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Engineering White Paper

MAXIMIZING DRYCOOLER EFFICIENCY THROUGH PROPER SYSTEM DESIGN

EMERSON™
Network Power

SUMMARY

A glycol loop can be used to supplement air conditioning systems to provide “free cooling” by using cool glycol fluid to remove heat from the evaporator units’ return air. In addition to providing this free cooling, glycol loops reduce the number of external heat exchangers (drycoolers) required and eliminate long refrigerant piping runs.

However, operating problems can result if the system is poorly designed. To ensure efficient, reliable operation of a glycol loop, proper attention must be paid to pump selection, the glycol loop design, pipe and expansion tank selection and sizing, and glycol concentrations.

When each of these factors is optimized to the application, the glycol loop provides an effective and efficient heat removal system that can significantly reduce the operating costs of a data center cooling system.

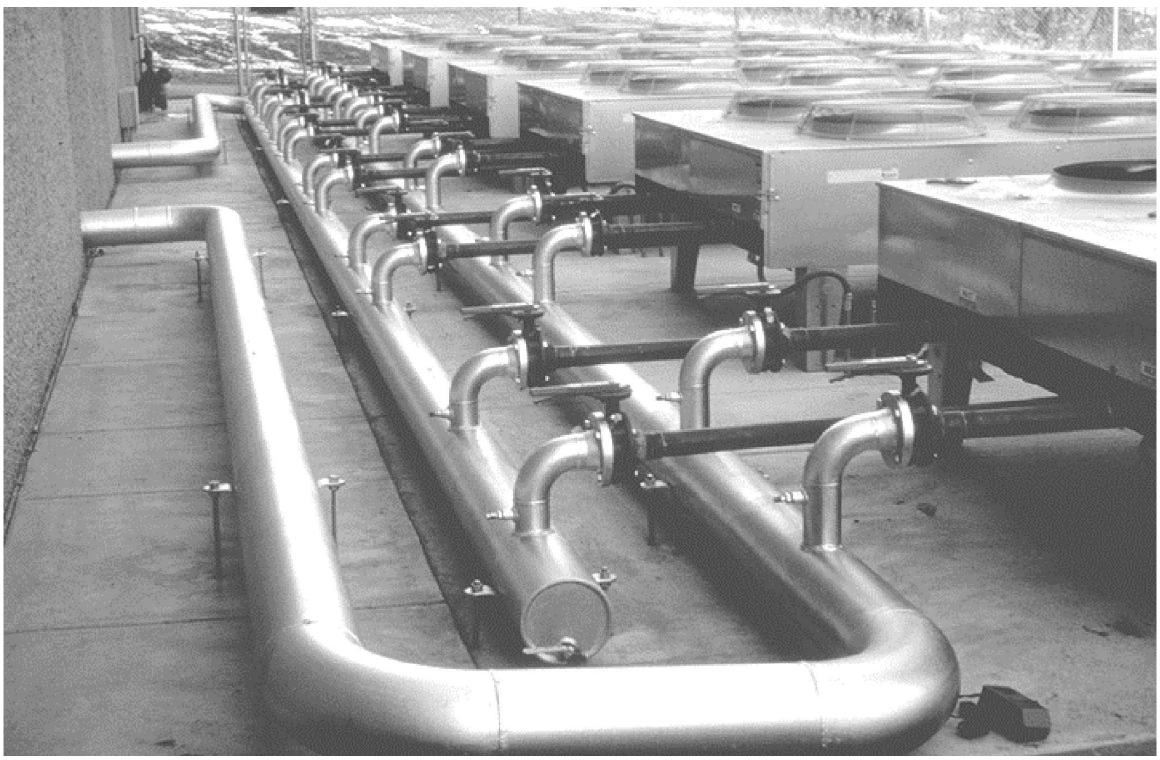

Figure 1. A glycol loop can significantly reduce the number of drycoolers required for an application.

