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ANTI-FREEZE IN HEATING SYSTEMS

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ANTI-FREEZE IN HEATING SYSTEMS

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1.0 INTRODUCTION

1.1 Purpose

This publication is a technical support document to DRM 10-7/51, Building Design and is intended to:

a. outline the characteristics of anti-freeze, offer advice in selection and describe the effects of various types on design of glycol sub-system components; and

b. describe preventive measures to ensure safe operation of the sub-system.

1.2 Background

The antifreeze sub-system is an important component of any heating system having large ventilation rates and requiring the installation of make-up air units with coils that must be protected against freezing. The best means of protection are water-glycol solutions containing corrosion inhibitors. These solutions also protect the components of the secondary side of the water-glycol heat exchanger during emergencies such as control failure, electrical failure and freezing of dampers.

1.3 Scope and Application

This publication is intended for designers, operators and maintenance personnel considering anti-freeze in hot-water heating systems for buildings located in cold climates. The main focus is on corrosion-inhibiting, water-glycol solutions and their effects on the design parameters and choice of equipment in the secondary side of the water-glycol heat exchange, including their effect on the heating system components.

For the use of anti-freeze in space conditioning systems, refer to TSD-51-23, Space Conditioning Systems for Buildings, Design Considerations.

2.0 GLYCOLS

2.1 General Remarks

There are two types of glycols: ethylene and propylene. Both contain inhibitors for corrosion control and are widely used as freeze-up deterrents in heating systems. In this respect, their main attributes are their ability to lower the freezing point of water, low volatility and relatively low corrosivity (when properly inhibited).

Ethylene glycol solutions are normaly preferable to propylene glycol solutions because of their more desirable physical properties at lower temperatures and their wide availability. However, ethylene glycol may be lethal if mixed with domestic water or foods. Therefore, DIAND requires the use of propylene glycols only.

2.2 Particulars of Glycol Solutions

Glycol solutions have the following characteristics:

a. A 50% glycol solution has a slightly higher density than water but a lower specific heat. Therefore, an increased volumetric flow is required to maintain the same conveyance rate and design temperatures in the terminal units and heat exchanger. Use Table A-1 to determine the increased flow requirement.

b. The coils of the make-up air unit may be exposed to outside cold air. The temperature of the coils can fall below freezing if the primary circuit fails. The cold glycol solution may continue to flow, causing the heat transfer to reverse and the primary circuit components to freeze up.

c. Glycol solutions may leak through piping at points were water cannot. This is because glycols have a greater fluidity than water.

d. Glycol solutions can cause sludging in the heat exchanger because of:

(1) the reaction of the glycol inhibitor with zinc in galvanized piping;

(2) the reaction of the glycol itself with chromate-type water treatments added by the owner; or

(3) the reaction of the glycol with pipe dope-cutting oils, solder flux and dirt.

2.3 Effects of Glycol Solutions on Design of Sub-system Components

2.3.1 Make-up Air Unit Coil

In general, the coil size is not affected by 50% glycol solutions at a temperature range of 65 to 93°C (150 to 200°F), which is the most common combination.

2.3.2 Heat Exchanger

The heat exchanger can be selected from catalogued glycol data, or, if such data is not available, the exchanger is initially selected from data for water to water conditions.

When a glycol solution is used in the heat exchanger tube, the external coefficient remains the same, and the load and temperature differences remain constant. The velocity of the tube-side glycol solution is greater than water velocity.

The only new variable is the effect of the glycol solution on the internal coefficient. The required additional heat transfer area is provided simply by lengthening the tube bundle, while the shell diameter and number of passes remain constant. Refer to Table A-2 for the correction factors that determine the shell length for various water-glycol temperatures.

To avoid sludging in the heat exchanger, stipulate in the specification that galvanized piping and chromate water treatment shall not be used; that sub-system piping shall be thoroughly cleaned and flushed with a heated tri-sodium phosphate solution before adding the glycol solution, and that inhibitor checking service as well as additional inhibitor shall be provided by the glycol manufacturer.

2.3.3 Pumps

Conventional water system practice is followed in initially determining all water pumping heads for piping, control valves, make-up air coil, heat exchanger, etc. However, the use of glycol solutions affects the system pumping head in two ways:

a. The increased flow rate (refer to 2.2) will increase the pump head requirement.

b. At any given flow rate, water and 50% glycol solution have different friction characteristics. Refer to Table A-3 to determine the pressure drop for 50% glycol solutions at equal flow rates and increased flow rates for various temperatures. Mechanical seal-type pumps shall be installed to avoid leakage.

