to Dow customers on request.

For applications where there is no chance of accidental contact with food or beverage products, and where there is no possibility of incidental contact with drinking water, DOWTHERM ethylene glycol-based fluids are generally used because of their greater heat transfer efficiency and superior low temperature performance. (Request Form No. 180-1190, "Engineering and Operating Guide for DOWTHERM SR-1 and DOWTHERM 4000 Inhibited Ethylene Glycol-based Heat Transfer Fluids.")

Preparing Systems for the Addition of DOWFROST or DOWFROST HD Heat Transfer Fluid

Existing systems

In existing systems, all lines and materials should be cleaned and flushed thoroughly before charging the system with DOWFROST fluid. This is especially important if fluid previously in the system is incompatible with the new inhibited glycol fluid. A Dow technical service representative can help you determine the compatibility of other fluids with DOWFROST and DOWFROST HD heat transfer fluids.

If a fluid containing silicates (such as automotive antifreeze) was previously used, it may be necessary to clean silicate residues from the system.

It is also important to remove all rust, scale, and sediment in the system. Traces of chloride should be removed—whether from old fluid or residue from acid cleaner—because chlorides can contribute to corrosion. For large systems, or systems where corrosion is already evident, consult a professional industrial cleaning organization. For heavily fouled or corroded systems, an optimum cleaning procedure includes the use of an inhibited acid followed by neutralization and phosphatization. This procedure is quite involved and should be done by a company experienced in industrial cleaning. If chemical cleaning is used, it is important that all traces of the cleaning agent be removed, and the system be thoroughly flushed with water.

New systems

New systems are typically coated with oil, grease or a protective film during fabrication, storage, or construction. Dirt, solder flux, and welding and pipe scale can also cause problems. Therefore, thorough cleaning of new systems is recommended. A solution of 1 to 2 percent trisodium phosphate can be used with water for flushing the system. Other commercially available cleaning products may also work. System volume can be calculated during this stage by metering in the initial fill of the system, or by chemical analysis of cleaning chemicals after known quantities are introduced into the system.

Selecting the Proper Concentration of DOWFROST Fluid

The minimum recommended concentration is 25% as glycol for most applications. Diluting the concentration below 25% as glycol may reduce the inhibitor concentration to a level that may not provide adequate corrosion protection. Solutions of glycol less than 20% may be at risk for bacterial contamination. The maximum recommended concentration of glycol is 60% for efficient heat transfer.

Between 25% and 60%, the actual concentration of glycol-based heat transfer fluid required in a system depends on the kind of protection needed in winter, or the operating temperature if the system involves refrigeration. There are two basic types of protection available: "burst protection" and "freeze protection."

Burst protection

Burst protection is sufficient if the system will remain dormant when the temperature is below the freezing point of the solution. In HVAC applications, burst protection is considered an appropriate safeguard in systems where there is adequate space to accommodate the expansion of an ice/slush mixture *and* the system is inactive during the winter.

Inhibited glycol-based fluids provide burst protection in the following manner: as the temperature drops below the solution's freezing point, ice crystals begin to form. Because water in the solution freezes first, the remaining glycol solution becomes further concentrated and remains fluid. The combination of ice crystals and fluid results in a flowable slush. Fluid volume increases as this slush forms, with the extra volume flowing into available expansion volume in the system. If the concentration of glycol is sufficient, system damage will not occur.

For burst protection, a 35 percent (volume) solution of propylene glycol (36.6 percent DOWFROST or 37.2 percent DOWFROST HD) is usually adequate. See Table 4 for typical propylene glycol concentrations required to achieve burst protection at various temperatures.

Freeze protection

Freeze protection is required in systems where fluid must be pumped at the lowest anticipated temperature. Freeze protection is essential in cases where no ice crystals can be permitted to form or where there is inadequate expansion volume available to accommodate ice/slush formation.

For freeze protection, the required concentration of inhibited glycol fluid in the system depends on the operating conditions of the system and the lowest expected ambient temperature. HVAC systems that are subject to prolonged winter shutdown—but which must start-up again while the weather is still cold —may require freeze protection. Freeze protection is also appropriate for closed-loop systems that must be protected in the event of power or pump failure.

To obtain adequate freeze protection, the glycol solution must maintain a freezing point at least 5°F (3°C) below the lowest anticipated ambient temperature. Table 4 lists typical concentrations of DOWFROST fluids required to provide freeze protection. Refer to Table 3 for a complete list of the concentrations of inhibited propylene glycol to be added for freeze protection.

Table 4—Typical Concentrations of DOWFROST Fluids Required to Provide Freeze and Burst Protection at Various Temperatures

Temperature °F	Temperature °C	Percent (vol.) DOWFROST Fluid Concentration Required			
		For Freeze Protection		For Burst Protection	
		Volume % DOWFROST	Volume % DOWFROST HD	Volume % DOWFROST	Volume % DOWFROST HD
20	(-7)	18.8†	19.1†	12.6†	12.8†
10	(-12)	30.4	30.9	20.9†	21.3†
0	(-18)	37.7	38.3	25.1	25.5
-10	(-23)	44.0	44.7	29.3	29.8
-20	(-29)	48.2	48.9	31.4	31.9
-30	(-34)	52.4	53.2	34.6	35.1
-40	(-40)	56.5	57.4	36.6	37.2
-50	(-46)	59.7	60.6	36.6	37.2
-60	(-51)	62.8	63.8	36.6	37.2

† Inhibitor levels in glycol solutions less than 25–30% may not provide adequate corrosion protection. Glycol concentrations less than 20% may be at risk for bacterial contamination.

NOTE: These figures are examples only and may not be appropriate to your situation. Generally, for an extended margin of protection, you should select a temperature in this table that is at least 5°F lower than the expected lowest ambient temperature.

ATTENTION: These are typical numbers only and are not to be regarded as specifications. As use conditions are not within its control, Dow does not guarantee results from use of the information or products herein; and gives no warranty, express or implied.

Preparing Solutions of DOWFROST Fluids

Dilution water quality

Water used to dilute DOWFROST fluids must meet certain minimum standards for purity. Impurities in dilution water can increase metal corrosion, aggravate pitting of cast iron and steel, reduce the effectiveness of corrosion inhibitors, increase inhibitor depletion rate, cause formation of scale and other deposits on heat transfer surfaces, and cause clogging of system components.

To assure inhibitor effectiveness, the levels of chlorides and sulfates in water used to dilute DOWFROST fluids should be less than 25 ppm each. Total hardness should be less than 100 ppm expressed as ppm calcium carbonate. (See Table 5.) Distilled or deionized water is recommended. DOWFROST HD fluid contains a patented additive that keeps the corrosion inhibitors in solution when mixed with hard water ions (calcium and magnesium). This helps to protect the system from depletion of the inhibitor package due to accidental use of hard water. However, since additional contaminants are typically found in hard water (such as chloride, sulfate, iron, etc.), Dow continues to recommend the use of distilled or deionized water for dilution of this product.

DOWFROST fluid does not contain this patented additive, therefore the use of good quality water is critical to the success of DOWFROST fluid in your system. If good quality water is unavailable, pre-diluted solutions of DOWFROST fluids are available from Dow.

Table 5— Dilution Water Quality Requirements

Impurity	Level
Chlorides	25 ppm, max
Sulfates	25 ppm, max
Total Hardness, as $CaCO_3$	100 ppm, max

Note: 17.1 ppm = 1 grain

Solution make-up

As indicated above, good quality water must be used for fluid make-up. In addition, any flush water remaining in the system should be taken into account when introducing and diluting DOWFROST fluids. In an industrial system, it is not unusual to have "hold-up" of up to 20 percent or greater of the total system volume, although 10 percent is more common.

Introducing DOWFROST fluids into your system

In most cases, solutions containing glycol-based heat transfer fluid are mixed on a volume basis. If you wish to mix by weight percent, use Table 3 to obtain the volume-to-weight conversion. Following is the mixing procedure for installing these fluids:

1. Calculate the quantity of fluid needed to achieve the desired results. Table 6 which provides the number of gallons per 100 feet of pipe, may be helpful in the calculation.

2. Introduce a sufficient quantity of water to check the system for tightness. Pressure testing the system at this stage can be helpful. Often pressure testing can be accomplished during the initial cleaning or flushing of the system.

3. Drain enough water from the system to provide space for the inhibited glycol quantity as calculated in Step 1.

4. Add the correct amount of fluid and any water needed to completely refill the system, allowing for liquid expansion as needed due to the operating temperature.

5. Circulate for at least 24 hours to ensure complete mixing. Check the liquid concentration with a refractometer or other method to assure that the correct mixture is obtained.

Increasing or decreasing the concentration of inhibited glycol in the system

It is sometimes necessary to increase the concentration of the glycol solution in your system, either to protect against cold weather, or to replace fluid lost through leakage or moisture absorbed from the atmosphere. There are other conditions which may require the dilution of inhibited glycol already in the system. Either adjustment can be carried out in batch or continuous operation.

Procedure for adjusting freezing point of glycol fluids

If a lower freezing point is required, the concentration of glycol must be increased accordingly. Use the formula below to determine the amount of solution to drain and the number of gallons of DOWFROST fluid to add to increase glycol concentration.

$$A=V(D-P)/(100-P)$$

To decrease the glycol concentration, the following formula should be used to determine the volume to drain and replace with high quality water:

$$A=V(P-D)/P$$

Where,

A = The quantity (in gallons or liters) of DOWFROST fluid to be added to the system to lower the freeze point, or the quantity (in gallons or liters) of glycol solution that must be drained from the system to decrease glycol concentration.

V = The total solution capacity of the system, in gallons (or liters).

D = The volume percent of DOWFROST fluid desired in the system.

P = The volume percent of DOWFROST fluid presently in the system.

Table 6—Volume of Heat Transfer Fluid per Length of Pipe†

Nominal Pipe Size inches	Nominal Pipe Size mm	Wall Thickness inches	Wall Thickness mm	Inside Diameter inches	Inside Diameter mm	USG per 100 ft of pipe	Liters per 1 m of pipe
1/4	8	0.088	2.24	0.364	9.25	0.541	0.067
3/8	10	0.091	2.31	0.493	12.52	0.992	0.123
1/2	15	0.109	2.77	0.622	15.80	1.579	0.196
3/4	20	0.113	2.87	0.824	20.93	2.770	0.344
1	25	0.133	3.38	1.049	26.64	4.490	0.558
1 1/4	32	0.14	3.56	1.380	35.05	7.770	0.965
1 1/2	40	0.145	3.68	1.610	40.89	10.576	1.313
2	50	0.154	3.91	2.067	52.50	17.433	2.165
2 1/2	65	0.203	5.16	2.469	62.71	24.873	3.089
3	80	0.216	5.49	3.068	77.93	38.406	4.769
3 1/2	90	0.226	5.74	3.548	90.11	51.363	6.378
4	100	0.237	6.02	4.026	102.26	66.135	8.213
5	125	0.258	6.55	5.047	128.19	103.933	12.906
6	150	0.28	7.11	6.065	154.05	150.089	18.638
8	200	0.322	8.18	7.981	202.70	259.897	32.274
10	250	0.365	9.27	10.020	254.50	409.659	50.871
12	300	0.406	10.31	11.938	303.20	581.501	72.211

† *Commercial steel pipe—schedule 40 and standard weight as per ASTM B36.10*

System Design Considerations

Following is a general discussion of system design and other engineering considerations related to the use of DOWFROST propylene glycol-based heat transfer fluids. For information regarding a specific system problem or question, contact Dow's Technical Service and Development staff for assistance at 1-800-447-4369.

Materials of construction

Standard system materials can be used with DOWFROST heat transfer fluids. Steel, cast iron, copper, brass, bronze, solder and most plastic piping materials are all generally acceptable. DOWFROST fluids can also be used with aluminum at temperatures below 150°F (66°C). At temperatures above 150°F (66°C), use of aluminum is not recommended because the inhibitors will not fully protect aluminum components in the system. Galvanized steel is not recommended because the zinc will react with the inhibitor in the fluids, causing precipitate formation, depletion of the inhibitor package, and removal of the protective zinc coating, particularly above 100°F (38°C). Precipitation can also lead to localized corrosion.

Centrifugal pumps are commonly used with solutions of DOWFROST fluids. Reciprocating pumps are necessary where fluids must be pumped at high head pressures. Pumps can be made of ordinary steel or ductile iron because the fluids are inhibited. Piping, valves, and fittings can also be made of ordinary steel or ductile iron. Use of gray iron components is not recommended.

Typically, the same types of pump packing or mechanical seals used for water may be used with solutions of DOWFROST fluids. Packing and seal manufacturers should be consulted for materials appropriate to your application and operating temperature.

Solutions of DOWFROST fluids are also compatible with most plastics and elastomers. Generally, any material that can be used with uninhibited glycols may be used with DOWFROST fluids. Before using a particular elastomer, check with the manufacturer to determine the suitability of the material with propylene glycol over the anticipated temperature and pressure ranges.

If the use of coatings is desired (for example, to protect the vapor space of an expansion tank) several options are available. Suitable coatings include novolac-based vinyl ester resins (e.g., DERAKANE* 470-36 vinyl ester resin), high-bake phenolic resins, polypropylene, and polyvinylidine fluoride. To ensure that the coating is suitable for a particular application and temperature, the coating manufacturer should be consulted.

Bypass filters are recommended for removal of foreign solids. This is especially important if the quality of solution water does not conform to the recommendations on page 10 of this guide. Precipitates and sludge deposited by solution water can lead to localized corrosion. Filters made of non-absorbent cotton, fiber, or cellulose-type media have been used successfully.

Using dissimilar metals in a system is not recommended because galvanic corrosion may result. This type of corrosion can occur in electrolytic solutions when dissimilar metals (referencing the galvanic series in sea water) are in contact with or near each other. (Aluminum directly connected to copper is an example.) Solutions of DOWFROST fluids are better than plain water, but still cannot protect against galvanic corrosion of dissimilar metals electrically coupled in a system. Electrical isolation eliminates galvanic corrosion concerns.

Fluid temperature range and system design

DOWFROST inhibited glycol-based fluid has an effective operating temperature range of -50°F to 250°F (-46°C to 121°C), while DOWFROST HD inhibited glycol-based fluid is effective from -50°F to 325°F (-46° to 163°C). At temperatures below 0°F (-18°C), increased viscosity (>1,000 cPs [>1,000 mPa•s]) can make use of these fluids impractical unless larger pumps are installed.

At the upper end of the operating range for DOWFROST fluid, a maximum bulk temperature of 250°F (121°C) is recommended. Film temperatures should not exceed 300°F (149°C). In the case of DOWFROST HD fluid, a maximum bulk temperature of 325°F (163°C) is recommended, with film temperatures not to exceed 375°F (191°C).

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DOWFROST and DOWFROST HD fluids can tolerate brief temperature excursions up to 100°F (56°C) above the maximum recommended temperatures. However, extended exposure of the fluids to temperatures in excess of 50°F (28°C) above the maximum recommended temperatures will result in accelerated degradation of the glycol and inhibitor systems.