The Benefits of a Glycol-System Drycooler Loop

When designing a system for heat removal, drycooler loops provide a number of benefits that can increase the efficiency and reduce the operating costs of the heat removal system:

1. A multi-evaporator unit glycol system reduces the number of outdoor units required because multiple indoor units are connected to fewer drycoolers, as opposed to a single air cooled condenser per indoor unit.

2. With a glycol system, long refrigerant piping runs are eliminated because the condenser is located within the evaporator section, where the compressors are also located. This eliminates concerns regarding oil return to the compressor due to long runs of refrigerant pipes.

3. Glycol systems can provide “free” cooling when the evaporator unit is equipped with a separate coil or circuit in which glycol circulates through and cools the return air passing over it. When the glycol temperature leaving the drycooler is cooled to 8°F below the evaporator unit’s return air temperature, partial “free” cooling occurs. When the glycol temperature is cooled to 45°F, 100 percent “free” cooling is achieved, eliminating the need for compressor operation. Generally, this will occur when ambient temperatures are below 35°F.

Selecting a Drycooler

When selecting a drycooler, it is important to know the following:

1. Fluid flow rate. For optimum performance, flow should be between 1.5 and 3.0 GPM per internal circuit of the drycooler.

2. Type of Glycol: Ethylene or Propylene.

3. Percentage of glycol solution: 30%, 40% or 50%.

4. Design ambient: entering air temperature at the drycooler (EAT).

5. Total heat of rejection required: (BTUH).

6. Entering and leaving fluid temperatures (EFT and LFT).

7. Altitude: feet above sea level.

Piping Considerations

For glycol systems to run at peak efficiency, all components must be sized and fitted properly, including the piping. Piping is a major consideration in glycol system efficiency. The pipe material, diameter, velocity and friction loss (pressure drop) should be carefully considered to achieve peak performance of a glycol loop. A reverse return piping system is preferred. With this type of system, when there are multiple identical drycoolers on the loop, the need for individual flow balancing to each drycooler is eliminated.

Sizing
Piping is sized based on flow rate. When piping is undersized, there could be excessive pressure drop that requires larger pumps. Noise levels, erosion levels, and pumping costs can be unfavorable as well. When piping is too large, installation costs are excessive.

A piping layout should be developed to determine the sizes of pipes needed.

Pressure Drop
In determining the final system friction loss, the first cost of the piping system and the pump as well as the operating costs of the pump should be considered. In general, lower heads and larger piping are more economical for longer amortization periods, especially in larger systems.

