

TABLE 7. PHYSICAL PROPERTIES OF ANTIFREEZE SOLUTIONS

FLUID	FREEZING PROTECTION Temp. F	ITEM	FLUID TEMPERATURE—Fahrenheit							
			-20	0	20	40	120	140	160	200
Ethylene Glycol 15.3% by vol.	+20	$\nu \times 10^4$ c w	— — —	— — —	— — —	2.64 0.935 64.0	0.840 0.956 62.8	0.687 0.960 62.5	0.577 0.962 62.1	0.458 0.969 58.8
Ethylene Glycol 31.4% by vol.	0	$\nu \times 10^4$ c w	— — —	— — —	6.88 0.833 65.7	4.18 0.850 65.4	1.19 0.895 64.1	0.955 0.905 63.7	0.784 0.910 63.3	0.609 0.923 60.0
Ethylene Glycol 42.7% by vol.	-20	$\nu \times 10^4$ c w	— — —	16.1 0.764 66.8	9.47 0.775 66.7	5.75 0.788 66.3	1.46 0.832 65.3	1.20 0.845 64.9	0.950 0.856 64.4	0.748 0.884 60.6
Ethylene Glycol 51.3% by vol.	-40	$\nu \times 10^4$ c w	46.3 0.682 68.2	21.3 0.717 67.6	12.13 0.725 67.4	7.54 0.745 67.2	1.77 0.809 65.9	1.46 0.823 65.4	1.14 0.835 65.0	0.870 0.854 61.1
Heat Transfer Oil	-40	$\nu \times 10^4$ c w	105 0.382 62.9	43.1 0.390 62.5	29.7 0.400 62.0	14.0 0.408 61.6	3.13 0.444 59.1	2.51 0.452 58.6	2.06 0.462 57.6	1.48 0.480 55.3
Water	+32	$\nu \times 10^4$ c w	— — —	— — —	— — —	1.71 1.005 62.4	0.803 0.999 61.7	0.494 0.999 61.4	0.413 1.001 61.0	0.328 1.005 60.1

ν = Kinematic viscosity, (feet squared per second) (e.g. for oil at 40 F, ν = 0.000140 ft² per sec.)

c = specific heat, Btu per (pound) (Fahrenheit degree).

w = specific weight, pounds per cubic foot.

These solutions do not freeze, and they are effective fire extinguishing agents.

Petroleum distillates suitable for fluids in snow-melting systems are classified as non-flammable, but have fire points between 300 and 350 F. When using fluids of this type, care should be taken to collect any oil dripping from the seals on the pump. It is good practice also to provide some barrier between the oil lines and the boiler so that in the event of a leak, a flash back from the boiler will not ignite the oil.

There are other non-flammable fluids, such as those used in some transformers, that can be used as the antifreeze. These fluids are three or four times as expensive as the glycols or oils, but combine the fire protection of the glycols with the corrosion protection of the oils.

Internal Corrosion

Ethylene glycol solutions tend to become corrosive in service; therefore, rust inhibitors are generally included. Even with an inhibitor, the solution should be tested annually to determine any change in acidity. If the test indicates that the inhibitor has been exhausted, the entire system should be drained and a fresh solution installed.

To increase the life of the inhibitor, the heat exchanger surfaces should be kept below 285 F which corresponds to about 40 psig steam. Temperatures above 300 F accelerate the deterioration of the inhibitors.

Slab Construction

It has been found satisfactory to use $\frac{3}{4}$ pipe or tubing on 12-in. centers as a standard coil. If pumping loads require a reduction in friction the pipe size may be increased to 1-in., but the slab depth must be increased accordingly.