In addition, the film temperature should remain within 50°F (28°C) of the bulk fluid temperature and the pressure at all points in the system should be at least 5 PSI (35 kPa) greater than the vapor pressure exerted by the fluid to avoid localized boiling and resulting precipitation.

At temperatures above 150°F (66°C), the system must be closed to avoid rapid oxidation of the propylene glycol, inhibitor depletion, and subsequent increased corrosion.

Automatic make-up water systems

Automatic make-up water systems should be avoided in order to prevent undetected dilution or loss of glycol and consequent loss of freeze and corrosion protection. Glycol feed tanks that deliver the same concentration of fluid as being used in the system, coupled with a low level alarm, are recommended.

Flammability

When mixed with water, neither DOWFROST nor DOWFROST HD fluids are flammable because they have no measurable flash point (Pensky-Martens Closed Cup) in concentrations up to 80% glycol. Undiluted DOWFROST and DOWFROST HD fluids have a flash point of 214°F (101°C) (Pensky-Martens Closed Cup). It is possible to ignite solutions of propylene glycol if enough water has been vaporized and the concentration of propylene glycol increases to greater than 80 percent.

Film coefficients of inhibited glycols and water

The film coefficient of a fluid must be determined in order to evaluate the heat transfer surface required. Since solutions of DOWFROST and DOWFROST HD fluids have heat transfer properties different from those of plain water, they typically have lower film coefficients under equivalent flow conditions.

This may affect the design and operation of the system, depending on factors such as the heat transfer coefficient of the material being heated or cooled. Additional discussion of film coefficient and a method of calculating it appear on page 17 of this brochure.

The FLUIDFILE* software program, available exclusively from Dow, is designed to calculate fluid film coefficient based on your specific operating conditions. This fast, accurate, engineering tool is available without charge. Just call toll free: 1-800-447-4369.

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Efficiency vs. concentration

Ethylene glycol-based fluids and propylene glycol-based fluids offer different degrees of heat transfer efficiency depending on the specific application and system. For information regarding DOWTHERM ethylene glycol-based fluids, request Form No. 180-1190, "Engineering and Operating Guide for DOWTHERM SR-1 and DOWTHERM 4000 Inhibited Ethylene Glycol-based Heat Transfer Fluids."

To obtain maximum heat transfer efficiency while achieving adequate freeze protection, avoid using excess concentrations of DOWFROST fluids in water. Generally when the fluid is used for either freeze protection or secondary cooling, the specified concentration should yield a freeze point about 5°F (3°C) lower than the lowest anticipated temperature. For burst protection, when slush (or ice crystals) in the fluid is not a problem, consult Table 4. It is rarely necessary to use concentrations higher than 50% to 55% glycol in water. The less glycol used, the higher the relative heat transfer efficiency of the solution.

For optimum corrosion protection, the concentration of DOWFROST fluid in water should provide at least 25–30% (by volume) glycol. If operation at lower concentrations is desired, consult your Dow technical service representative for information.

Expansion factor

Like any fluids, solutions of DOWFROST fluids expand as temperature increases. Therefore, expansion tanks must be sized appropriately. To determine the volume of expansion, use the following formula:

$$\frac{\rho(T_{LOW})-\rho(T_{HIGH})}{\rho(T_{HIGH})} \times \text{Volume} = \text{Expansion Volume}$$

Where,

$\rho(T_{LOW})$ = the density at the lowest anticipated temperature.

$\rho(T_{HIGH})$ = the density at the highest anticipated temperature.

Density data for DOWFROST and DOWFROST HD fluids are given in Tables 9 through 12.

One method for sizing an expansion tank is to use the determined expansion volume to calculate the total size of the tank. A typical tank size would allow the fluid to fluctuate between the levels associated with 15% and 80% full. The tank size is calculated from:

Expansion Volume/.65 = Tank Size

When using this method, ensure that the minimum amount of fluid in the tank will provide the NPSH (net positive suction head) of the pump if the tank is a portion of the source of head.

An alternative method of sizing the tank is to determine the volume of the system and specify a large enough tank to accommodate the entire fluid volume at maximum temperature. This method allows the system to be drained to the expansion tank for maintenance. Industrial users of DOWTHERM fluids will typically use this procedure.

Also note that, as temperatures drop below the freeze point of a glycol solution, ice crystals begin to form. This causes the solution to expand and the slush to flow to available expansion volume. The lower the temperature is, the greater the expansion. This expansion should be used for expansion tank sizing.

However, when it becomes cold enough for *glycol* crystals to form, the volume of the solution will contract. At very low temperatures, the entire mass freezes and contracts.

How to use glycols for HVAC freeze protection without sacrificing heat transfer efficiency

Compared to water, glycols are widely believed to have a negative effect on the performance of HVAC systems. In reality, however, the use of a glycol solution in a closed-loop, water-based HVAC system can have relatively little effect on how well that system performs, particularly if the system is prudently engineered.

If the system has excess design capacity, the decline in capacity resulting from the use of glycol will most likely not even be noticed by building occupants. On the other hand, if the system is already nearing its design load, the use of glycol might aggravate the situation. But any problems will only be noticed on the hottest days of the year.

In cases where increased pressure drop and resulting decline in capacity is a problem, a two-step solution can be employed. First, flow of solution through the system should be reduced in order to return the pressure drop to its original value. This will have the beneficial side effects of lowering pump horsepower requirements and reducing energy consumption. Next, reduce the chiller operating temperature to lower the fluid temperature into the coil. Reducing the chiller operating temperature compensates for the reduction in fluid flow and returns the coil capacity to its original level.

In some cases, this process of shifting the cooling burden from pumps to chiller can actually improve the overall efficiency of the system. Unlike pumps, chillers only use energy in proportion to system load. And, chillers have become increasingly energy efficient in recent years.

How DOWFROST Inhibited Fluids Protect Against Corrosion

DOWFROST and DOWFROST HD glycol-based coolants contain specially formulated industrial inhibitor packages that are effective in preventing corrosion of metals commonly used in HVAC, food processing, and process heat transfer equipment. These inhibitors prevent corrosion of metals in two ways.

First, they passivate the surface of metals, reacting with the surface to prevent acids from attacking it. Unlike inhibitors used in some other fluids, Dow inhibitors perform this passivation process without fouling heat transfer surfaces. The inhibitors in automotive antifreeze, on the other hand, contain silicates that coat heat transfer surfaces with a thick silicate gel that reduces heat transfer.

Second, the inhibitors in DOWFROST fluids buffer any acids formed as a result of glycol oxidation. All glycols produce organic acids as degradation products. This degradation is accelerated in the presence of oxygen and/or heat. Left in solution, such acids lower pH and contribute to corrosion. Properly formulated inhibitors such as those in DOWFROST fluids neutralize these acids.

The standard ASTM D1384 corrosion test is a screening test that measures the relative corrosion protection provided by different solutions on standard metals under standard test conditions. The data in Table 7 show relative corrosion rates for DOWFROST and DOWFROST HD fluids compared to uninhibited propylene glycol and plain water. The data indicate that solutions of DOWFROST fluids fall well within the generally accepted corrosion limits considered adequate under this test. Rates in excess of 0.5 mpy (2.5 mpy for aluminum) are generally evidence of inadequate corrosion protection. (Since it is only a screening test, ASTM D1384 may not be indicative of performance in an actual system.)

The presence of excessive amounts (>25 ppm) of contaminants such as chlorides, sulfates, and/or ammonia could contribute to system corrosion not evident in these tests. For example, excessive concentrations of chloride ions will result in the formation of iron chloride. With any available oxygen, iron chloride will react to form iron oxide, which is insoluble. The resulting deposition of precipitant forms an area where under-deposit corrosion can occur. This corrosion will be further accelerated by the presence of chlorides and cannot be eliminated through the use of a non-chromate-based inhibitor. This underscores the importance of dilution water quality, discussed on page 10 of this guide.

Table 7— Corrosion Test Results/Mils Penetration per Year (Weight Loss in Milligrams Rates in Excess of 0.5 mpy [2.5 mpy for Aluminum] Are Generally Evidence of Inadequate Corrosion Protection.)

	Water	Propylene Glycol	DOWFROST Fluid	DOWFROST HD Fluid
Copper	0.08 (2)	0.16 (4)	0.12 (3)	0.04 (1)
Solder	3.14 (99)	34.7 (1095)	0.03 (1)	0.06 (2)
Brass	0.23 (5)	0.20 (5)	0.16 (4)	0.08 (2)
Mild Steel	9.69 (212)	9.80 (214)	0.04 (1)	0.04 (1)
Cast Iron	21.2 (450)	16.2 (345)	0.15 (3)	0.05 (1)
Aluminum	13.2 (110)	1.80 (15)	+0.26 (+2)	+0.36 (+3)

Samples with a "+" showed weight gain.

ASTM D1384—190°F (88°C) for 2 weeks. 30% by volume glycol, air bubbling.

Maintaining DOWFROST
Heat Transfer Fluids Within Your System

Free analytical service from Dow

To help its customers to ensure that corrosion and freeze protection are maintained in their systems, Dow offers a free fluid analysis service. This service is free for systems containing 250 gallons (950 liters) or more of DOWFROST fluid. It is designed to help assure the long-term performance of DOWFROST fluids and help minimize replacement fluid requirements as well as system maintenance and repair costs. Typically performed on an annual basis, the analysis includes determination of current inhibitor and glycol levels, plus Dow's recommendations for maintaining proper corrosion protection.

Dow has developed special Thermal Fluids Sampling Kits for use by customers participating in the analysis program. These kits permit easy and accurate labeling of fluid samples and safe shipment of samples to Dow for analysis. Kits may be obtained by calling 1-800-447-4369. Or write:

The Dow Chemical Company
Larkin Lab
1691 North Swede Road
Midland, Michigan 48674

Thermal Fluids Testing Lab

How the service works

After the system has been filled and circulated for 24 hours, an initial four-ounce sample should be withdrawn and sent to Dow using one of the Thermal Fluids Sampling Kits.

After the system is in operation, it is recommended that samples be taken once a year. Before withdrawing a sample, the fluid should be well circulated in the system so the sample is representative. **Remember to closely follow the sampling instructions included with the sample kit provided by Dow. Proper sampling is essential to ensure meaningful assessment of fluid condition.**

Approximately three weeks after the sample is received by Dow, a report will be sent to you detailing results of the analysis, discussing unusual or troublesome conditions (if any), and offering recommendations.

Analytical tools available for self-testing

Dow recommends that systems containing less than 250 gallons (950 liters) of DOWFROST fluid be checked using on-site fluid analysis.

Misco Products refractometer, model 7084VP(°F) and 7064VP(°C) — These refractometers measure the glycol solution concentration of DOWTHERM fluids and give the freezing points of the fluids. This instrument requires only a few drops of fluid for testing and requires no adjustment for fluid temperature. Diluted solutions with concentrations from 0 to 60% glycol may be tested directly. Stronger concentrations require a simple dilution procedure prior to testing. Contact Misco Products at 1-800-358-1100 and ask for the Dow discount.

Testing your fluid's pH level — Control of pH between 8 and 10 is important to minimize corrosion and glycol degradation. Using narrow range pH paper such as pHydrion Control paper with a 7.2 to 8.8 pH range is an easy and reliable way to read your pH level.

A pH tester can also measure alkalinity or acidity of the fluid. The desirable pH range should fall between 8.0 and 10.0. Adjustments can be made by using a 50% solution of sodium hydroxide or potassium hydroxide if the pH is between 7.0 and 8.0. Any fluid with a pH below 7.0 should be replaced. An inexpensive pH tester is available from Misco Products. The accuracy of this instrument is +/- 0.5 pH. Contact Misco Products at 1-800-358-1100 and ask for the Dow discount.

Also, you can quickly determine the condition of your fluid by examining its appearance and odor. Any drastic variation from the initial fluid specifications, such as a black or dark-grey color, presence of an oily layer, burnt odor, or any heavy sludge in the fluid may indicate the need for fluid replacement.

Dow Thermal Fluids Sampling Kit

Product Properties and Engineering Data for DOWFROST Fluids

Data exhibits on pages 18 through 33 provide engineering properties for DOWFROST and DOWFROST HD fluids. General information about film coefficients, pressure drop in pipes, and vapor pressure for DOWFROST fluids is provided in the paragraphs below. Accompanying data for these properties begins on page 34. This information is useful to engineers, designers, operators and maintenance personnel involved in solving problems related to heat transfer.

Film coefficients

Process heat transfer deals with transfer rates as they occur in engineering and chemical process equipment. The overall film or heat transfer coefficient (U) must be determined in the design process in order to evaluate the heat transfer surface required in the system. The overall heat transfer coefficient may be expressed by the following equation:

$$q = UA\Delta t_{LM}$$

The overall film coefficient is influenced by the fluid film heat transfer rates on each side of the tube (h_i and h_o), the resistance through the tube wall (r_w), and a fouling factor (r_f). In terms of these individual factors, the following equation can be written:

$$1/U = 1/h_i + 1/h_o + r_w + r_f$$

If one film coefficient is small and the other very large, the smaller coefficient provides the major resistance to heat flow. The overall heat transfer coefficient for the equipment is then very nearly equal to the smaller or "controlling" film coefficient. In many applications where DOWFROST heat transfer fluids are used, it is the material being heated or cooled that offers the major resistance to heat transfer. In such cases, the overall coefficient can be significantly increased only by increasing the film coefficient of that other material.

Dow calculates liquid film coefficients for solutions of DOWFROST fluids using the Seider and Tate correlation equation:

$$Nu = 0.027\ Re^{0.8} Pr^{0.33} (\mu/\mu_w)^{0.14}$$

Where,

$$Re = 300\ dG/\mu = 300\ dv\rho/\mu$$

$$Pr = Cp\ \mu/k$$

$$Nu = hd/12\ k$$

The film coefficients in this brochure are based on the assumption that:

$$(\mu/\mu_w)^{0.14} = 1$$

This correlation holds only for fully developed turbulent flow and should not be used for Reynolds numbers less than 10,000. Film coefficients for DOWFROST and DOWFROST HD fluids may be calculated using the equation provided here and the data for density, viscosity, thermal conductivity, and specific heat found in Tables 9 through 24.

Pressure drop

When a fluid flows over a surface, the pressure of the fluid decreases along the surface due to friction. This is called the pressure drop of the system. The Darcy equation for pressure drop of fluids in turbulent flow is:

$$\Delta P_{100} = 0.1294\ f\rho v^2/d = 0.0216\ f\rho Q^2/d^5$$

Values of f may be obtained from f versus Reynolds number plots given in standard texts.

Figures 1 through 6 show pressure drop for various concentrations of propylene glycol. Temperature correction factor data are also provided.

Vapor pressure

Tables 25 and 26 provide vapor pressure data for DOWFROST and DOWFROST HD fluids.

