Heat Pump Design for
100% Outdoor Air Systems

INTRODUCTION

This technical bulletin will review the basics of water source heating and cooling loops, and the technology used by HVAC equipment to use the earth’s energy efficiently. This bulletin will focus on how a 100% outdoor air dehumidifier can use such a loop to provide highly efficient heating in the winter, while also enhancing its ability to dehumidify in the summer and deliver treated ventilation air to the space. Different types of refrigerant designs will be reviewed and compared.

Many hybrid loops are being developed to help reduce the length of piping installed in the ground. The earth handles the majority of the load, but a boiler is installed to lend support during peak heating times, and a cooling tower or chiller is installed to assist during maximum cooling times. (Refer to Figure 2.)

BACKGROUND ON LOOPS

According to the EPA, by 2010 millions of buildings will use a basic ground source heating and cooling loop. Running an HVAC system is a major factor in the operating budget of any building. Harnessing the energy of the earth significantly reduces energy costs. Experts see this as the driving force behind the enormous increase in the use of loops over the next 10 years. In addition, this type of loop allows the mechanical engineer the flexibility to simultaneously address the heating and cooling demands in different parts of a building.

A hydronic loop is installed in such a manner that it links all of the HVAC equipment to the temperature-stable mass of the earth. Ground water temperatures are very stable year round, but they vary geographically. The ground acts as a heat sink when there is an excess of heat (typically the summer) and as a source of heat in the winter. The loop can be designed in four basic ways. (Refer to Figures 1 and 2.)

1.) Ground Loop - A well 200-300 feet deep (closed or open).

2.) Surface Loop - Trench 4-6 feet below the surface, with a total running length in excess of 600 feet.

3.) Lagoon Loop - Coil in lagoon or lake deeper than 10 feet.

4.) Ground Loop (Hybrid) - Boiler/tower water loop system. - (Figure 2)
HEAT PUMP PRINCIPLES

A heat pump essentially performs just as its name implies, by pumping energy from a hot source to a cold source. For HVAC applications, this process must also pump energy from a cold source to a hot source in order to achieve cooling. When this device is in the heating mode it draws energy from the water and transfers it to the air. In the cooling mode the reverse must occur, thus, heat from the air is transferred to the water.

This energy transfer takes place through a refrigeration system with the compressor acting as the energy pump. In the heating mode, the water coil accepts cold refrigerant gas from the TXV valve. The ground source water is significantly warmer and transfers heat from the water to the refrigerant. The refrigerant then circulates to the compressor, picks up the heat of compression and becomes a hot gas. In this state, it is directed to the air coil where it gives up heat to the cold air stream. The refrigerant quickly returns back to a cool, saturated vapor and the process is repeated. (Refer to Figure 3.)

In the cooling mode, the cold gas from the TXV valve is directed to the air coil. The refrigerant cools the air to its dewpoint and water condenses, giving up more energy. The refrigerant once again flows through the compressor and ends up in the water condenser where it gives up heat to the ground source loop. (Refer to Figure 4.)

REVERSE CYCLE HEAT PUMP - OLD DESIGN

A 100% outdoor air heat pump dehumidifier must operate in both the heating and dehumidification/cooling modes to handle a wide range of outdoor ambient conditions. The most conventional method is to add a reversing valve to the two-element refrigeration loop to allow the energy flow to go in either direction. The valve is reversed when the outdoor air reaches its set point (dew point or dry bulb temperature). (Refer to Figures 5 and 6.)

Several design issues must be considered when applying a reverse cycle system to a 100% outdoor air application. For instance, one must consider the range of conditions that the coil will be exposed
The second major design consideration is the amount of variable heat required to adjust the temperature of outdoor air to the designated space temperature. Only a part of the energy in the heat pump loop is needed to reheat the air, therefore, a second condenser in series with the first is required to reject the total heat of rejection of the system. This further complicates the refrigeration balance and creates the risk of oil returning to the compressor. The basic reverse-cycle system does not control the leaving air temperature.

Desert Aire’s Q-Pump™ system (protected by patent #6,666,040 and an additional patent applied) uses a four-element refrigeration system to overcome the typical problems of a two-element reverse cycle system, including:

1.) Reduced efficiency and performance.
2.) High cost of oversized refrigeration valves.
3.) Potential for liquid slugging and need for accumulators.
4.) Refrigerant suddenly flashing into vapor, violently expanding and damaging pipes.

Desert Aire’s Q-Pump™ dehumidifier uses a unique method of heating 100% outdoor winter air without the need for a separate auxiliary heat source such as a gas furnace. The system utilizes an Electronic Expansion Valve (EXV) to insure the best performance and operation at low outside air temperatures while reducing the set-up time. At typical airflow for DOAS, our basic system is effective down to 0°F winter design temperature. With an optional enthalpy wheel, the system is effective down to minus 10°F.

A second unique feature to Desert Aire’s Q-Pump™ is its sophisticated control logic that automatically adjusts the systems condensing temperature to allow the system to have enough heat on cold winter days to meet the desired leaving air temperatures. Without enthalpy wheels, conventional heat pumps turn off at entering temperatures below 40°F and must utilize auxiliary heating devices to heat the air. During this operating period, these devices have COP’s less than 1.0. Desert Aire’s Q-Pump™ uses the following sequence to eliminate this problem:

- First stage is to adjust the EMV (what is EMV?) valves to regulate the amount of hot gas to the hot gas reheat coil. This controls the air temperature while keeping power consumption low. COP for this mode will generally fall between 3.5 and 4.0.
If feasible, the installation of a heat pump into an HVAC application provides many advantages. First and foremost, this type of system provides such an efficient exchange of energy that a facility can expect an average of 50% savings in heating and cooling bills with respect to the 100% outside air dehumidifier.

While the concept of a heat pump is simple, the application requires precise, flawless engineering. Because Desert Aire’s TotalAire™ dehumidifiers are specifically designed for energy recovery, a Q-Pump™ can be easily incorporated into the system. Desert Aire’s Q-Pump™ provides these unique benefits:

- Lowest operating cost by utilizing dedicated evaporators for the dehumidification and heat extraction
- Control of heating set-points at the lowest entering air conditions
- Automatic adjustment of system set-up using electronic expansion valve

Contact your local Desert Aire representative if you would like more information or assistance about incorporating a TotalAire™ dehumidifier and heat pump into your HVAC system.

**Optimizing Solutions Through Superior Dehumidification Technology**

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