2.3.4 Controls

As mentioned before, failures in the primary circuit may stop the water flow, but the glycol solution pump may still drive this fluid at a freezing temperature through its circuit. Install a low-temperature sensor in the heat exchanger and interlock it with the glycol solution pump to avoid this problem.

2.3.5 Compression Tank

To avoid corrosion, a closed sub-system shall be designed to prevent oxygen contamination. When sizing the compression tank, keep in mind that the expansion rate of a 50% glycol solution is 1.2 times greater than that of water. Often the tank will be oversized considerably to provide the extra capacity needed to prevent leakage.

2.3.6 Piping and Valves

Because of the better fluidity of glycol solutions, weld or sweat joints should be used where possible. Where screwed joints are required, they should be tightly drawn and specially taped. The subsystem piping connecting the heat exchanger with the make-up air units or terminal heat transfer unit shall be sized in the same manner as for a conventional all-water system. The same procedure applies to control valves (two or three-way type).

3.0 PREVENTIVE MEASURES TO ENSURE SAFE OPERATION

3.1 Direct Connection of Glycol Sub-systems to Water Systems

The glycol sub-system must not be connected directly to the domestic water system for filling. A direct connection is dangerous to human health and makes it more difficult to control the quality of glycol solutions.

With a direct connection, it is impossible to guarantee that glycol solutions will not contaminate the domestic water system in case of valve or check-valve failures. Furthermore, a direct connection often requires a pressure-reducing valve to get the right operational pressure into the sub-system lines. The use of such a control device is unsafe because any slight, continuous leak causes dilution of the glycol solutions.

3.2 Indirect Connection

Indirect connection (See Appendix B) is the only safe method of linkage. The steps below describe how the connection should be made and operated.

a. For water supply bring an ordinary water line of 1/2" O close to the heat exchanger. Terminate the line by a faucet with a threaded spout on which a flexible rubber hose can be connected.

b. On the glycol sub-system side of the fill line, install the following accessories in this order: a funnel, a hand-fill pump, a gate valve equipped with a drain plug, and a check valve. The gate valve is normally open when the sub-system is filled.

c. Weigh and mix the correct amount of glycol with water to obtain the desired freezing point and concentration according to the manufacturer's specification. Pour the solution into the funnel and start pumping.

3.3 Operation of the Sub-system

When glycol solutions are used, a monitoring shedule must be established to avoid inhibitor depletion. Analyze the water regularly to check for corrosive elements which reduce the effectiveness of the inhibitor. Soft waters, with sulfate and chloride concentrations less than 100 ppm each, should be used.

4.0 RECOMMENDATIONS

Connect the glycol sub-system indirectly to the water system for filling.

Use only propylene glycol in departmental heating systems requiring anti-freeze.

A "Warning" card (Appendix C), which should be placed in a conspicuous location in the room where anti-freeze is used in the heating system.

Appendix A

CORRECTION FACTOR TABLES

TABLE A-1

CORRECTION FACTORS TO APPLY TO WATER BASE FLOW

Requirements for maintaining the same heat conveyance with a 50 per cent glycol solution as with water

Fluid temperature °C	°F	Flow rate correction factor
4	40	1.22
38	100	1.16
60	140	1.15
82	180	1.14
104	220	1.14

TABLE A-2

CORRECTION FACTORS TO APPLY TO HEAT EXCHANGER

Shell length to maintain the same heat transfer with a 50 per cent glycol solution as with water. Tube velocity is greater than 0.305 m/s (1 fps.)

Fluid temperature °C	°F	Shell length correction factor
49	120	1.53
60	140	1.45
71	160	1.38
82	180	1.30
93	200	1.25
104	220	1.18
116	240	1.10

TABLE A-3

CORRECTION FACTORS (RIGHT HAND COLUMN) TO APPLY TO WATER BASE HEAD REQUIREMENT

To account for effects of increased flow and different friction loss characteristics when using a 50 per cent glycol solution.

Fluid Temperature °C	°F	Correction factor (flow rates equal)	Correction factor (increased flow)
4	40	1.45	2.14
38	100	1.10	1.49
60	140	1.00	1.32
82	180	0.95	1.23
104	220	0.90	1.18

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