Table 8—Nomenclature and Symbols

		English Units	SI Units
A	Heat Transfer Surface Area	ft^2	m^2
C_p	Specific Heat	Btu/(lb·°F)	kJ/(kg·K)
d	Diameter	Inch	cm
f	Friction Factor	Dimensionless	
G	Mass Velocity	lb/(sec·ft^2)	kg/(sec·m^2)
h	Average Film Coefficient	Btu/(hr·ft^2·°F)	W/(m^2·K)
k	Thermal Conductivity	Btu/(hr·ft^2)(°F/ft)	W/(m·K)
Q	Flow Rate	gal/min	m^3/sec
q	Heat Flow	Btu/hr	W
r	Tube Resistance	(hr·ft^2·°F)/Btu	m^2·K/W
U	Overall Heat Transfer Coefficient	Btu/(hr·ft^2·°F)	W/(m^2·K)
v	Fluid Velocity	ft/sec	m/sec
Nu	Nusselt Number	dimensionless	
Pr	Prandtl Number	dimensionless	
ΔP	Pressure Drop	psi	kPa
Δt_{LM}	Log Mean Temperature Difference	°F	°C
μ	Viscosity (cps x 2.42 = lb/(hr·ft))	lb/(hr·ft)	mPa·sec
ρ	Density	lb/ft^3	kg/m^3
Re	Reynolds Number	dimensionless	

Subscripts

f	fouling
i	inside
o	outside
w	wall

Table 9—Densities (lb/ft³) of Aqueous Solutions of DOWFROST Fluid—English Units

Temp.	Volume Percent Propylene Glycol									
°F	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%
-30							67.05	67.47	68.38	68.25
-20						66.46	66.93	67.34	68.13	68.00
-10						66.35	66.81	67.20	67.87	67.75
0					65.71	66.23	66.68	67.05	67.62	67.49
10				65.00	65.60	66.11	66.54	66.89	67.36	67.23
20			64.23	64.90	65.48	65.97	66.38	66.72	67.10	66.97
30		63.38	64.14	64.79	65.35	65.82	66.22	66.54	66.83	66.71
40	62.42	63.30	64.03	64.67	65.21	65.67	66.05	66.35	66.57	66.44
50	62.38	63.20	63.92	64.53	65.06	65.50	65.87	66.16	66.30	66.18
60	62.34	63.10	63.79	64.39	64.90	65.33	65.68	65.95	66.04	65.91
70	62.27	62.98	63.66	64.24	64.73	65.14	65.47	65.73	65.77	65.64
80	62.19	62.86	63.52	64.08	64.55	64.95	65.26	65.51	65.49	65.37
90	62.11	62.73	63.37	63.91	64.36	64.74	65.04	65.27	65.22	65.09
100	62.00	62.59	63.20	63.73	64.16	64.53	64.81	65.03	64.95	64.82
110	61.84	62.44	63.03	63.54	63.95	64.30	64.57	64.77	64.67	64.54
120	61.73	62.28	62.85	63.33	63.74	64.06	64.32	64.51	64.39	64.26
130	61.54	62.11	62.66	63.12	63.51	63.82	64.06	64.23	64.11	63.98
140	61.39	61.93	62.46	62.90	63.27	63.57	63.79	63.95	63.83	63.70
150	61.20	61.74	62.25	62.67	63.02	63.30	63.51	63.66	63.55	63.42
160	61.01	61.54	62.03	62.43	62.76	63.03	63.22	63.35	63.26	63.13
170	60.79	61.33	61.80	62.18	62.49	62.74	62.92	63.04	62.97	62.85
180	60.57	61.11	61.56	61.92	62.22	62.45	62.61	62.72	62.68	62.56
190	60.35	60.89	61.31	61.65	61.93	62.14	62.29	62.39	62.39	62.27
200	60.13	60.65	61.05	61.37	61.63	61.83	61.97	62.05	62.10	61.97
210	59.88	60.41	60.78	61.08	61.32	61.50	61.63	61.69	61.81	61.68
220	59.63	60.15	60.50	60.78	61.00	61.17	61.28	61.33	61.51	61.38
230	59.38	59.89	60.21	60.47	60.68	60.83	60.92	60.96	61.21	61.08
240	59.10	59.61	59.91	60.15	60.34	60.47	60.55	60.58	60.91	60.78
250	58.82	59.33	59.60	59.82	59.99	60.11	60.18	60.19	60.61	60.48

= Above atmospheric boiling point.

NOTE: To determine specific gravity, divide the density of the fluid by the density of water at 68°F.

Table 10—Densities (kg/m³) Aqueous Solutions of DOWFROST Fluid—SI Units

Temp.	Volume Percent Propylene Glycol									
°C	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%
-35							1074.1	1080.9	1095.7	1093.7
-30						1064.8	1072.5	1079.0	1092.1	1090.0
-25						1063.3	1070.8	1077.0	1088.4	1086.4
-20					1053.1	1061.7	1068.9	1074.9	1084.7	1082.7
-15					1051.6	1059.9	1066.9	1072.7	1081.0	1078.9
-10				1040.6	1050.0	1058.0	1064.8	1070.4	1077.2	1075.2
-5			1028.4	1039.1	1048.2	1056.0	1062.6	1067.9	1073.5	1071.4
0		1015.0	1027.0	1037.4	1046.3	1053.9	1060.2	1065.3	1069.7	1067.7
5	1006.7	1013.7	1025.5	1035.6	1044.3	1051.6	1057.7	1062.6	1065.9	1063.8
10	1004.3	1012.4	1023.8	1033.7	1042.1	1049.2	1055.1	1059.7	1062.0	1060.0
15	1001.9	1010.9	1022.0	1031.7	1039.8	1046.7	1052.3	1056.7	1058.2	1056.1
20	999.4	1009.3	1020.2	1029.5	1037.4	1044.0	1049.4	1053.6	1054.3	1052.3
25	996.9	1007.5	1018.1	1027.2	1034.9	1041.3	1046.4	1050.4	1050.4	1048.4
30	994.3	1005.7	1016.0	1024.8	1032.2	1038.3	1043.3	1047.0	1046.5	1044.4
35	991.7	1003.7	1013.7	1022.2	1029.4	1035.3	1040.0	1043.6	1042.5	1040.5
40	989.0	1001.6	1011.3	1019.6	1026.4	1032.1	1036.6	1040.0	1038.5	1036.5
45	986.3	999.4	1008.8	1016.8	1023.4	1028.8	1033.1	1036.3	1034.5	1032.5
50	983.5	997.0	1006.1	1013.8	1020.2	1025.4	1029.5	1032.4	1030.5	1028.5
55	980.7	994.5	1003.3	1010.8	1016.9	1021.9	1025.7	1028.4	1026.5	1024.4
60	977.8	991.9	1000.4	1007.6	1013.4	1018.2	1021.8	1024.3	1022.4	1020.4
65	974.9	989.2	997.4	1004.3	1009.9	1014.4	1017.8	1020.1	1018.3	1016.3
70	971.9	986.4	994.2	1000.8	1006.2	1010.4	1013.6	1015.8	1014.2	1012.2
75	968.8	983.4	991.0	997.2	1002.3	1006.4	1009.3	1011.3	1010.1	1008.0
80	965.7	980.3	987.5	993.5	998.4	1002.2	1004.9	1006.7	1005.9	1003.9
85	962.6	977.1	984.0	989.7	994.3	997.8	1000.4	1002.0	1001.7	999.7
90	959.3	973.8	980.4	985.8	990.1	993.4	995.7	997.1	997.5	995.5
95	956.0	970.3	976.6	981.7	985.7	988.8	991.0	992.2	993.3	991.3
100	952.6	966.8	972.7	977.5	981.2	984.1	986.0	987.1	989.1	987.0
105	949.2	963.1	968.6	973.1	976.6	979.3	981.0	981.9	984.8	982.7
110	945.7	959.2	964.5	968.6	971.9	974.3	975.8	976.5	980.5	978.4
115	942.1	955.3	960.2	964.1	967.0	969.2	970.5	971.0	976.2	974.1
120	938.5	951.2	955.7	959.3	962.0	964.0	965.1	965.5	971.8	969.8

= At or above atmospheric boiling point.

NOTE: To determine specific gravity, divide the density of the fluid by the density of water at 20°C.

Table 11—Densities (lb/ft³) of Aqueous Solutions of DOWFROST HD Fluid—English Units

Temp.	Volume Percent Propylene Glycol							
°F	0%	10%	20%	30%	40%	50%	60%	70%
-30							68.33	68.95
-20						67.52	68.20	68.80
-10						67.40	68.06	68.64
0					66.55	67.27	67.91	68.47
10				65.64	66.43	67.14	67.75	68.29
20			64.65	65.53	66.31	66.99	67.59	68.10
30		63.58	64.56	65.42	66.17	66.84	67.41	67.91
40	62.42	63.50	64.46	65.30	66.03	66.68	67.23	67.71
50	62.38	63.41	64.34	65.17	65.88	66.51	67.04	67.50
60	62.34	63.31	64.22	65.02	65.72	66.33	66.85	67.28
70	62.27	63.20	64.09	64.87	65.55	66.14	66.64	67.06
80	62.19	63.08	63.95	64.71	65.37	65.94	66.43	66.83
90	62.11	62.95	63.80	64.54	65.18	65.74	66.20	66.59
100	62.00	62.81	63.64	64.37	64.99	65.52	65.97	66.34
110	61.84	62.66	63.47	64.18	64.78	65.30	65.73	66.08
120	61.73	62.50	63.29	63.98	64.57	65.07	65.49	65.82
130	61.54	62.33	63.10	63.77	64.34	64.83	65.23	65.55
140	61.39	62.15	62.91	63.56	64.11	64.58	64.97	65.27
150	61.20	61.96	62.70	63.33	63.87	64.32	64.69	64.98
160	61.01	61.76	62.48	63.10	63.62	64.06	64.41	64.69
170	60.79	61.56	62.26	62.85	63.36	63.78	64.12	64.39
180	60.57	61.34	62.02	62.60	63.09	63.50	63.83	64.08
190	60.35	61.11	61.77	62.34	62.81	63.21	63.52	63.76
200	60.13	60.88	61.52	62.07	62.53	62.91	63.21	63.44
210	59.88	60.63	61.26	61.79	62.23	62.60	62.89	63.10
220	59.63	60.38	60.98	61.50	61.93	62.28	62.56	62.76
230	59.38	60.11	60.70	61.20	61.61	61.95	62.22	62.42
240	59.10	59.84	60.41	60.89	61.29	61.62	61.87	62.06
250	58.82	59.55	60.10	60.57	60.96	61.27	61.52	61.70
260	58.51	59.26	59.79	60.24	60.61	60.92	61.16	61.33
270	58.24	58.95	59.47	59.91	60.26	60.56	60.78	60.95
280	57.94	58.64	59.14	59.56	59.91	60.19	60.40	60.56
290	57.64	58.32	58.80	59.20	59.54	59.81	60.02	60.16
300	57.31	57.98	58.45	58.84	59.16	59.42	59.62	59.76
310	56.98	57.64	58.09	58.46	58.77	59.02	59.22	59.35
320	56.66	57.29	57.72	58.08	58.38	58.62	58.80	58.93
325	56.43	57.11	57.53	57.89	58.18	58.41	58.59	58.72

= Above atmospheric boiling point.

NOTE: To determine specific gravity, divide the density of the fluid by the density of water at 68°F.

Table 12—Densities (kg/m³) of Aqueous Solutions of DOWFROST HD Fluid—SI Units

Temp.	Volume Percent Propylene Glycol							
°C	0%	10%	20%	30%	40%	50%	60%	70%
-35							1094.7	1104.7
-30						1081.9	1092.8	1102.5
-25						1080.2	1090.8	1100.2
-20					1066.6	1078.4	1088.7	1097.8
-15					1065.0	1076.5	1086.5	1095.3
-10				1050.7	1063.3	1074.5	1084.2	1092.7
-5			1035.1	1049.2	1061.5	1072.4	1081.8	1089.9
0		1018.2	1033.8	1047.5	1059.5	1070.1	1079.3	1087.1
5	1006.7	1017.0	1032.3	1045.7	1057.5	1067.8	1076.6	1084.2
10	1004.3	1015.7	1030.6	1043.8	1055.3	1065.3	1073.9	1081.2
15	1001.9	1014.2	1028.9	1041.8	1053.0	1062.7	1071.1	1078.1
20	999.4	1012.6	1027.0	1039.6	1050.5	1060.0	1068.1	1074.9
25	996.9	1010.9	1025.0	1037.4	1048.0	1057.2	1065.0	1071.5
30	994.3	1009.1	1022.9	1035.0	1045.3	1054.3	1061.9	1068.1
35	991.7	1007.2	1020.7	1032.5	1042.6	1051.3	1058.6	1064.6
40	989.0	1005.1	1018.3	1029.8	1039.7	1048.1	1055.2	1061.0
45	986.3	1002.9	1015.8	1027.1	1036.7	1044.9	1051.7	1057.3
50	983.5	1000.6	1013.2	1024.2	1033.5	1041.5	1048.1	1053.4
55	980.7	998.1	1010.5	1021.2	1030.3	1038.0	1044.4	1049.5
60	977.8	995.5	1007.6	1018.1	1026.9	1034.5	1040.6	1045.5
65	974.9	992.8	1004.6	1014.8	1023.5	1030.8	1036.7	1041.4
70	971.9	990.0	1001.5	1011.5	1019.9	1026.9	1032.7	1037.2
75	968.8	987.0	998.3	1008.0	1016.2	1023.0	1028.5	1032.8
80	965.7	984.0	995.0	1004.4	1012.3	1019.0	1024.3	1028.4
85	962.6	980.7	991.5	1000.7	1008.4	1014.8	1020.0	1023.9
90	959.3	977.4	987.9	996.8	1004.3	1010.5	1015.5	1019.3
95	956.0	974.0	984.2	992.9	1000.1	1006.2	1010.9	1014.6
100	952.6	970.4	980.3	988.8	995.8	1001.7	1006.3	1009.7
105	949.2	966.7	976.3	984.6	991.4	997.1	1001.5	1004.8
110	945.7	962.8	972.3	980.2	986.9	992.3	996.6	999.8
115	942.1	958.9	968.0	975.8	982.2	987.5	991.6	994.7
120	938.5	954.8	963.7	971.2	977.5	982.6	986.5	989.4
125	934.7	950.6	959.2	966.5	972.6	977.5	981.3	984.1
130	930.9	946.3	954.7	961.7	967.6	972.3	976.0	978.7
135	927.1	941.8	949.9	956.8	962.5	967.1	970.6	973.1
140	923.1	937.2	945.1	951.8	957.2	961.7	965.1	967.5
145	919.1	932.5	940.2	946.6	951.9	956.2	959.5	961.8
150	914.9	927.7	935.1	941.3	946.4	950.5	953.7	956.0
155	910.7	922.7	929.9	935.9	940.8	944.8	947.9	950.0
160	906.4	917.7	924.5	930.3	935.1	939.0	941.9	944.0

= At or above atmospheric boiling point.

NOTE: To determine specific gravity, divide the density of the fluid by the density of water at 20°C.

