TECHNICAL TOPIC 2A

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ANTI-FREEZE IN HYDRONIC SYSTEMS

There are many applications of hydronic heating systems that require the use of an anti-freeze in the system. Some common applications are snow melting systems, agricultural buildings, intermittently heated buildings, solar systems, and vacation homes that may be used only a few times during the winter. In some areas anti-freeze is used in home heating systems to protect the system in the event of prolonged power failure.

TYPES

In addition to ethylene glycol, inhibited propylene glycol is finding more usage as a heat transfer fluid in heating and/or cooling applications. Desirable properties include high boiling points, stability over a wide temperature range, little or no fire hazard, high specific heats and thermal conductivities plus non-corrosivity.

Propylene glycol is commonly used in quick freezing of wrapped foods by direct immersion, so although it is practically non-toxic, it is not intended for human consumption. Ethylene glycol however is toxic.

A comparison of propylene glycol and ethylene glycol is shown in the table below:

		Ethylene Glycol	Propylene Glycol
1. Heat transfer @180F with no increase in flow rate	20% solution	.96 *	.97 *
	50% solution	.87 *	.90 *
2. G.P.M. Req'd. @180F, 20F /\ t (no correction to pump curve)		114% *	110% *
3. Pump head Req'd . @180F w/increase in G.P.M.		123% *	123% *
4. Specific gravity (water = 1.0)		1.125 - 1.135 *	1.045 - 1.055 *
5. Pounds/Gallon @60F (water = 8.3453 Pounds/Gallon)		9.42	8.77
6. pH @ 50% by volume		9.3	9.5
7. Freezing Point	55% by volume	-50F	--
	50%	-37F	-28F
	40%	-14F	-13F
	30%	+ 2F	+ 4F
	20%	+15F	+17F

* compared to water

FREEZE PROTECTION

The freezing point is that temperature at which a non-riged "slush" begins to form, not the point of total freeze-up. Thus equipment is actually protected against freeze-up at a temperature below the freeze point, and if there is room for expansion a 15% to 20% concentration will provide bursting protection. The equipment might not be operable at low temperatures, but bursting failure would be avoided.There can be no check valves or closed zone valves in the system that would isolate part of the system from the air cushion tank. The non-rigid "slush" must be allowed to expand. However for system operation and good performance at low temperatures, a greater concentration should be selected.

DESIGN CONSIDERATIONS

There are some differences in characteristics when a 50% solution of glycol and water is compared with water, and these differences must be considered in designing a system.

To compensate for the difference in density, the flow rate should be increased 14% for design temperatures between 180F and 220F.

The heat output of standard heat distributing units is not affected enough to be considered in sizing the units, when the flow rate has been increased.

Selection of the pump must account for the increased flow rate and a difference in friction loss. At design temperatures of 180F to 220F, the pump head requirement should be increased by about 23%.

A strainer, sediment trap, or some other means for cleaning the piping system must be provided. It should be located in the return line ahead of the boiler and pump or heat exchanger. This must be cleaned frequently during the initial operation of the system and any sludge that is formed removed from the system.

The glycol solution is expensive and leaks should be avoided, so weld or sweat joints should be used where possible, and special care taken where threaded joints must be used.

The anti-freeze solution must be checked at least once a year in the manner recommended by the manufacturer of the anti-freeze used. It includes a corrosion inhibitor that can become depleted in time, causing the solution to become corrosive. It is important that this be checked and the inhibitor be replenished or the system refilled with fresh anti-freeze solution, whichever may be required.

Check local regulations to see if systems containing these solutions must include a back-flow preventor, or an actual disconnection from the city water line.

AIR CUSHION TANKS

There are many factors that should be considered when sizing an air cushion tank to a system containing anti-freeze. Undersized and extremely oversized tanks should be avoided. The following data is necessary for the system designer to properly size a tank from a manufacturers catalog or the ASHRAE Guide:

- Entire System Volume in Gallons
- Percent of Glycol by Volume
- System Design Temperature
- Initial Fill Temperature
- Initial Fill Pressure
- Pressure Relief Valve Setting
- Allowable System Pressure Increase
- System Pump Location

In a typical residential hydronic heating system, a glycol mixture has an expansion rate about 1.2 times that of water alone, therefore a tank for an anti-freeze system should be at least 1.2 times greater in size.

SPECIAL REQUIREMENTS

- Do not use galvanized pipe in the system.
- Use water low in mineral content and make sure there is no petroleum based solution in the mixture. Make sure the system is clean.
- Mix solution at room temperature.
- Do not use a chromate treatment.
- Do not use an automotive type glycol - Use an inhibited glycol available for heat transfer applications.
- Do not use in a system that may have solution temperature over 300F.
- Do not use glycols in an open direct fired system.

ADDING ANTI-FREEZE TO A SYSTEM

1. Determine the capacity of the piping system from the attached tables. Obtain the capacity, in gallons, of the boiler from the manufacturer. Capacities of I=B=R boilers, currently in production, can be obtained from The Hydronics Institute.
2. Include any additional tanks or reservoirs that might be part of the system.
3. Select an air cushion tank of the conventional or diaphragm type and allow 50% of the tank capacity for the glycol solution.
4. With a figure in gallons for the entire system including the boiler, piping, radiation, tank, etc., and the percentage of glycol required to provide the protection desired, calculate the amount of anti-freeze to be used.
5. Add a sufficient quantity of water to the system to check for tightness.
6. If excess water was added, drain in order to have sufficient space available for the anti-freeze.
7. Add the calculated quantity of anti-freeze and fill the system with water. Circulate for 6 hours to insure good mixing.

TO LOWER THE FREEZE POINT OF A FIXED VOLUME SYSTEM

To increase the concentration of a system, test the solution in the system with a hydrometer, and determine the percent of solution (Pt.) With the knowledge of the system volume (Bs) and the percent of solution desired (Pd), complete the calculation shown below:

Withdraw the number of gallons (Qa) from the system and replace with glycol.

Qa = Quantity, in gallons, to be added
Vs = Volume of System
Pd = Percent of solution desired
Pt = Percent of solution from test

$$Qa = Vs \frac{(Pd - Pt)}{(100 - Pt)}$$

EXAMPLE

Vs = 120 gallons in system
Pd = 50% desired solution (-34F)
Pt = 30% solution by test (+4F)

$$Qa = \frac{120\ (50-30)}{100 - 30} \qquad Qa = \frac{120 \times 20}{70} \qquad Qa = \frac{2400}{70}$$

Qa = 34.3 gallons to be added to bring solution to -34F

CAPACITY OF PIPE OR TUBE IN GALLONS

Ft. of Pipe or Tube	Steel Pipe - IPS					Copper Tube -Nom.				
	3/4"	1"	1 1/4"	1 1/2"	2"	3/4"	1"	1 1/4"	1 1/2"	2"
1	0.027	0.044	0.077	0.105	0.173	0.025	0.044	0.068	0.095	0.16
5	0.1	0.2	0.4	0.5	0.9	0.1	0.2	0.3	0.5	0.8
10	0.3	0.4	0.8	1.1	1.7	0.3	0.4	0.7	1.0	1.6
50	1.4	2.2	3.9	5.3	8.7	1.3	2.2	3.4	4.8	8.2
100	2.7	4.4	7.7	10.5	17.3	2.5	4.4	6.8	9.5	16.4