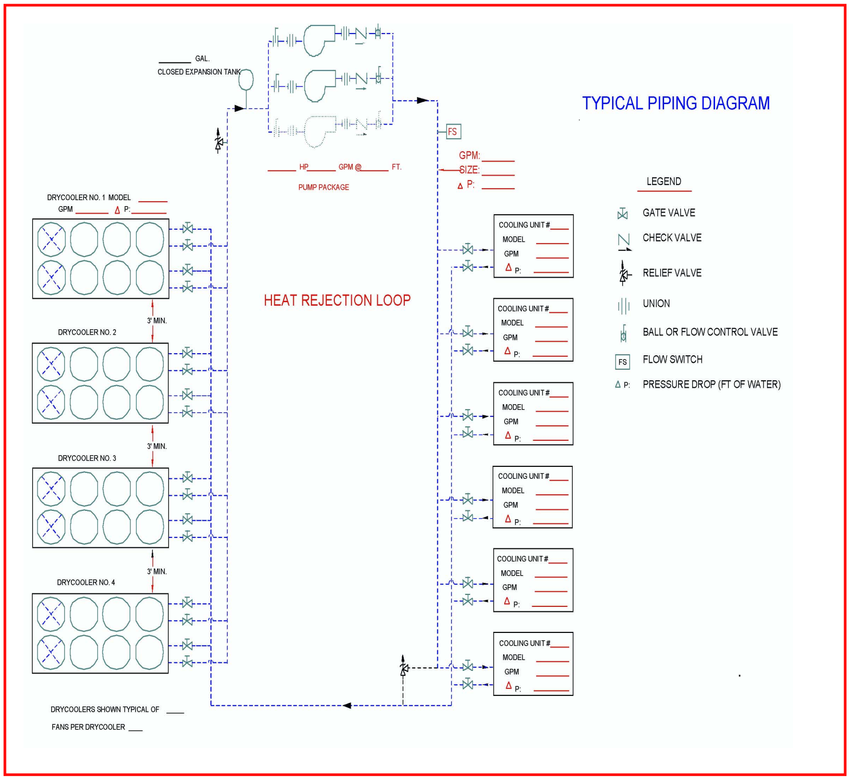

Figure 2. Sample heat rejection loop.

However, adjustments should be made in the piping design and pump selection until optimum efficiency has been achieved.

When the final piping layout has been established, the friction loss for each section of the piping system can be determined from pressure drop charts. These friction losses should include calculations for all fittings, terminal units and valves as well as piping. Pipe size should be based on a friction loss of 5 feet or less per 100 feet of pipe and a velocity of 5 feet/ second or less.

Types of Piping
Materials used in piping also need to be considered in sizing pipes and determining friction loss. Studies have shown that iron pipes seem to be the most susceptible to corrosion, followed by galvanized steel, lead, copper, and copper alloys such as brass. PVC is generally not corrosive.

Pump System Selection

Once the design flow has been determined and the friction losses through the evaporator unit, drycooler, piping, fittings, valves, etc. ("total head") have been summarized the pump can be selected.

The heart of all glycol loops is the pumping system. The design of the pumping system is of critical importance for the control and performance of the system. Improper pumping system design can cause problems ranging from high installation costs to excessive downtime to inefficient operation.

Pump Sizing

Pumps should be sized based on the total design flow rate of all evaporator units on the loop and the total head required. Since all of the evaporators and drycoolers are piped in parallel, the total head required is determined by the sum total of the following:

- Highest evaporator unit heat exchanger pressure drop
- Highest drycooler pressure drop
- Pressure drop of the supply and return glycol piping
- Pressure drop of all fittings and valves.

When the pump flow is undersized, there is not enough flow to meet the design requirement of the evaporator units heat exchangers and the units will not provide the scheduled capacities. If the flow is considerably undersized, the units can trip off on high head pressure. When pumps are too large, there are additional up front expenditures because of the higher initial cost of the pump(s) and the added expense of larger fittings, valves and piping associated with them.

Figure 3. Pump package

Packaged Pump Configurations

Today, many engineers are specifying — and end-users are purchasing — “packaged” pump systems: pre-packaged configurations, ready for final piping and electrical connections.

Prepackaged systems offer engineers, contractors and owners more control over scheduling, quality, completion time, reliability, operation and maintenance. These prepackaged systems also have lower installation costs, resulting in lower total cost of ownership over the life of a facility.

Pump packages are available in a wide variety of configurations, from simple to complex. The following factors should be considered when selecting a pump package:

- Number of primary and standby pumps
- Type and percentage of fluid by volume
- Total flow requirement (GPM)
- Total head required (feet of water)
- Pump RPM (e.g. 1750 or 3500)
- Pump location (indoor or outdoor; with or without an enclosure)
- Voltage phase and frequency

The choice of pump packages is ultimately based on specific application needs. Designers should consider alternate and additional configurations, including the following:

Constant Speed, Dual Pump:
A dual-pump package features two pumps, sized identically, with one pump

serving as a the primary unit and one pump serving as backup in the event of failure of the primary pump. With dual-pump packages, each pump is sized for the required total flow (GPM) and the total head (feet of water).

Constant Speed, Triple Pump:
Triple pump packages feature three pumps, all sized identically, two pumps operate in parallel with the third pump serving as a backup in the even of failure of either of the primary pumps. Each of the two primary pumps delivers the same flow (GPM) equal to 50 percent of the total flow requirement, and each pump is sized for the total head (feet of water) required.