Table 13—Viscosities (cps) of Aqueous Solutions of DOWFROST Fluid—English Units

Temp.	Volume Percent Propylene Glycol									
°F	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%
-30							497.57	864.87	1363.75	3555.22
-20							298.75	493.93	820.58	1819.72
-10						95.97	182.96	291.28	495.68	983.05
0					40.92	61.32	114.90	177.73	303.94	558.32
10				13.42	26.99	40.62	74.19	112.20	190.41	332.02
20			5.36	9.89	18.50	27.83	49.29	73.22	122.30	205.91
30		2.80	4.23	7.46	13.12	19.66	33.68	49.32	80.66	132.67
40	1.53	2.28	3.41	5.75	9.60	14.28	23.65	34.22	54.64	88.51
50	1.30	1.89	2.79	4.52	7.21	10.65	17.05	24.41	37.99	60.93
60	1.12	1.60	2.32	3.62	5.56	8.13	12.59	17.86	27.10	43.16
70	0.98	1.38	1.95	2.94	4.38	6.34	9.51	13.38	19.79	31.37
80	0.86	1.20	1.66	2.43	3.52	5.04	7.34	10.25	14.79	23.35
90	0.76	1.05	1.43	2.04	2.88	4.08	5.77	8.00	11.29	17.75
100	0.68	0.93	1.25	1.73	2.40	3.35	4.62	6.37	8.79	13.76
110	0.61	0.83	1.10	1.49	2.03	2.79	3.76	5.15	6.97	10.86
120	0.55	0.75	0.97	1.30	1.73	2.36	3.11	4.23	5.62	8.71
130	0.51	0.68	0.87	1.14	1.50	2.02	2.61	3.53	4.60	7.09
140	0.46	0.62	0.78	1.01	1.31	1.75	2.22	2.98	3.82	5.85
150	0.43	0.57	0.71	0.91	1.16	1.53	1.91	2.54	3.22	4.89
160	0.39	0.52	0.64	0.82	1.04	1.35	1.66	2.19	2.75	4.13
170	0.37	0.48	0.59	0.74	0.93	1.20	1.45	1.91	2.37	3.52
180	0.34	0.44	0.54	0.68	0.85	1.08	1.29	1.69	2.07	3.04
190	0.32	0.41	0.50	0.62	0.77	0.97	1.15	1.50	1.82	2.64
200	0.30	0.38	0.46	0.58	0.71	0.88	1.04	1.34	1.61	2.31
210	0.28	0.36	0.43	0.54	0.66	0.81	0.94	1.21	1.45	2.04
220	0.27	0.34	0.40	0.50	0.61	0.74	0.86	1.10	1.31	1.82
230	0.25	0.32	0.38	0.47	0.57	0.69	0.79	1.00	1.19	1.63
240	0.24	0.30	0.36	0.44	0.53	0.64	0.73	0.92	1.09	1.47
250	0.23	0.28	0.34	0.42	0.50	0.59	0.68	0.85	1.00	1.33

= Above atmospheric boiling point.

Table 14—Viscosities (mPa sec) of Aqueous Solutions of DOWFROST Fluid—SI Units

Temp.	Volume Percent Propylene Glycol									
°C	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%
-35							524.01	916.18	1434.22	3813.29
-30						171.54	330.39	551.12	908.47	2071.34
-25						109.69	211.43	340.09	575.92	1176.09
-20					48.90	72.42	137.96	215.67	368.77	696.09
-15					33.07	49.29	92.00	140.62	239.86	428.19
-10				11.84	23.11	34.51	62.78	94.23	159.02	272.94
-5			4.98	9.07	16.63	24.81	43.84	64.83	107.64	179.78
0		2.68	4.05	7.07	12.30	18.28	31.32	45.74	74.45	122.03
5	1.51	2.23	3.34	5.61	9.32	13.77	22.87	33.04	52.63	85.15
10	1.30	1.89	2.79	4.52	7.21	10.59	17.05	24.41	37.99	60.93
15	1.14	1.63	2.36	3.69	5.70	8.30	12.96	18.41	28.00	44.62
20	1.00	1.42	2.02	3.06	4.59	6.62	10.04	14.15	21.04	33.38
25	0.89	1.25	1.74	2.57	3.75	5.36	7.91	11.08	16.10	25.45
30	0.79	1.11	1.52	2.19	3.12	4.41	6.34	8.81	12.55	19.76
35	0.72	0.99	1.34	1.88	2.62	3.68	5.15	7.12	9.94	15.60
40	0.65	0.89	1.18	1.63	2.24	3.10	4.25	5.84	7.99	12.49
45	0.59	0.81	1.06	1.43	1.93	2.65	3.55	4.85	6.52	10.15
50	0.54	0.73	0.95	1.26	1.68	2.28	3.00	4.08	5.39	8.35
55	0.50	0.67	0.86	1.13	1.48	1.99	2.57	3.46	4.51	6.95
60	0.46	0.62	0.78	1.01	1.31	1.75	2.22	2.98	3.82	5.85
65	0.43	0.57	0.71	0.92	1.18	1.55	1.93	2.58	3.28	4.97
70	0.40	0.53	0.66	0.83	1.06	1.38	1.70	2.26	2.83	4.26
75	0.37	0.49	0.60	0.76	0.96	1.24	1.51	1.99	2.47	3.69
80	0.35	0.46	0.56	0.70	0.88	1.12	1.35	1.77	2.18	3.22
85	0.33	0.43	0.52	0.65	0.81	1.02	1.22	1.59	1.94	2.83
90	0.31	0.40	0.49	0.60	0.75	0.93	1.10	1.43	1.73	2.50
95	0.29	0.38	0.45	0.56	0.69	0.86	1.01	1.30	1.56	2.23
100	0.28	0.35	0.43	0.53	0.65	0.79	0.92	1.18	1.42	2.00
105	0.27	0.33	0.40	0.50	0.60	0.74	0.85	1.08	1.29	1.80
110	0.25	0.32	0.38	0.47	0.57	0.69	0.79	1.00	1.19	1.63
115	0.24	0.30	0.36	0.45	0.54	0.64	0.74	0.93	1.09	1.48
120	0.23	0.28	0.34	0.42	0.51	0.60	0.69	0.86	1.02	1.35

= At or above atmospheric boiling point.

Table 15—Viscosities (cps) of Aqueous Solutions of DOWFROST HD Fluid—English Units

Temp.	Volume Percent Propylene Glycol							
°F	0%	10%	20%	30%	40%	50%	60%	70%
-30							497.57	864.87
-20							298.75	493.93
-10						95.97	182.96	291.28
0					40.92	61.32	114.90	177.73
10				13.42	26.99	40.62	74.19	112.20
20			5.36	9.89	18.50	27.83	49.29	73.22
30		2.80	4.23	7.46	13.12	19.66	33.68	49.32
40	1.53	2.28	3.41	5.75	9.60	14.28	23.65	34.22
50	1.30	1.89	2.79	4.52	7.21	10.65	17.05	24.41
60	1.12	1.60	2.32	3.62	5.56	8.13	12.59	17.86
70	0.98	1.38	1.95	2.94	4.38	6.34	9.51	13.38
80	0.86	1.20	1.66	2.43	3.52	5.04	7.34	10.25
90	0.76	1.05	1.43	2.04	2.88	4.08	5.77	8.00
100	0.68	0.93	1.25	1.73	2.40	3.35	4.62	6.37
110	0.61	0.83	1.10	1.49	2.03	2.79	3.76	5.15
120	0.55	0.75	0.97	1.30	1.73	2.36	3.11	4.23
130	0.51	0.68	0.87	1.14	1.50	2.02	2.61	3.53
140	0.46	0.62	0.78	1.01	1.31	1.75	2.22	2.98
150	0.43	0.57	0.71	0.91	1.16	1.53	1.91	2.54
160	0.39	0.52	0.64	0.82	1.04	1.35	1.66	2.19
170	0.37	0.48	0.59	0.74	0.93	1.20	1.45	1.91
180	0.34	0.44	0.54	0.68	0.85	1.08	1.29	1.69
190	0.32	0.41	0.50	0.62	0.77	0.97	1.15	1.50
200	0.30	0.38	0.46	0.58	0.71	0.88	1.04	1.34
210	0.28	0.36	0.43	0.54	0.66	0.81	0.94	1.21
220	0.26	0.34	0.40	0.50	0.61	0.74	0.86	1.10
230	0.25	0.32	0.38	0.47	0.57	0.69	0.79	1.00
240	0.24	0.30	0.36	0.44	0.53	0.64	0.73	0.92
250	0.23	0.28	0.34	0.42	0.50	0.59	0.68	0.85
260	0.22	0.27	0.32	0.40	0.48	0.56	0.63	0.79
270	0.21	0.25	0.30	0.38	0.45	0.52	0.59	0.73
280	0.20	0.24	0.29	0.36	0.43	0.49	0.56	0.69
290	0.19	0.23	0.27	0.35	0.41	0.47	0.53	0.64
300	0.18	0.22	0.26	0.33	0.39	0.44	0.50	0.61
325	0.17	0.19	0.24	0.31	0.36	0.40	0.45	0.53

= Above atmospheric boiling point.

Table 16—Viscosities (mPa sec) of Aqueous Solutions of DOWFROST HD Fluid—SI Units

Temp.	Volume Percent Propylene Glycol							
°C	0%	10%	20%	30%	40%	50%	60%	70%
-35							524.01	916.18
-30						171.54	330.39	551.12
-25						109.69	211.43	340.09
-20					48.90	72.42	137.96	215.67
-15					33.07	49.29	92.00	140.62
-10				11.84	23.11	34.51	62.78	94.23
-5			4.98	9.07	16.63	24.81	43.84	64.83
0		2.68	4.05	7.07	12.30	18.28	31.32	45.74
5	1.51	2.23	3.34	5.61	9.32	13.77	22.87	33.04
10	1.30	1.89	2.79	4.52	7.21	10.59	17.05	24.41
15	1.14	1.63	2.36	3.69	5.70	8.30	12.96	18.41
20	1.00	1.42	2.02	3.06	4.59	6.62	10.04	14.15
25	0.89	1.25	1.74	2.57	3.75	5.36	7.91	11.08
30	0.79	1.11	1.52	2.19	3.12	4.41	6.34	8.81
35	0.72	0.99	1.34	1.88	2.62	3.68	5.15	7.12
40	0.65	0.89	1.18	1.63	2.24	3.10	4.25	5.84
45	0.59	0.81	1.06	1.43	1.93	2.65	3.55	4.85
50	0.54	0.73	0.95	1.26	1.68	2.28	3.00	4.08
55	0.50	0.67	0.86	1.13	1.48	1.99	2.57	3.46
60	0.46	0.62	0.78	1.01	1.31	1.75	2.22	2.98
65	0.43	0.57	0.71	0.92	1.18	1.55	1.93	2.58
70	0.40	0.53	0.66	0.83	1.06	1.38	1.70	2.26
75	0.37	0.49	0.60	0.76	0.96	1.24	1.51	1.99
80	0.35	0.46	0.56	0.70	0.88	1.12	1.35	1.77
85	0.33	0.43	0.52	0.65	0.81	1.02	1.22	1.59
90	0.31	0.40	0.49	0.60	0.75	0.93	1.10	1.43
95	0.29	0.38	0.45	0.56	0.69	0.86	1.01	1.30
100	0.28	0.35	0.43	0.53	0.65	0.79	0.92	1.18
105	0.27	0.33	0.40	0.50	0.60	0.74	0.85	1.08
110	0.25	0.32	0.38	0.47	0.57	0.69	0.79	1.00
115	0.24	0.30	0.36	0.45	0.54	0.64	0.74	0.93
120	0.23	0.28	0.34	0.42	0.51	0.60	0.69	0.86
125	0.22	0.27	0.32	0.41	0.48	0.57	0.65	0.80
130	0.21	0.26	0.31	0.39	0.46	0.54	0.61	0.75
135	0.20	0.24	0.29	0.37	0.44	0.51	0.58	0.71
140	0.19	0.23	0.28	0.36	0.42	0.48	0.55	0.67
145	0.18	0.22	0.27	0.34	0.40	0.46	0.52	0.63
150	0.18	0.21	0.26	0.33	0.39	0.44	0.50	0.60
155	0.17	0.20	0.25	0.32	0.38	0.42	0.48	0.57
160	0.16	0.20	0.24	0.31	0.36	0.40	0.46	0.55

= At or above atmospheric boiling point.

Table 17—Thermal Conductivity (Btu/(hr·ft²)(°F/ft)) of Aqueous Solutions of DOWFROST Fluid—English Units

Temp.	Volume Percent Propylene Glycol									
°F	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%
-30							0.156	0.140	0.127	0.117
-20						0.175	0.158	0.142	0.129	0.118
-10						0.178	0.160	0.143	0.130	0.119
0					0.201	0.181	0.162	0.145	0.131	0.119
10				0.228	0.205	0.183	0.164	0.146	0.132	0.120
20				0.232	0.208	0.186	0.166	0.148	0.133	0.121
30			0.263	0.236	0.211	0.188	0.168	0.149	0.134	0.122
40	0.330	0.298	0.267	0.240	0.214	0.191	0.170	0.151	0.135	0.122
50	0.336	0.303	0.272	0.243	0.217	0.193	0.171	0.152	0.136	0.123
60	0.342	0.308	0.276	0.247	0.220	0.195	0.173	0.153	0.137	0.123
70	0.347	0.312	0.280	0.250	0.223	0.198	0.175	0.154	0.137	0.124
80	0.352	0.317	0.284	0.253	0.225	0.200	0.176	0.155	0.138	0.124
90	0.357	0.321	0.287	0.256	0.228	0.202	0.178	0.156	0.139	0.125
100	0.362	0.325	0.291	0.259	0.230	0.203	0.179	0.157	0.139	0.125
110	0.366	0.329	0.294	0.261	0.232	0.205	0.180	0.158	0.140	0.125
120	0.370	0.332	0.296	0.264	0.234	0.206	0.181	0.159	0.140	0.126
130	0.374	0.335	0.299	0.266	0.236	0.208	0.183	0.160	0.141	0.126
140	0.377	0.338	0.301	0.268	0.237	0.209	0.183	0.160	0.141	0.126
150	0.380	0.340	0.304	0.270	0.239	0.210	0.184	0.161	0.142	0.126
160	0.383	0.343	0.305	0.271	0.240	0.211	0.185	0.161	0.142	0.126
170	0.385	0.345	0.307	0.273	0.241	0.212	0.185	0.162	0.142	0.126
180	0.387	0.347	0.309	0.274	0.242	0.213	0.186	0.162	0.142	0.126
190	0.389	0.348	0.310	0.275	0.243	0.213	0.186	0.162	0.142	0.126
200	0.391	0.349	0.311	0.276	0.243	0.214	0.187	0.162	0.142	0.126
210	0.392	0.350	0.312	0.276	0.244	0.214	0.187	0.162	0.142	0.126
220	0.393	0.351	0.313	0.277	0.244	0.214	0.187	0.162	0.142	0.126
230	0.394	0.352	0.313	0.277	0.244	0.214	0.187	0.162	0.142	0.126
240	0.395	0.353	0.313	0.277	0.245	0.214	0.187	0.162	0.142	0.125
250	0.395	0.353	0.314	0.278	0.245	0.214	0.187	0.162	0.142	0.125

= Above atmospheric boiling point.

