WHITE PAPER #:

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THE SMART SOLUTION FOR ENERGY EFFICIENCY

CLIMATEMASTER KNOWLEDGE SERIES: HEAT PUMP DESIGN FOR 100% OUTSIDE AIR SYSTEMS

CLIMATEMASTER®
WATER-SOURCE HEAT PUMP SYSTEMS

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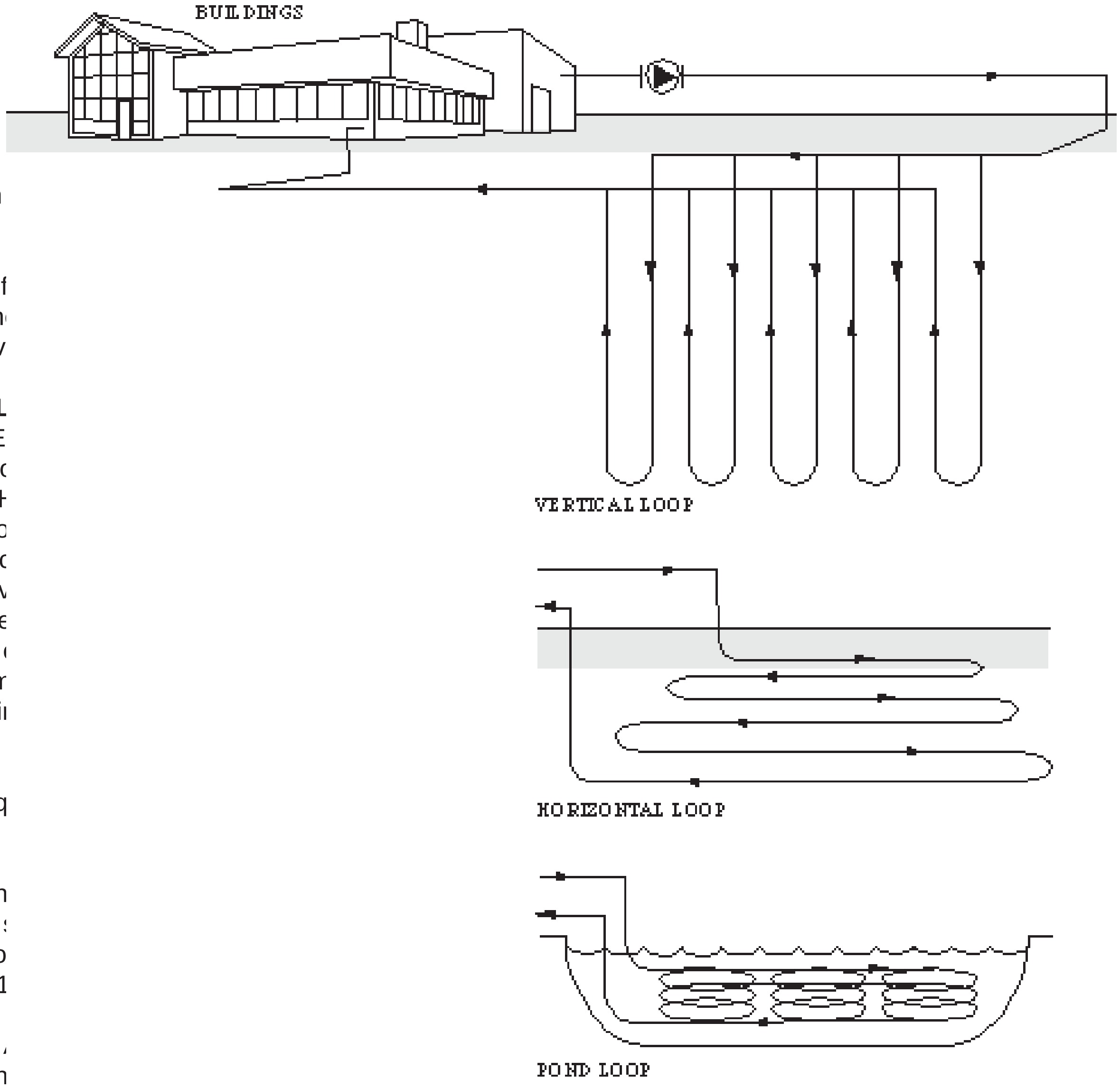
Introduction

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 dehumidif ventilation air to th designs will be rev

Figure 1: Ground Source Loop



Background On L

According to the E will use a basic gro loop. Running an H operating budget o of the earth signific see this as the driv increase in the use addition, this type o the flexibility to sim cooling demands in