The piping should be supported in such a manner that there is a minimum

TABLE 8. CONVERSION OF KINEMATIC VISCOSITY UNITS*

CENTISTOKES	Sq. Ft./Sec.	SSU ^b	CENTISTOKES	Sq. Ft./Sec.	SSU ^{ab}
2	2.15×10^{-4}	32.6	31	33.4×10^{-4}	145.7
2.5	2.69×10^{-4}	34.4	32	34.4×10^{-4}	150.2
3	3.23×10^{-4}	36.0	33	35.5×10^{-4}	154.7
3.5	3.77×10^{-4}	37.6	34	36.6×10^{-4}	159.2
4	4.30×10^{-4}	39.1	35	37.7×10^{-4}	163.7
4.5	4.84×10^{-4}	40.8			
5	5.38×10^{-4}	42.4			
6	6.46×10^{-4}	45.6	36	38.7×10^{-4}	168.2
7	7.53×10^{-4}	48.8	37	39.8×10^{-4}	172.7
8	8.61×10^{-4}	52.1	38	40.9×10^{-4}	177.3
9	9.68×10^{-4}	55.5	39	42.0×10^{-4}	181.8
10	10.8×10^{-4}	58.9	40	43.0×10^{-4}	186.3
11	11.8×10^{-4}	62.4	41	44.1×10^{-4}	190.8
12	12.9×10^{-4}	66.0	42	45.2×10^{-4}	195.3
13	14.0×10^{-4}	69.8	43	46.3×10^{-4}	199.8
14	15.1×10^{-4}	73.6	44	47.3×10^{-4}	204.4
15	16.1×10^{-4}	77.4	45	48.4×10^{-4}	209.1
16	17.2×10^{-4}	81.3	46	49.5×10^{-4}	213.7
17	18.3×10^{-4}	85.3	47	50.6×10^{-4}	218.3
18	19.4×10^{-4}	89.4	48	51.6×10^{-4}	222.9
19	20.4×10^{-4}	93.6	49	52.7×10^{-4}	227.5
20	21.5×10^{-4}	97.8	50	53.8×10^{-4}	232.1
21	22.6×10^{-4}	102.0	55	59.2×10^{-4}	255.2
22	23.7×10^{-4}	106.4	60	64.6×10^{-4}	278.3
23	24.7×10^{-4}	110.7	65	69.9×10^{-4}	301.4
24	25.8×10^{-4}	115.0	70	75.3×10^{-4}	324.4
25	26.9×10^{-4}	119.3			
26	28.0×10^{-4}	123.7			
27	29.1×10^{-4}	128.1			
28	30.1×10^{-4}	132.5			
29	31.2×10^{-4}	136.9			
30	32.3×10^{-4}	141.3			

Over 70.0 centistokes, SSU = $4.635 \times$ centistokes.

* Kinematic viscosity in ft² sec⁻¹ = $1.076 \times 10^{-4} \times$ centistokes.

^b Values listed for SSU (Saybolt Seconds—Universal) are for fluid temperatures of 100 F. To obtain the Saybolt Universal viscosity equivalent to a kinematic viscosity determined at a Fahrenheit temperature t , multiply the equivalent Saybolt Universal viscosity at 100 F by $1 + (t - 100) 0.000064$; for example, 10 centistokes at 210 F are equivalent to 58.9×1.0070 or 59.3 sec. Saybolt Universal at 210 F. (Taken from ASTM D 445-53.)

of 2 in. of concrete above and below the pipe. This requires a 5-in. slab for $\frac{3}{4}$ -in. pipe and $5\frac{3}{8}$ -in. for 1-in. pipe.

If an insulating material is used, it is generally good practice to provide a moisture barrier between the insulation and the fill. A roofing material (such as a 55 lb felt) is often used as a moisture barrier. The joints should be mopped, and the fill made smooth enough so that there will be no holes or gaps for moisture transfer. Also, the edges of the barrier should be flashed to the surface of the slab so that the ends are sealed. See Fig. 19.

If the pipe must pass through an expansion joint, a protective coating should be applied to the pipe for a foot or two on both sides of the joint.

If the pipe is kept dry at all times in both summer and winter, no external corrosion problems will occur.

Thermal Stresses

This problem is discussed in Reference 19. In general, there will be no ill effects from the thermal stresses if these rules of installation and operation are followed:

1. Keep the temperature difference between the fluid and the slab surface to a minimum by:
 - a. Close pipe spacing (see Fig. 19).
 - b. Low temperature drop in fluid, $\Delta t \leq 20$ F deg.
 - c. Continuous operation (if economically feasible).