Table 18—Thermal Conductivity (W/mK) of Aqueous Solutions of DOWFROST Fluid—SI Units

Temp.	Volume Percent Propylene Glycol									
°C	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%
-35							0.269	0.242	0.220	0.203
-30						0.302	0.272	0.245	0.222	0.204
-25						0.306	0.275	0.247	0.224	0.205
-20					0.346	0.311	0.278	0.250	0.226	0.206
-15					0.351	0.315	0.282	0.252	0.227	0.207
-10				0.397	0.356	0.319	0.285	0.254	0.229	0.208
-5			0.449	0.403	0.361	0.323	0.288	0.256	0.230	0.209
0		0.510	0.456	0.409	0.366	0.327	0.291	0.259	0.232	0.210
5	0.572	0.518	0.463	0.415	0.371	0.331	0.294	0.261	0.233	0.211
10	0.582	0.526	0.470	0.421	0.376	0.334	0.297	0.263	0.235	0.212
15	0.591	0.534	0.477	0.426	0.380	0.338	0.299	0.265	0.236	0.213
20	0.599	0.541	0.483	0.431	0.384	0.341	0.302	0.267	0.237	0.214
25	0.608	0.548	0.489	0.436	0.388	0.344	0.304	0.268	0.239	0.215
30	0.615	0.555	0.494	0.441	0.392	0.347	0.307	0.270	0.240	0.215
35	0.623	0.561	0.500	0.445	0.396	0.350	0.309	0.272	0.241	0.216
40	0.630	0.567	0.505	0.450	0.399	0.353	0.311	0.273	0.242	0.216
45	0.636	0.573	0.509	0.453	0.402	0.355	0.313	0.274	0.242	0.217
50	0.642	0.578	0.514	0.457	0.405	0.358	0.314	0.275	0.243	0.217
55	0.648	0.583	0.518	0.460	0.408	0.360	0.316	0.277	0.244	0.218
60	0.653	0.587	0.521	0.463	0.410	0.362	0.317	0.277	0.244	0.218
65	0.657	0.591	0.525	0.466	0.413	0.363	0.319	0.278	0.245	0.218
70	0.662	0.595	0.528	0.469	0.415	0.365	0.320	0.279	0.245	0.218
75	0.666	0.598	0.531	0.471	0.416	0.366	0.321	0.280	0.246	0.218
80	0.669	0.601	0.533	0.473	0.418	0.367	0.321	0.280	0.246	0.218
85	0.672	0.604	0.535	0.474	0.419	0.368	0.322	0.281	0.246	0.218
90	0.675	0.606	0.537	0.476	0.420	0.369	0.323	0.281	0.246	0.218
95	0.677	0.608	0.538	0.477	0.421	0.370	0.323	0.281	0.246	0.218
100	0.679	0.609	0.540	0.478	0.422	0.370	0.323	0.281	0.246	0.218
105	0.681	0.611	0.541	0.479	0.423	0.371	0.323	0.281	0.246	0.218
110	0.682	0.612	0.542	0.480	0.423	0.371	0.323	0.281	0.246	0.217
115	0.683	0.613	0.542	0.480	0.423	0.371	0.323	0.281	0.245	0.217
120	0.684	0.613	0.543	0.480	0.423	0.371	0.323	0.280	0.245	0.216

= At or above atmospheric boiling point.

Table 19—Thermal Conductivity (Btu/hr ft²(°F/ft)) of Aqueous Solutions of DOWFROST HD Fluid—English Units

Temp.	Volume Percent Propylene Glycol							
°F	0%	10%	20%	30%	40%	50%	60%	70%
-30							0.156	0.140
-20						0.175	0.158	0.142
-10						0.178	0.160	0.143
0					0.201	0.181	0.162	0.145
10				0.228	0.205	0.183	0.164	0.146
20				0.232	0.208	0.186	0.166	0.148
30			0.263	0.236	0.211	0.188	0.168	0.149
40	0.330	0.298	0.267	0.240	0.214	0.191	0.170	0.151
50	0.336	0.303	0.272	0.243	0.217	0.193	0.171	0.152
60	0.342	0.308	0.276	0.247	0.220	0.195	0.173	0.153
70	0.347	0.312	0.280	0.250	0.223	0.198	0.175	0.154
80	0.352	0.317	0.284	0.253	0.225	0.200	0.176	0.155
90	0.357	0.321	0.287	0.256	0.228	0.202	0.178	0.156
100	0.362	0.325	0.291	0.259	0.230	0.203	0.179	0.157
110	0.366	0.329	0.294	0.261	0.232	0.205	0.180	0.158
120	0.370	0.332	0.296	0.264	0.234	0.206	0.181	0.159
130	0.374	0.335	0.299	0.266	0.236	0.208	0.183	0.160
140	0.377	0.338	0.301	0.268	0.237	0.209	0.183	0.160
150	0.380	0.340	0.304	0.270	0.239	0.210	0.184	0.161
160	0.383	0.343	0.305	0.271	0.240	0.211	0.185	0.161
170	0.385	0.345	0.307	0.273	0.241	0.212	0.185	0.162
180	0.387	0.347	0.309	0.274	0.242	0.213	0.186	0.162
190	0.389	0.348	0.310	0.275	0.243	0.213	0.186	0.162
200	0.391	0.349	0.311	0.276	0.243	0.214	0.187	0.162
210	0.392	0.350	0.312	0.276	0.244	0.214	0.187	0.162
220	0.393	0.351	0.313	0.277	0.244	0.214	0.187	0.162
230	0.394	0.352	0.313	0.277	0.244	0.214	0.187	0.162
240	0.395	0.353	0.313	0.277	0.245	0.214	0.187	0.162
250	0.395	0.353	0.314	0.278	0.245	0.214	0.187	0.162
260	0.395	0.353	0.314	0.278	0.244	0.214	0.187	0.162
270	0.395	0.353	0.314	0.277	0.244	0.214	0.186	0.161
280	0.395	0.353	0.313	0.277	0.244	0.213	0.186	0.161
290	0.395	0.353	0.313	0.277	0.244	0.213	0.185	0.160
300	0.395	0.352	0.313	0.276	0.243	0.213	0.185	0.160
310	0.394	0.352	0.312	0.276	0.242	0.212	0.184	0.159
320	0.393	0.351	0.311	0.275	0.242	0.211	0.184	0.159
325	0.393	0.350	0.311	0.274	0.241	0.211	0.183	0.158

= Above atmospheric boiling point.

Table 20—Thermal Conductivity (W/mK) of Aqueous Solutions of DOWFROST HD Fluid—SI Units

Temp.	Volume Percent Propylene Glycol							
°C	0%	10%	20%	30%	40%	50%	60%	70%
-35							0.269	0.242
-30						0.302	0.272	0.245
-25						0.306	0.275	0.247
-20					0.346	0.311	0.278	0.250
-15					0.351	0.315	0.282	0.252
-10				0.397	0.356	0.319	0.285	0.254
-5			0.449	0.403	0.361	0.323	0.288	0.256
0		0.510	0.456	0.409	0.366	0.327	0.291	0.259
5	0.572	0.518	0.463	0.415	0.371	0.331	0.294	0.261
10	0.582	0.526	0.470	0.421	0.376	0.334	0.297	0.263
15	0.591	0.534	0.477	0.426	0.380	0.338	0.299	0.265
20	0.599	0.541	0.483	0.431	0.384	0.341	0.302	0.267
25	0.608	0.548	0.489	0.436	0.388	0.344	0.304	0.268
30	0.615	0.555	0.494	0.441	0.392	0.347	0.307	0.270
35	0.623	0.561	0.500	0.445	0.396	0.350	0.309	0.272
40	0.630	0.567	0.505	0.450	0.399	0.353	0.311	0.273
45	0.636	0.573	0.509	0.453	0.402	0.355	0.313	0.274
50	0.642	0.578	0.514	0.457	0.405	0.358	0.314	0.275
55	0.648	0.583	0.518	0.460	0.408	0.360	0.316	0.277
60	0.653	0.587	0.521	0.463	0.410	0.362	0.317	0.277
65	0.657	0.591	0.525	0.466	0.413	0.363	0.319	0.278
70	0.662	0.595	0.528	0.469	0.415	0.365	0.320	0.279
75	0.666	0.598	0.531	0.471	0.416	0.366	0.321	0.280
80	0.669	0.601	0.533	0.473	0.418	0.367	0.321	0.280
85	0.672	0.604	0.535	0.474	0.419	0.368	0.322	0.281
90	0.675	0.606	0.537	0.476	0.420	0.369	0.323	0.281
95	0.677	0.608	0.538	0.477	0.421	0.370	0.323	0.281
100	0.679	0.609	0.540	0.478	0.422	0.370	0.323	0.281
105	0.681	0.611	0.541	0.479	0.423	0.371	0.323	0.281
110	0.682	0.612	0.542	0.480	0.423	0.371	0.323	0.281
115	0.683	0.613	0.542	0.480	0.423	0.371	0.323	0.281
120	0.684	0.613	0.543	0.480	0.423	0.371	0.323	0.280
125	0.684	0.613	0.543	0.480	0.423	0.370	0.323	0.280
130	0.684	0.614	0.543	0.480	0.423	0.370	0.322	0.279
135	0.684	0.613	0.542	0.480	0.422	0.370	0.322	0.279
140	0.684	0.613	0.542	0.479	0.422	0.369	0.321	0.278
145	0.684	0.613	0.541	0.478	0.421	0.368	0.320	0.277
150	0.683	0.612	0.541	0.478	0.420	0.367	0.320	0.276
155	0.682	0.611	0.540	0.477	0.419	0.366	0.319	0.275
160	0.681	0.610	0.538	0.476	0.418	0.365	0.317	0.274

= At or above atmospheric boiling point.

Table 21—Specific Heat (Btu/(lb·°F)) of Aqueous Solutions of DOWFROST Fluid—English Units

Temp.	Volume Percent Propylene Glycol									
°F	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%
-30							0.741	0.680	0.615	0.542
-20						0.799	0.746	0.687	0.623	0.550
-10						0.804	0.752	0.693	0.630	0.558
0					0.855	0.809	0.758	0.700	0.637	0.566
10				0.898	0.859	0.814	0.764	0.707	0.645	0.574
20			0.936	0.902	0.864	0.820	0.770	0.713	0.652	0.583
30		0.966	0.938	0.906	0.868	0.825	0.776	0.720	0.660	0.591
40	1.004	0.968	0.941	0.909	0.872	0.830	0.782	0.726	0.667	0.599
50	1.001	0.970	0.944	0.913	0.877	0.835	0.787	0.733	0.674	0.607
60	1.000	0.972	0.947	0.917	0.881	0.840	0.793	0.740	0.682	0.615
70	0.999	0.974	0.950	0.920	0.886	0.845	0.799	0.746	0.689	0.623
80	0.998	0.976	0.953	0.924	0.890	0.850	0.805	0.753	0.696	0.631
90	0.998	0.979	0.956	0.928	0.894	0.855	0.811	0.760	0.704	0.639
100	0.998	0.981	0.959	0.931	0.899	0.861	0.817	0.766	0.711	0.647
110	0.998	0.983	0.962	0.935	0.903	0.866	0.823	0.773	0.718	0.656
120	0.998	0.985	0.965	0.939	0.908	0.871	0.828	0.779	0.726	0.664
130	0.999	0.987	0.967	0.942	0.912	0.876	0.834	0.786	0.733	0.672
140	0.999	0.989	0.970	0.946	0.916	0.881	0.840	0.793	0.740	0.680
150	1.000	0.991	0.973	0.950	0.921	0.886	0.846	0.799	0.748	0.688
160	1.001	0.993	0.976	0.953	0.925	0.891	0.852	0.806	0.755	0.696
170	1.002	0.995	0.979	0.957	0.929	0.896	0.858	0.812	0.762	0.704
180	1.003	0.996	0.982	0.961	0.934	0.902	0.864	0.819	0.770	0.712
190	1.004	0.998	0.985	0.964	0.938	0.907	0.869	0.826	0.777	0.720
200	1.005	1.000	0.988	0.968	0.943	0.912	0.875	0.832	0.784	0.729
210	1.007	1.002	0.991	0.971	0.947	0.917	0.881	0.839	0.792	0.737
220	1.008	1.003	0.994	0.975	0.951	0.922	0.887	0.845	0.799	0.745
230	1.010	1.005	0.996	0.979	0.956	0.927	0.893	0.852	0.806	0.753
240	1.012	1.007	0.999	0.982	0.960	0.932	0.899	0.859	0.814	0.761
250	1.014	1.009	1.002	0.986	0.965	0.937	0.905	0.865	0.821	0.769

= Above atmospheric boiling point.

Table 22—Specific Heat (kJ/ kg K) of Aqueous Solutions of DOWFROST Fluid—SI Units

Temp.	Volume Percent Propylene Glycol									
°C	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%
-35							3.096	2.843	2.572	2.264
-30						3.339	3.118	2.868	2.600	2.295
-25						3.358	3.140	2.893	2.627	2.326
-20					3.569	3.378	3.162	2.918	2.655	2.356
-15					3.586	3.397	3.184	2.943	2.683	2.387
-10				3.765	3.603	3.416	3.206	2.968	2.710	2.417
-5			3.918	3.779	3.619	3.435	3.228	2.993	2.738	2.448
0		4.042	3.929	3.793	3.636	3.455	3.250	3.018	2.766	2.478
5	4.229	4.050	3.940	3.807	3.652	3.474	3.272	3.042	2.793	2.509
10	4.195	4.058	3.951	3.820	3.669	3.493	3.295	3.067	2.821	2.539
15	4.168	4.067	3.962	3.834	3.685	3.513	3.317	3.092	2.849	2.570
20	4.147	4.075	3.973	3.848	3.702	3.532	3.339	3.117	2.876	2.600
25	4.132	4.083	3.983	3.862	3.718	3.551	3.361	3.142	2.904	2.631
30	4.121	4.091	3.994	3.875	3.735	3.570	3.383	3.167	2.931	2.661
35	4.115	4.099	4.005	3.889	3.751	3.590	3.405	3.192	2.959	2.692
40	4.114	4.107	4.016	3.903	3.768	3.609	3.427	3.217	2.987	2.723
45	4.115	4.115	4.027	3.917	3.784	3.628	3.449	3.242	3.014	2.753
50	4.120	4.123	4.038	3.930	3.801	3.648	3.471	3.266	3.042	2.784
55	4.128	4.131	4.049	3.944	3.817	3.667	3.493	3.291	3.070	2.814
60	4.138	4.139	4.060	3.958	3.834	3.686	3.515	3.316	3.097	2.845
65	4.150	4.147	4.071	3.972	3.850	3.706	3.537	3.341	3.125	2.875
70	4.164	4.155	4.082	3.985	3.867	3.725	3.559	3.366	3.153	2.906
75	4.179	4.163	4.093	3.999	3.883	3.744	3.581	3.391	3.180	2.936
80	4.196	4.171	4.104	4.013	3.900	3.763	3.603	3.416	3.208	2.967
85	4.213	4.179	4.115	4.027	3.916	3.783	3.625	3.441	3.236	2.997
90	4.231	4.187	4.126	4.040	3.933	3.802	3.647	3.465	3.263	3.028
95	4.249	4.195	4.136	4.054	3.949	3.821	3.670	3.490	3.291	3.058
100	4.267	4.203	4.147	4.068	3.966	3.841	3.692	3.515	3.319	3.089
105	4.285	4.211	4.158	4.082	3.982	3.860	3.714	3.540	3.346	3.119
110	4.303	4.219	4.169	4.095	3.999	3.879	3.736	3.565	3.374	3.150
115	4.321	4.227	4.180	4.109	4.015	3.898	3.758	3.590	3.402	3.181
120	4.338	4.235	4.191	4.123	4.032	3.918	3.780	3.615	3.429	3.211

= At or above atmospheric boiling point.