A hydronic loop is all of the HVAC eq mass of the earth. stable year round, ground acts as a h heat (typically the s the winter. The loo (Refer to Figures 1

1. Vertical Loop - A (closed or open

2. Horizontal Loop with a total runn

3. Pond Loop - Co

4. Ground Loop (H system. - (Figur

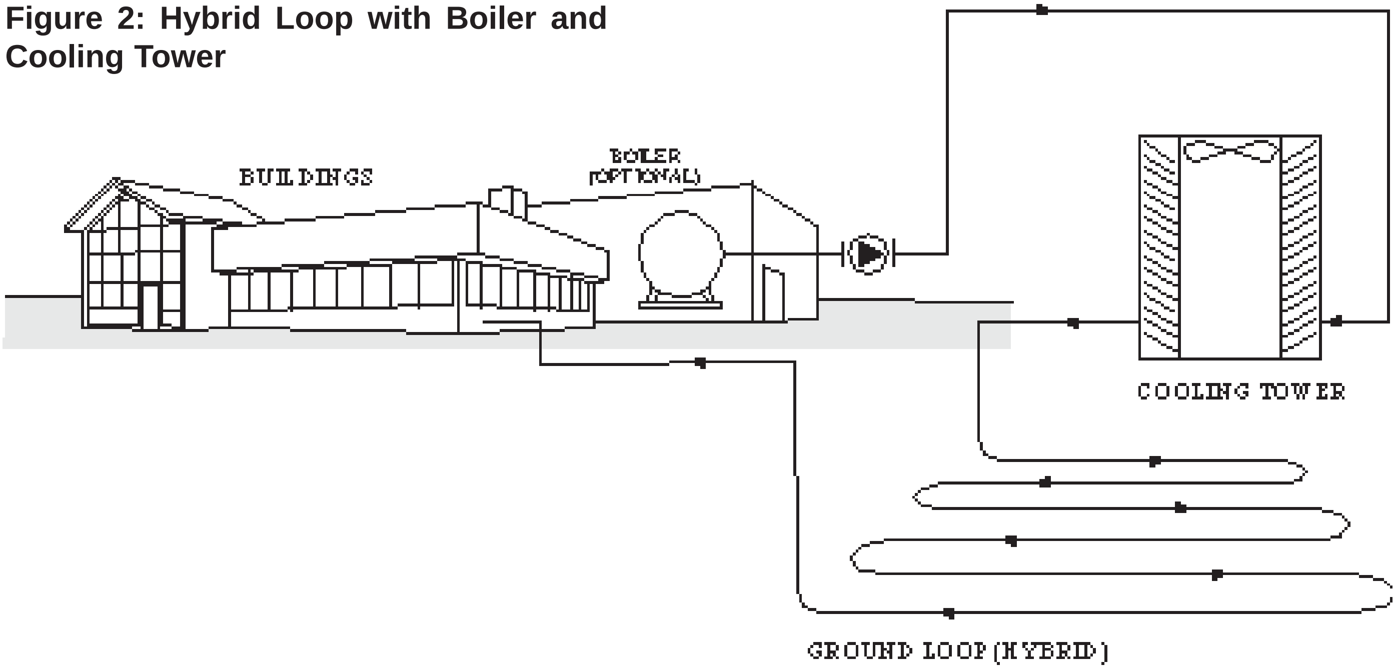
Many hybrid loops the length of piping handles the majori is installed to lend and a cooling towe maximum cooling t

Heat Pump Principles

A heat pump essentially performs just as its name implies, by "pumping" energy from a hot source to a cold

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.)

Figure 2: Hybrid Loop with Boiler and Cooling Tower



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 to. Plus, it is important to remember that the air-side and water-side exchangers must function efficiently as evaporators and condensing coils. Bi-directional flow is a very difficult refrigeration design that must accept significant performance degradation in order to operate in all modes under all ambient conditions.