Variable Speed (VSD)
In this configuration pump speed is regulated in response to changing flow requirements as a result of changing load conditions that may occur throughout the system/loop. This type of system saves energy because the lower operating speed requires less horsepower. VSD pumps can be configured in either dual or triple pump packages.

Expansion Tanks

Expansion tanks are needed to establish and maintain system pressure within an acceptable range as well as remove air that may have entered into the system. Tanks accept changes in system's fluid volume as the fluid density changes with temperature to keep system pressures in check.

There are several types of expansion tanks that can be used:

- "Plain steel" atmospheric tanks.
- Pressurized "compression" tanks in which there is no separation between the fluid and any air that may have entered the system. Compression tanks work by allowing fluid to compress a chamber of air as the fluid expands with the change in the fluid temperature. If the pressure in the tank reaches the relief valve rating, the air is vented to the atmosphere.
- Bladder or diaphragm tanks, which have a flexible bladder or diaphragm usually made of heavy-duty rubber which provides total separation of the fluid from any air that may have entered the system. Bladder and diaphragm tanks are used in conjunction with an air separator and air vent. The separator separates air from the fluid and the air vent vents it to the atmosphere.

Expansion tanks are typically sized based on a percentage of the system's total volumetric capacity, which is determined by the total volume of the evaporator(s) unit heat exchanger(s), drycooler(s) and all interconnecting piping in the loop. A generally accepted, conservative rule of thumb is that the expansion tank should be sized to hold at least 6 percent of the system's volumetric capacity. This percentage may vary based on the type of tank and other variables.

Compression and bladder/ diaphragm tank sizing should be based on the following criteria:

- Total volumetric capacity of the system
- Design glycol temperature
- Design temperature drop of the glycol
- Type of glycol (ethylene or propylene) and percentage of mixture by system volume
- System fill pressure
- Elevation of the tank, (in feet) relative to the glycol relief valve
- Elevation of the highest point, relative to the pump suction

Glycol Selection

The type of glycol used is important, and winter temperatures determine the concentration, which is based on a percentage of volume. Water is the base element. Glycol is added to prevent freezing and to protect piping and fittings from corrosion.

Ethylene and propylene are the two most commonly used glycols. Both are odorless and colorless and completely water-soluble. Ethylene is the most efficient because of the ease in which it reacts with other chemical intermediates and for its solvent, lubricant, plasticizing and hygroscopic properties.

Propylene glycol is nontoxic, and, under certain conditions, is less efficient than ethylene.

> **NOTE:** Automotive antifreeze should never be used. In addition, “uninhibited”, or plain glycols, do not adequately protect against, oxygen, chlorides, sulfates, metallic impurities and other contaminants, and should not be used.

A rule of thumb is that a minimum of 30 percent glycol-to-water mixture should be used in order for the inhibitors to be effective.

Freeze protection requires a glycol concentration level sufficient to prevent the formation of ice crystals at the lowest temperature experienced by the fluid. Freeze protection is needed when the system requires pumping.

Burst protection requires a glycol concentration high enough to prevent bursting and other mechanical damage as a result of freezing, but not necessarily high enough to keep the fluid pumpable. Burst protection requires less glycol than freeze protection, and is suitable for chilled water systems that are dormant in the winter.

<u>Ethylene Glycol Concentrations</u>

% Glycol by Volume	30	40	50
Freezing Point (°F)	4	-11	-34

<u>Propylene Glycol Concentrations</u>

% Glycol by Volume	30	40	50
Freezing Point (°F)	9	-5	-29

Conclusion

Glycol cooling is one of the most cost-efficient methods of heat rejection available today. However, for maximum cost-efficiency and peak performance, all components of a drycooler loop must be sized properly and in conjunction with each other. Pumps, pipes, tanks, valves and fittings need to be large enough to do the job, but not so large that they incur additional installation and operating costs. A qualified design engineer is the best resource for proper sizing and superior performance of your application.

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