Table 23—Specific Heat (Btu/(lb·°F)) of Aqueous Solutions of DOWFROST HD Fluid—English Units

Temp.	Volume Percent Propylene Glycol							
°F	0%	10%	20%	30%	40%	50%	60%	70%
-30							0.684	0.608
-20						0.758	0.691	0.616
-10						0.764	0.698	0.625
0					0.827	0.770	0.705	0.633
10				0.882	0.832	0.776	0.712	0.641
20			0.929	0.886	0.837	0.782	0.719	0.649
30		0.969	0.932	0.890	0.842	0.788	0.727	0.658
40	1.004	0.970	0.935	0.894	0.847	0.794	0.734	0.666
50	1.001	0.972	0.937	0.897	0.852	0.800	0.741	0.674
60	1.000	0.973	0.940	0.901	0.857	0.806	0.748	0.682
70	0.999	0.975	0.943	0.905	0.862	0.812	0.755	0.691
80	0.998	0.976	0.945	0.909	0.867	0.818	0.762	0.699
90	0.998	0.978	0.948	0.913	0.871	0.824	0.769	0.707
100	0.998	0.979	0.951	0.916	0.876	0.830	0.776	0.715
110	0.998	0.981	0.953	0.920	0.881	0.836	0.783	0.724
120	0.998	0.982	0.956	0.924	0.886	0.842	0.791	0.732
130	0.999	0.984	0.959	0.928	0.891	0.848	0.798	0.740
140	0.999	0.985	0.961	0.932	0.896	0.854	0.805	0.748
150	1.000	0.987	0.964	0.935	0.901	0.860	0.812	0.756
160	1.001	0.988	0.967	0.939	0.906	0.866	0.819	0.765
170	1.002	0.990	0.969	0.943	0.911	0.872	0.826	0.773
180	1.003	0.991	0.972	0.947	0.916	0.878	0.833	0.781
190	1.004	0.993	0.975	0.951	0.920	0.884	0.840	0.789
200	1.005	0.994	0.977	0.954	0.925	0.890	0.847	0.798
210	1.007	0.996	0.980	0.958	0.930	0.896	0.855	0.806
220	1.008	0.997	0.983	0.962	0.935	0.902	0.862	0.814
230	1.010	0.999	0.985	0.966	0.940	0.908	0.869	0.822
240	1.012	1.000	0.988	0.97	0.945	0.914	0.876	0.831
250	1.014	1.002	0.991	0.973	0.950	0.920	0.883	0.839
260	1.017	1.005	0.993	0.977	0.955	0.926	0.890	0.847
270	1.019	1.008	0.996	0.981	0.960	0.932	0.897	0.855
280	1.022	1.011	0.999	0.985	0.965	0.938	0.904	0.864
290	1.025	1.013	1.001	0.989	0.969	0.944	0.912	0.872
300	1.029	1.016	1.004	0.992	0.974	0.950	0.919	0.880
310	1.032	1.019	1.007	0.996	0.979	0.956	0.926	0.888
320	1.036	1.022	1.009	1.000	0.984	0.962	0.933	0.897
325	1.038	1.025	1.011	1.002	0.987	0.965	0.936	0.901

= Above atmospheric boiling point.

Table 24—Specific Heat (kJ/kg K) of Aqueous Solutions of DOWFROST HD Fluid—SI Units

Temp.	Volume Percent Propylene Glycol							
°C	0%	10%	20%	30%	40%	50%	60%	70%
-35							2.860	2.542
-30						3.166	2.887	2.573
-25						3.189	2.913	2.604
-20					3.455	3.211	2.940	2.635
-15					3.473	3.234	2.967	2.666
-10				3.699	3.492	3.256	2.994	2.697
-5			3.893	3.714	3.510	3.279	3.021	2.728
0		4.057	3.903	3.728	3.529	3.302	3.047	2.760
5	4.229	4.063	3.913	3.742	3.547	3.324	3.074	2.791
10	4.195	4.069	3.923	3.757	3.566	3.347	3.101	2.822
15	4.168	4.074	3.933	3.771	3.584	3.370	3.128	2.853
20	4.147	4.080	3.944	3.785	3.602	3.392	3.155	2.884
25	4.132	4.085	3.954	3.800	3.621	3.415	3.181	2.915
30	4.121	4.091	3.964	3.814	3.639	3.437	3.208	2.946
35	4.115	4.096	3.974	3.828	3.658	3.460	3.235	2.977
40	4.114	4.102	3.984	3.842	3.676	3.483	3.262	3.008
45	4.115	4.107	3.994	3.857	3.695	3.505	3.288	3.039
50	4.120	4.113	4.004	3.871	3.713	3.528	3.315	3.070
55	4.128	4.119	4.014	3.885	3.732	3.551	3.342	3.101
60	4.138	4.124	4.024	3.900	3.750	3.573	3.369	3.132
65	4.150	4.130	4.034	3.914	3.769	3.596	3.396	3.163
70	4.164	4.135	4.044	3.928	3.787	3.618	3.422	3.194
75	4.179	4.141	4.054	3.943	3.806	3.641	3.449	3.225
80	4.196	4.146	4.064	3.957	3.824	3.664	3.476	3.256
85	4.213	4.152	4.074	3.971	3.842	3.686	3.503	3.287
90	4.231	4.157	4.084	3.985	3.861	3.709	3.530	3.318
95	4.249	4.163	4.094	4.000	3.879	3.732	3.556	3.349
100	4.267	4.169	4.104	4.014	3.898	3.754	3.583	3.380
105	4.285	4.174	4.114	4.028	3.916	3.777	3.610	3.411
110	4.303	4.180	4.124	4.043	3.935	3.800	3.637	3.442
115	4.321	4.185	4.134	4.057	3.953	3.822	3.664	3.474
120	4.338	4.191	4.145	4.071	3.972	3.845	3.690	3.505
125	4.355	4.196	4.155	4.086	3.990	3.867	3.717	3.536
130	4.371	4.202	4.165	4.100	4.009	3.890	3.744	3.567
135	4.387	4.208	4.175	4.114	4.027	3.913	3.771	3.598
140	4.402	4.213	4.185	4.128	4.046	3.935	3.798	3.629
145	4.416	4.219	4.195	4.143	4.064	3.958	3.824	3.660
150	4.430	4.224	4.205	4.157	4.083	3.981	3.851	3.691
155	4.443	4.230	4.215	4.171	4.101	4.003	3.878	3.722
160	4.456	4.235	4.225	4.186	4.119	4.026	3.905	3.753

= At or above atmospheric boiling point.

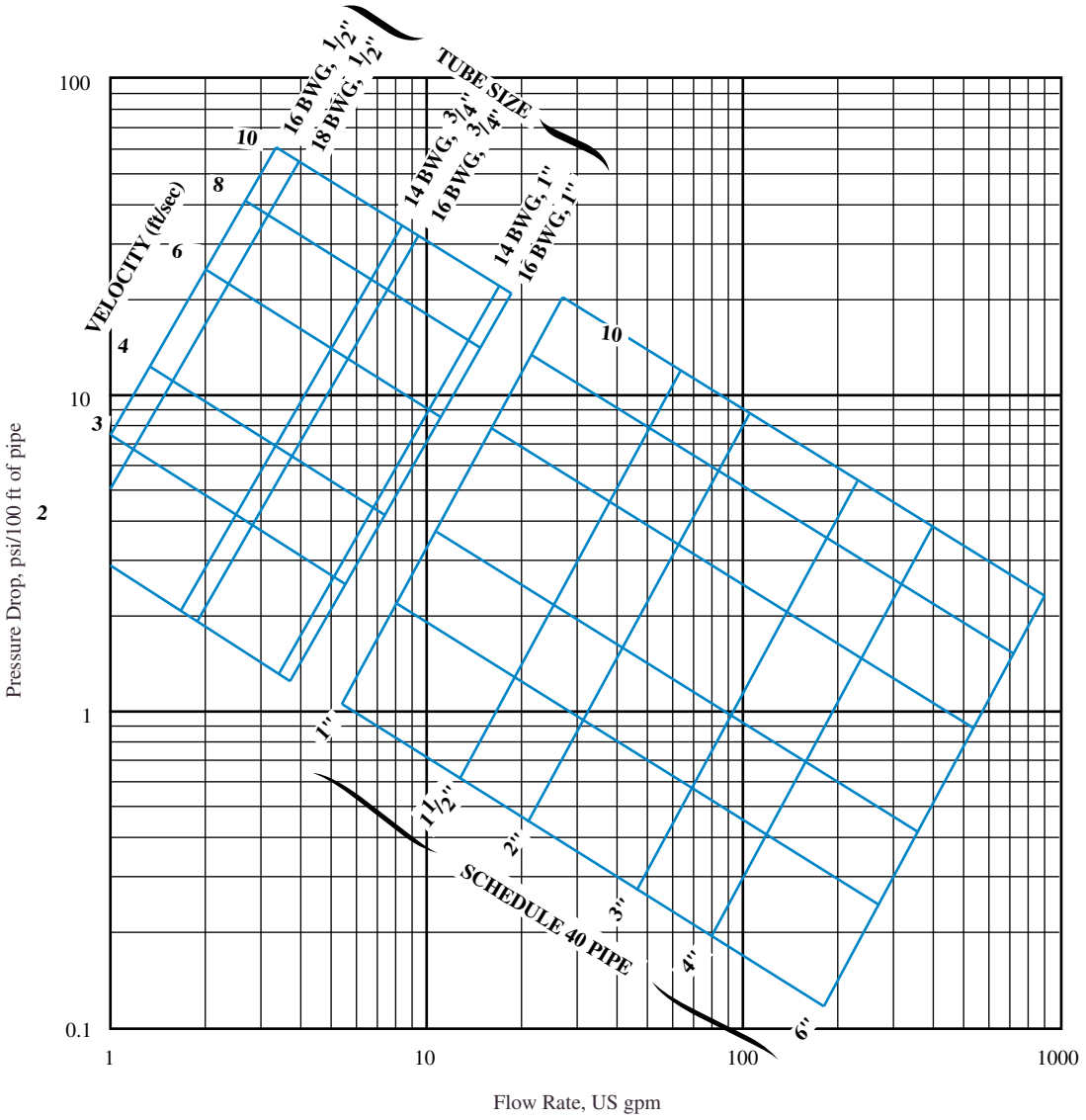
Table 25—Vapor Pressure of Aqueous Solutions of DOWFROST and DOWFROST HD Fluids, psia—English Units

Temp.	Volume Percent Propylene Glycol									
°F	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%
100	1.0	1.0	0.9	0.9	0.9					
110	1.3	1.3	1.3	1.2	1.2	1.1	1.0			
120	1.7	1.7	1.7	1.6	1.5	1.5	1.4	1.2	1.0	
130	2.2	2.2	2.2	2.1	2.0	1.9	1.8	1.5	1.3	
140	2.9	2.9	2.8	2.7	2.6	2.5	2.3	2.0	1.7	
150	3.7	3.7	3.6	3.5	3.4	3.2	3.0	2.5	2.1	1.2
160	4.7	4.7	4.6	4.4	4.3	4.1	3.8	3.2	2.7	1.5
170	6.0	5.9	5.8	5.6	5.4	5.2	4.8	4.1	3.5	1.9
180	7.5	7.4	7.2	7.0	6.7	6.5	5.9	5.1	4.4	2.4
190	9.3	9.2	9.0	8.7	8.3	8.1	7.4	6.3	5.4	3.1
200	11.5	11.3	11.0	10.7	10.2	9.9	9.1	7.8	6.7	3.9
210	14.1	13.8	13.5	13.1	12.5	12.1	11.1	9.5	8.2	4.8
220	17.2	16.8	16.4	15.9	15.2	14.8	13.6	11.6	10.0	5.9
230	20.8	20.3	19.8	19.2	18.4	17.8	16.4	14.0	12.1	7.2
240	25.0	24.4	23.8	23.0	22.0	21.4	19.7	16.8	14.6	8.8
250	29.8	29.1	28.4	27.4	26.3	25.6	23.5	20.1	17.5	10.7
260	35.4	34.6	33.7	32.5	31.2	30.3	27.9	23.9	20.8	12.9
270	41.8	40.8	39.7	38.4	36.8	35.8	33.0	28.2	24.7	15.4
280	49.2	48.0	46.7	45.1	43.3	42.1	38.8	33.2	29.1	18.3
290	57.5	56.1	54.6	52.7	50.6	49.3	45.4	38.9	34.1	21.7
300	67.0	65.3	63.5	61.4	58.9	57.4	52.8	45.3	39.8	25.6
310	77.6	75.7	73.6	71.1	68.2	66.5	61.3	52.6	46.3	30.0
320	89.6	87.4	84.9	82.0	78.7	76.8	70.8	60.7	53.5	35.0
325	96.1	93.8	91.1	88.0	84.4	82.4	76.0	65.2	57.5	37.8

Table 26—Vapor Pressure of Aqueous Solutions of DOWFROST and DOWFROST HD Fluids, kPa—SI Units