For example, consider a typical air-side coil functioning as a condenser. The majority of the refrigerant passing through its tubes exists either as a superheated vapor or a low quality liquid/vapor mixture. This mixture must flow with a velocity sufficient to “sweep” refrigeration oil back to the compressor to ensure proper lubrication. When the system reverses and this same coil functions as an evaporator, the pressure drop of the refrigerant in the coil

Figure 3: Typical Water Source Heat Pump in Heating Mode

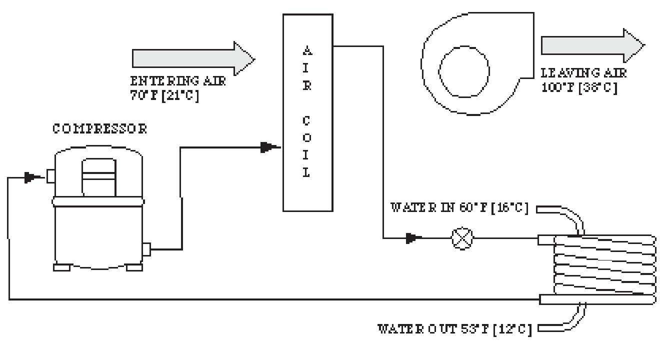


Figure 4: Typical Water Source Heat Pump in Cooling Mode

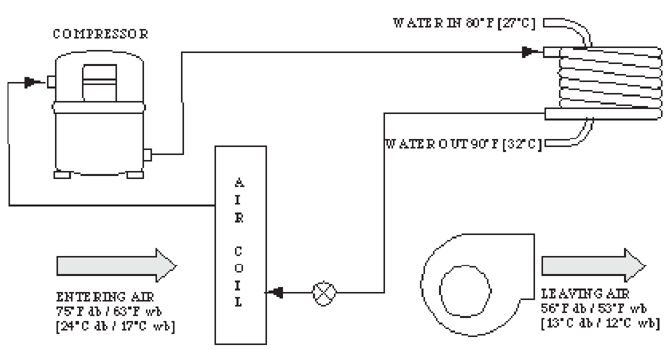


Figure 5: Typical 100% O/A Reverse Cycle Heat Pump in Heating Mode

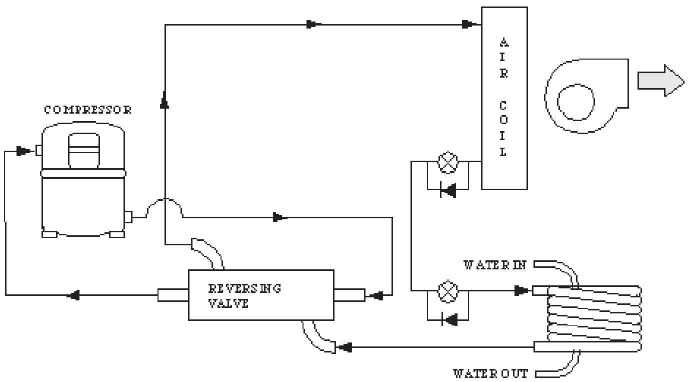
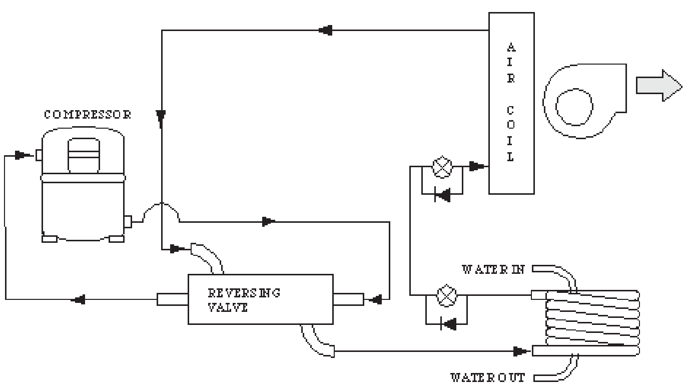


Figure 6: Typical 100% O/A Reverse Cycle Heat Pump in Cooling Mode



becomes much higher. This happens because the majority of the refrigerant passing through its tubes now exists as a sub-cooled liquid or high quality liquid/vapor mixture.

Unfortunately, high evaporator pressure reduces the cooling capacity of a heat pump because its compressor must work harder to overcome the friction between the liquid refrigerant and the tube walls of the evaporator coil. Although one can design a coil to reduce its refrigerant pressure losses when it functions as an evaporator, this same coil may not function well as a condenser. Its refrigerant velocity may then be insufficient to sweep lubricating oil back to the compressor.

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.

100% Outdoor Air System

ClimateMaster's dedicated outdoor air system (DOAS) heat pumps use 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.

The ClimateMaster DOAS unit uses a unique method of heating 100% outdoor winter air without the need for a separate auxiliary heat source such as gas. Our basic system is effective down to 15°F [-9°] winter design temperature without additional auxiliary heat. With an optional enthalpy wheel, the system is effective down to -10°F [-23°C], again, without additional auxiliary heat.