Temp.		Volume Percent Propylene Glycol								
°C	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%
50	12.3	12.3	12.1	11.7	11.3	10.8	9.9	8.5	7.1	
55	15.8	15.7	15.4	14.9	14.3	13.7	12.6	10.8	9.1	
60	19.9	19.8	19.4	18.8	18.0	17.3	15.9	13.6	11.5	
65	25.0	24.8	24.3	23.5	22.6	21.7	19.9	17.1	14.5	7.8
70	31.2	30.8	30.2	29.3	28.0	27.0	24.8	21.2	18.0	9.8
75	38.6	38.0	37.2	36.1	34.6	33.4	30.6	26.2	22.3	12.3
80	47.4	46.7	45.6	44.2	42.4	40.9	37.5	32.1	27.4	15.3
85	57.8	56.9	55.6	53.8	51.6	49.9	45.7	39.2	33.5	18.9
90	70.1	68.9	67.3	65.1	62.4	60.4	55.4	47.4	40.7	23.3
95	84.5	82.9	81.0	78.4	75.1	72.7	66.7	57.1	49.1	28.4
100	101.3	99.3	96.9	93.7	89.9	87.1	80.0	68.4	58.9	34.5
105	120.8	118.3	115.3	111.6	107.0	103.8	95.3	81.5	70.4	41.6
110	143.2	140.1	136.6	132.1	126.7	123.0	112.9	96.6	83.6	49.9
115	169.0	165.2	161.0	155.7	149.3	145.0	133.2	114.0	98.9	59.7
120	198.4	193.9	188.9	182.6	175.1	170.2	156.4	133.9	116.3	70.9
125	232.0	226.6	220.6	213.3	204.5	198.9	182.9	156.5	136.3	83.9
130	270.0	263.6	256.6	248.0	237.8	231.4	212.8	182.2	159.0	98.8
135	312.9	305.4	297.2	287.2	275.4	268.1	246.7	211.3	184.7	115.8
140	361.2	352.5	342.9	331.3	317.7	309.4	284.8	244.0	213.7	135.2
145	415.3	405.2	394.1	380.7	365.2	355.8	327.6	280.7	246.3	157.2
150	475.7	464.2	451.3	435.9	418.2	407.6	375.5	321.8	282.8	182.0
155	543.0	529.8	515.0	497.4	477.2	465.3	428.8	367.7	323.7	210.1
160	617.7	602.8	585.7	565.7	542.7	529.4	488.0	418.6	369.2	241.6

Figure 1—Pressure Drop at 30 Percent (volume) Propylene Glycol—English Units



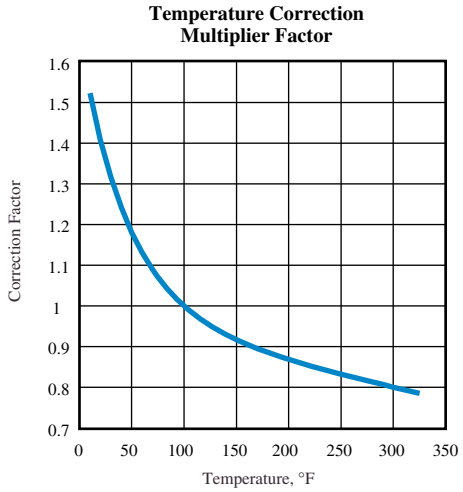
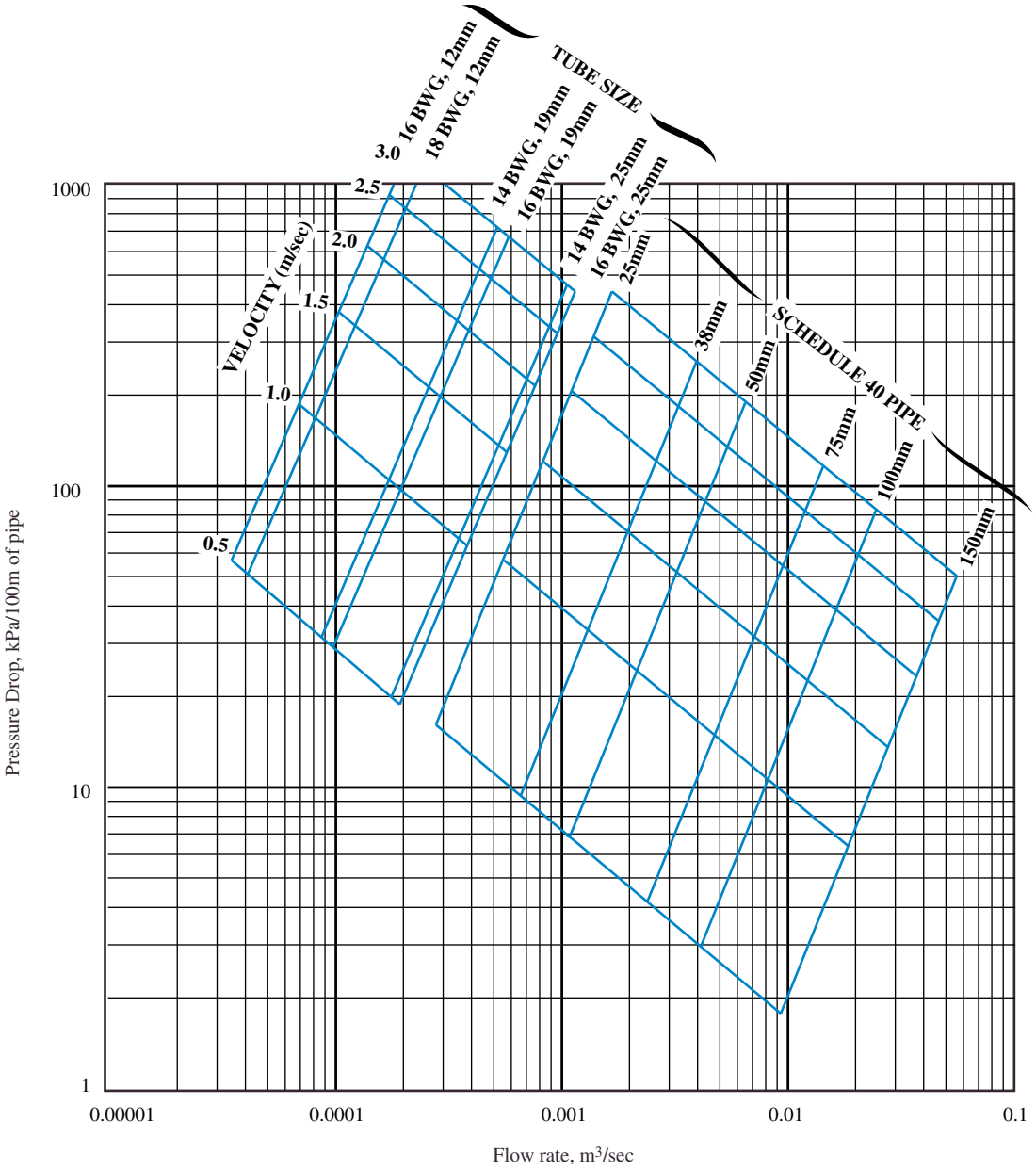


Figure 2—Pressure Drop at 30 Percent (volume) Propylene Glycol—SI Units



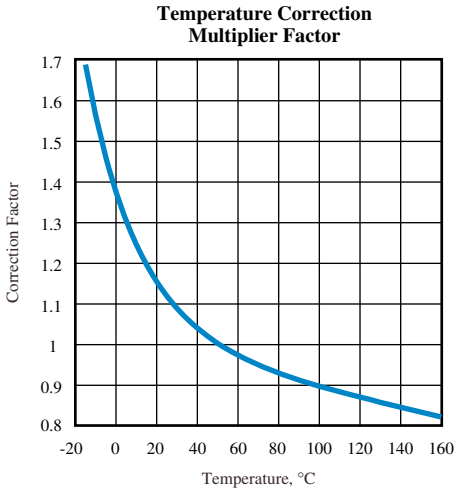
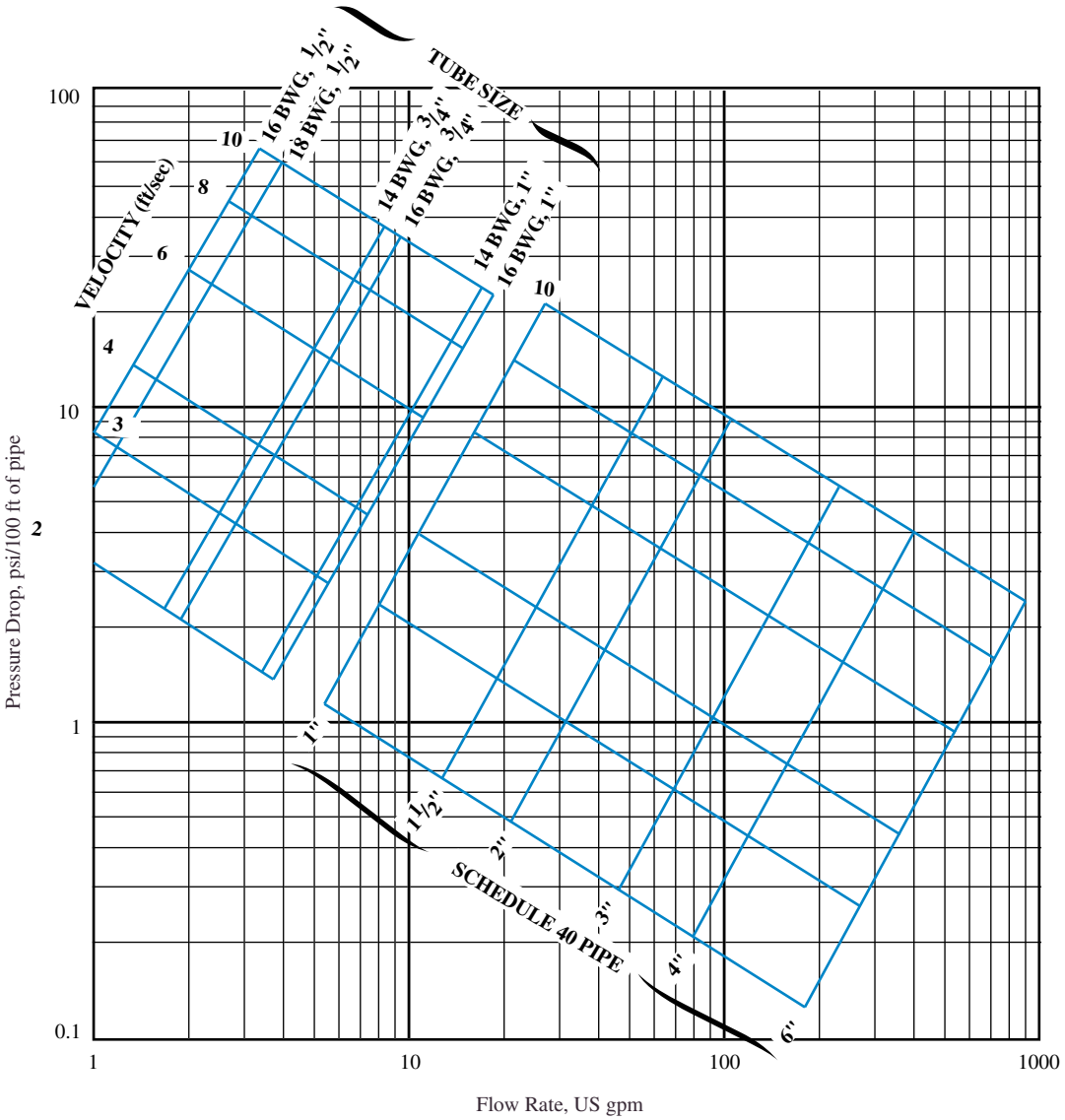


Figure 3—Pressure Drop at 40 Percent (volume) Propylene Glycol—English Units



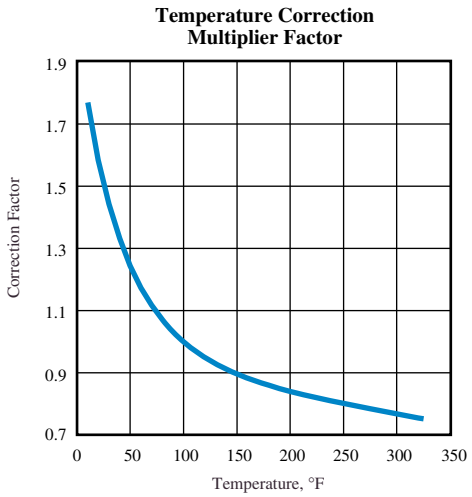
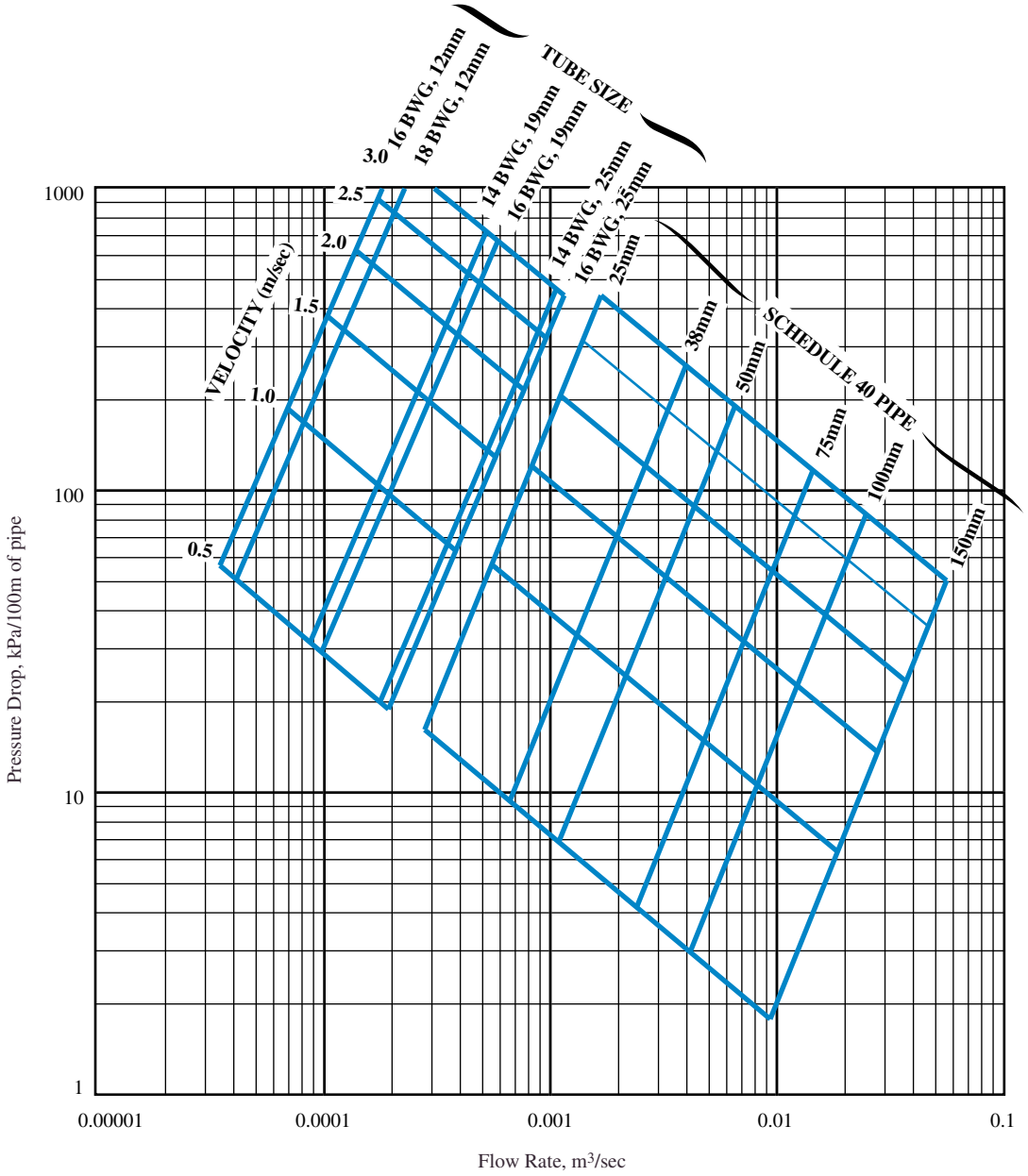


Figure 4—Pressure Drop at 40 Percent (volume) Propylene Glycol—SI Units



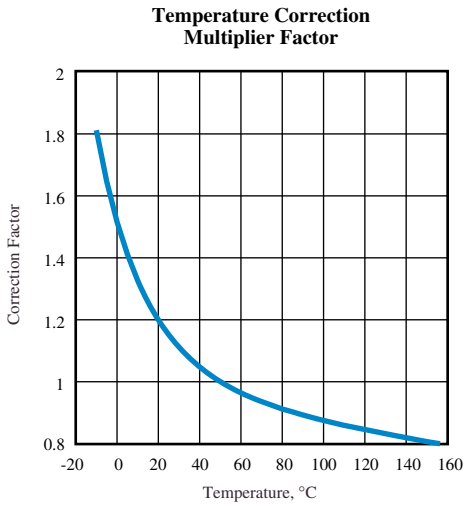
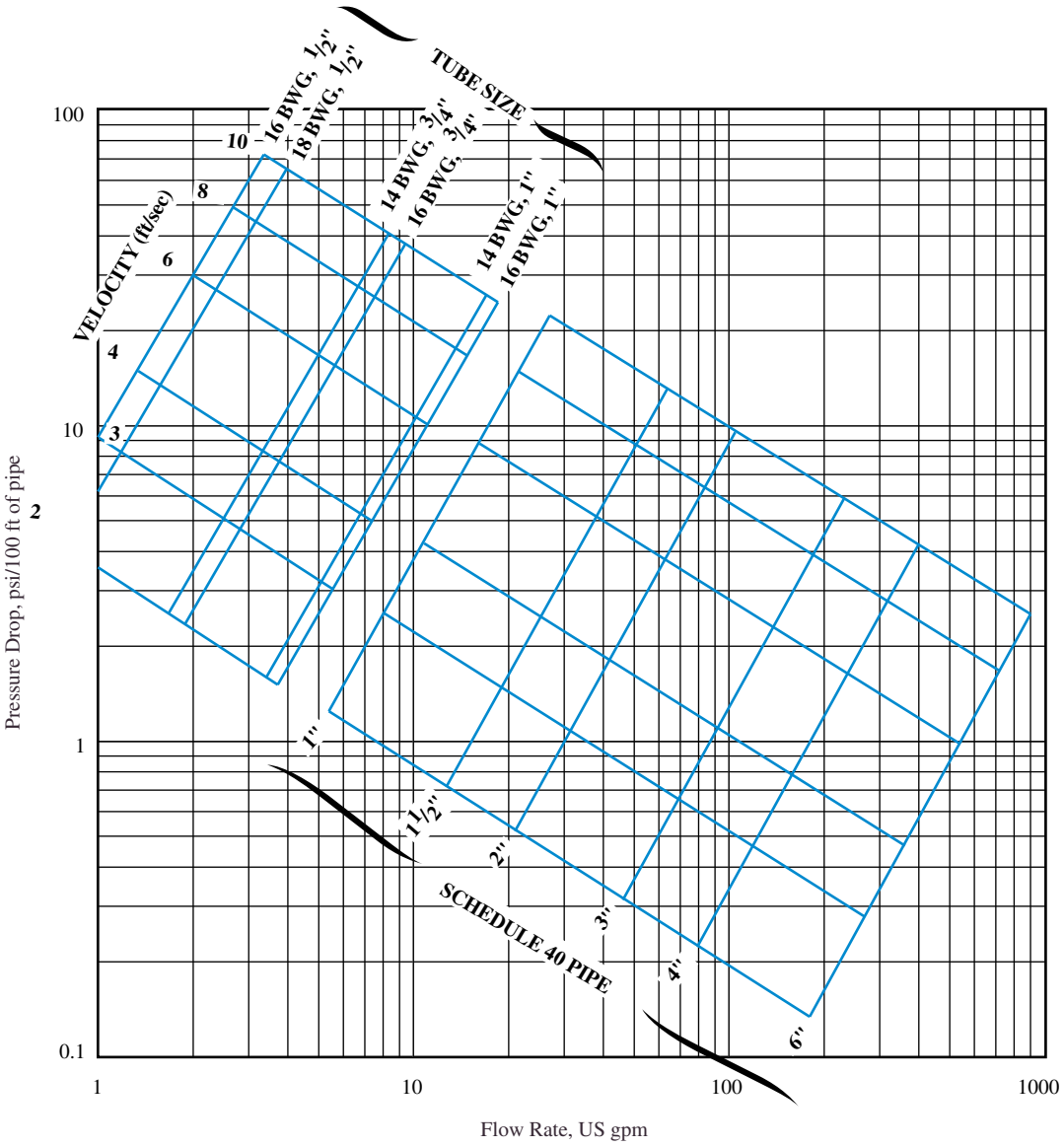


Figure 5—Pressure Drop at 50 Percent (volume) Propylene Glycol—English Units



Temperature Correction Multiplier Factor

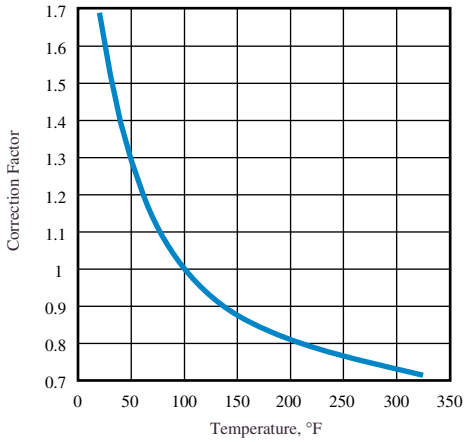
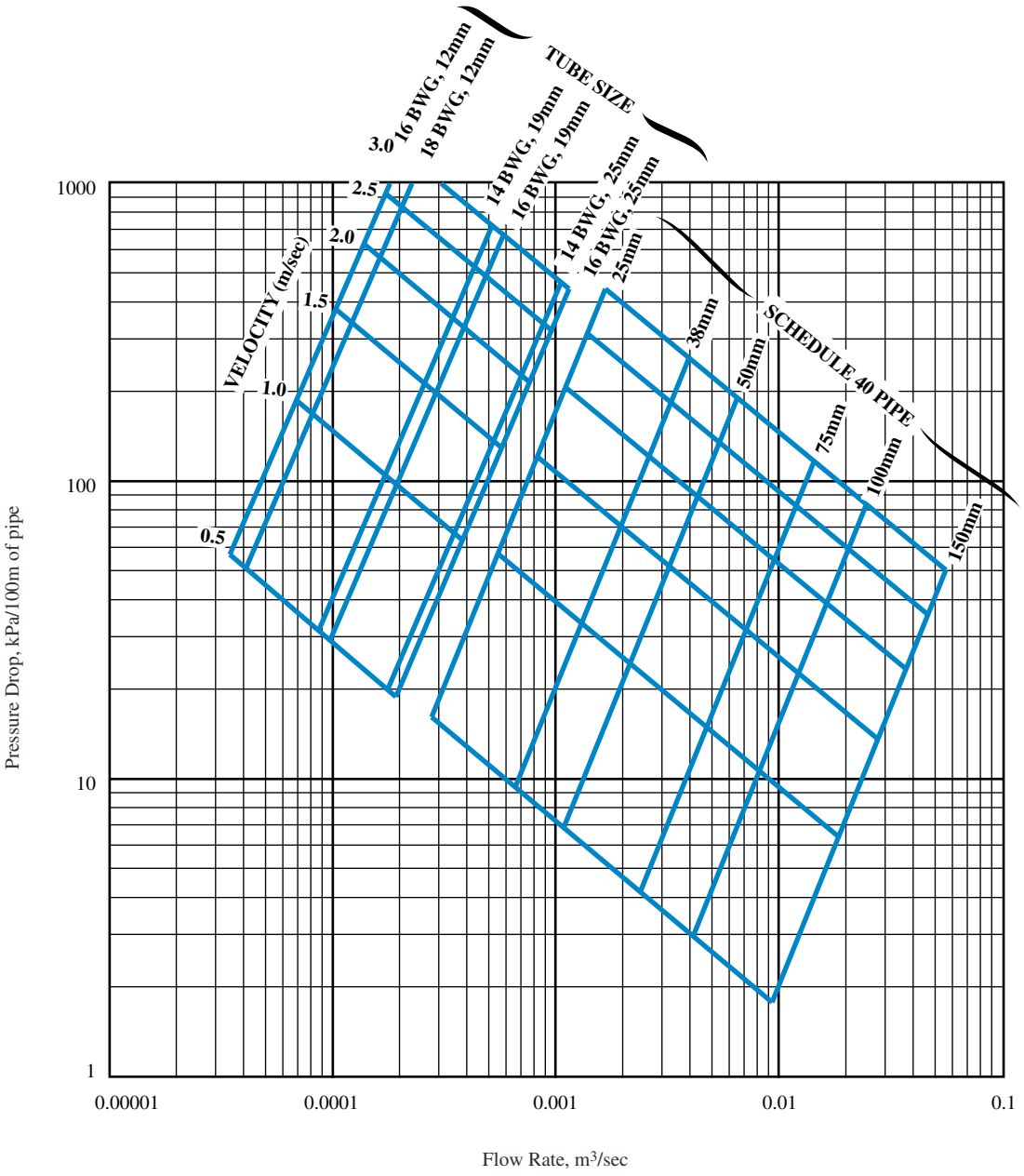
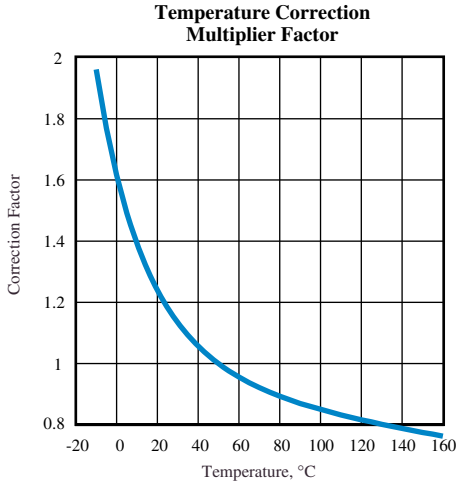


Figure 6— Pressure Drop at 50 Percent (volume) Propylene Glycol—SI Units





Safety, Handling, Storage, and Disposal of DOWFROST Propylene Glycol-based Fluids

Toxicology

For complete product toxicological information for DOWFROST fluids, request Material Safety Data (MSD) sheets from Dow. The MSD sheets provide the most up-to-date health and safety considerations related to the use of these products and should be consulted prior to use of the products.

Storage

Storage of DOWFROST glycol-based heat transfer fluids presents no unusual problems. The materials do not readily solidify, are low in toxicity, have high flash points, and can be handled without posing a hazard to health. As a precaution, however, sparks or flames should be avoided during transfer or processing operations because undiluted glycols can be ignited. Tank truck shipments can be emptied into storage tanks or clean drums.

Tank storage

Ordinary steel tanks are normally satisfactory for storage of DOWFROST fluids. However, during extended storage, slight discoloration may occur from iron contamination. Rusting may occur in the vapor space because there is no inhibitor where condensation occurs and oxygen is present. This problem can be minimized by closing any vent to the tank to limit oxygen intake. If this is not possible, see page 12 for a discussion of coatings suitable for protection of vapor space in tanks.

Insulation and heat are required for storage of DOWFROST fluids at low temperatures. This will prevent freezing or pumping problems due to high viscosity. Maintaining temperatures above 10°F (-12°C) is usually sufficient to avoid such problems.

Drum storage

DOWFROST fluids may be stored in the drums in which shipment is made. Because glycols are hygroscopic, it is important that the drum cap be replaced tightly after each withdrawal to keep the material in the drum from absorbing water. Drums should be stored inside a heated building when temperatures below 10°F (-12°C) are anticipated. This will assure that the glycol is in a liquid form when needed.

Environmental considerations

The biochemical oxygen demand (BOD) for propylene glycols approaches the theoretical oxygen demand (ThOD) value in the standard 20-day test period. This indicates that these materials are biodegradable and should not concentrate in common water systems. The possibility of spills in lakes or rivers, however, should be avoided, since rapid oxygen depletion may have harmful effects on aquatic organisms. Extensive testing of the effects of propylene glycol on aquatic organisms has shown the material to be practically non-toxic (LC 50 > 100 mg/L) with LC 50's ≥ 10,000 mg/L for fathead minnow, rainbow trout and Daphnia magna.

Table 16—Biochemical Oxygen Demand for Propylene Glycol

BOD	Parts Oxygen/Parts Propylene Glycol
5 day	1.12
10 day	1.22
20 day	1.42
ThOD	1.68

Spill, leak and disposal procedures

Using appropriate safety equipment, small spills may be soaked up with common absorbent material. For large spills, the fluid should be pumped into suitable containers located in diked areas. Residual material should be cleaned up with water. Concentrate can be handled according to local, state, and federal regulations.

Salvage

Some distributors of DOWFROST fluids are equipped to reclaim and/or dispose of spent or contaminated fluids. Occasionally, where regulations permit, diluted spent fluids that are not otherwise contaminated can be disposed of in local sewage treatment facilities, provided those facilities are advised and prepared for such disposal in advance. Aerobic bacteria easily oxidize the fluids to carbon dioxide and water within the usual 20-day test period. The Dow Chemical Company does not provide a disposal or reprocessing service for spent or contaminated glycol-based fluids.

Call 1-800-447-4369 to Receive These Free Thermal Fluid Evaluation Tools or Visit Our Website at www.dowfrost.com

FLUIDFILE software program: This menu-driven, IBM compatible data diskette displays and prints engineering properties of DOWTHERM and DOWFROST glycol-based fluids based on your operating temperature and glycol concentration input. The program also calculates fluid film coefficient and pressure drop based on your operating conditions.

Application-specific product literature: Select literature for your application from the Dow library of brochures about DOWTHERM and DOWFROST fluids. Applications brochures and data sheets are available for applications including HVAC and food processing. Also available are brochures detailing advantages of specific DOWTHERM and DOWFROST fluids.

HVAC Focus newsletter: Receive this informative newsletter to stay abreast of the latest information on HVAC system design and operation.

Outside the U.S. and Canada, call 1-517-832-1556 or fax 1-517-832-1465.

Engineering and Operating Guide

for DOWFROST and DOWFROST HD
Inhibited Propylene Glycol-based Heat Transfer Fluids

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