The key difference between the ClimateMaster system option and prior solutions is the use of two independent water coil. One acts as the true condenser for the balance of the total heat of rejection (THR) of the system and the other is the evaporator in the reverse cycle heating mode.

Figure 7: Schematic with LAT Control: Cooling Mode

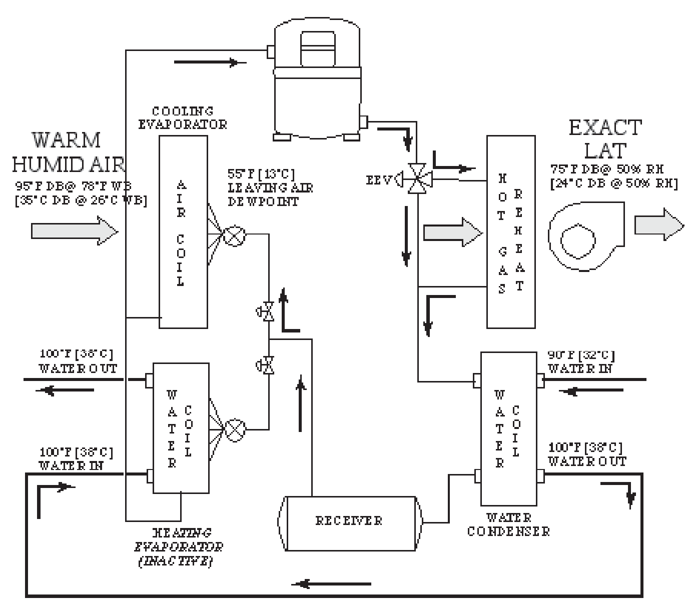
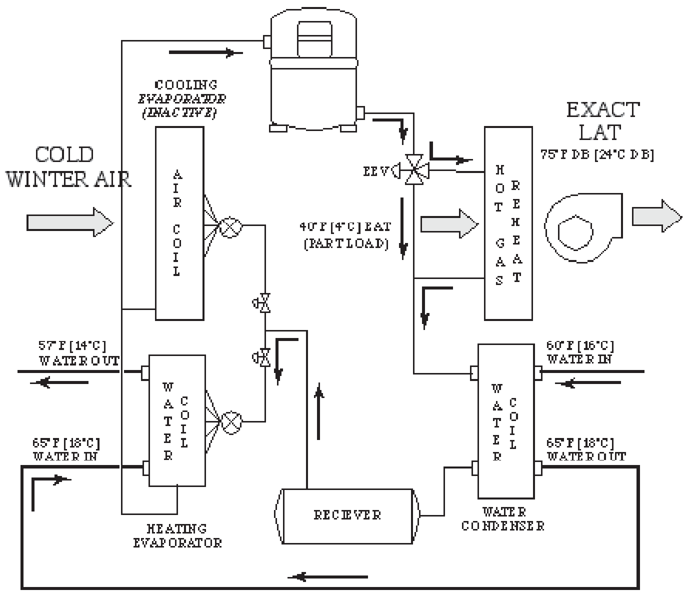


Figure 8: Schematic with LAT Control: Heating Mode



The hot gas reheat coil is sized to warm up cold air to space conditions, e.g. from 15° to 75°F [-9° to 24°C] with 60°F [16°C] water. During off-peak times, the unused heat of rejection boosts the water temperature before it is extracted from the loop. This added energy to the water loop increases the system's efficiency. In the summer mode the water evaporator is inactive and removed from the refrigeration loop by a solenoid valve. In the winter, the air evaporator coil is inactive and the water evaporator will pull energy from the slightly heated ground water loop. The evaporator reduces the water temperature by 5°- 6°F [3-4°C]. Figures 7 and 8 provide a detailed schematic of our innovative refrigeration circuit system and also show how it functions in the summer and winter modes.

Conclusion
The installation of a heat pump in 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 our dehumidifiers are specifically designed for energy recovery, a ClimateMaster DOAS unit can be easily incorporated into the system. Our engineers have successfully incorporated this technology into ClimateMaster Genesis OA and Tranquility OA Series units. Contact your local ClimateMaster representative if you would like more information or assistance about incorporating a DOAS unit into your WSHP system.

Revision Log:

Date	Page #	Description
02/23/06	All	First Published

7300 S.W. 44th Street
Oklahoma City, OK 73179
Phone: 405-745-6000
Fax: 405-745-6058
www.climatemaster.com

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