



# Closing the Loop

*What's best for your system?*



**BALTIMORE AIRCOIL COMPANY**

# Closing the Loop

## Heat Rejection System Design Choices

Consulting Engineers have two choices when designing a heat rejection system – whether the cooling loop is open to the atmosphere or a closed circuit. Evaporatively cooled, open cooling loops are the most common and energy efficient method of heat rejection. Open circuit cooling towers, available in many configurations, enable direct contact of water with the cooling air over a heat transfer surface known as “fill”, where a small amount of water is evaporated to cool the remaining water to nearly the wet bulb, rather than the higher dry bulb of the air. Being open to the atmosphere, however, the cooling water can be exposed to airborne contaminants and must be properly treated. To maintain peak system efficiency over time, the cooling loop must be kept clean, in some cases with the help of side stream filtration.



*Traditional open circuit cooling towers are available in multiple configurations*

Alternatively, process fluids can be contained in a clean, closed loop isolated from the external environment. Many traditional open loop cooling systems, such as water cooled chillers, can benefit from “closing the loop”. Other systems, such as water source heat pump, water cooled VRF, and air compressor installations must utilize a closed loop for proper long term operation due to the use of many relatively small, distributed heat exchangers with narrow passageways. Benefits of closing the loop include:

**Higher Operational Efficiency:** Closed loop systems prevent oxygen and debris from entering the process cooling system, reducing the buildup of corrosion and environmental contaminants as well as limiting the risk of organic growth. This can result in up to a 30% system energy saving versus traditional open loop systems by maintaining high thermal performance over time due to reduced fouling of heat transfer surfaces. In addition, closed loops often have lower pumping power requirements than traditional open loops.

**Lower Maintenance Costs:** Closed loop systems deliver reduced maintenance and downtime costs due to significantly lower fouling as described above. In addition, water treatment is often easier due to the lower open loop water volume that must be treated.

**Greater Reliability:** Reduced fouling translates into reduced wear and tear on many system components leading to extended maintenance intervals as well as fewer unplanned shutdowns.

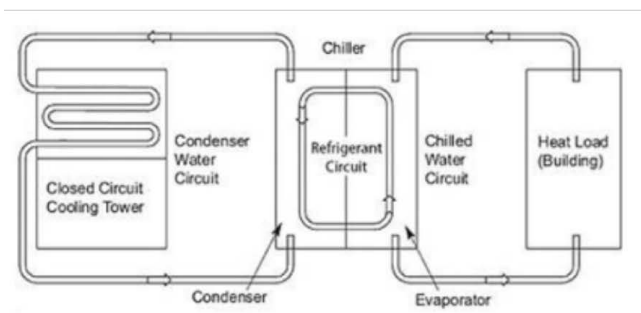
**Longer System Lifetime:** As a clean system does not have to work as hard as a dirty system, reduced stress on the system can extend the life of mechanical equipment and pipework. Reduced system maintenance requirements can also contribute to extended equipment lifetimes.

**Location Flexibility:** The closed loop allows designers to locate the heat rejection at grade or even below the load, providing design flexibility and lower installation costs.

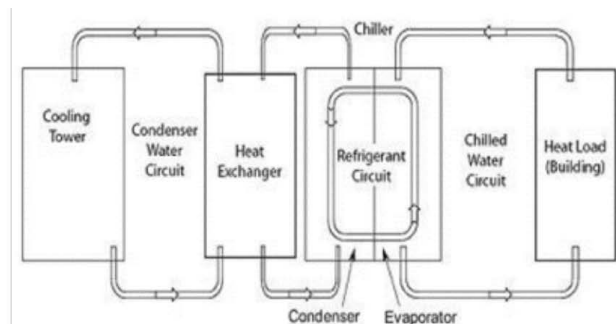
## How to Close the Loop?

Many options are available to close the loop, including dry coolers, ground source heat exchangers, and adiabatic fluid coolers. However, the two most efficient options in terms of both first cost and system energy consumption are the use of an open circuit cooling tower + heat exchanger combination and a closed circuit cooling tower, often called a “fluid cooler”. Both have been successfully applied on closed loop cooling systems for many years and both can supply the same process fluid temperature to the system. So given these two alternatives, what are the key considerations to determine the best choice for your next project?

### *Closed Circuit Cooling Tower*



### *Open Tower + Plate & Frame HX*



## *Water Cooled Chiller Systems*

# Closing the Loop



## Comparing Fluid Coolers with Open Circuit Cooling Tower + Plate & Frame Heat Exchanger Combinations

**Efficiency:** Both alternatives utilize energy efficient evaporative cooling while maintaining a closed loop on the process side; keep in mind however that the open circuit cooling tower must be sized to accommodate the approach, or temperature difference between the entering cooling tower water and the leaving process fluid of the plate & frame heat exchanger, in order to supply the system with the same required design process fluid temperature.

**Simplified System:** A fluid cooler is a single, self-contained unit, combining the function of a heat exchanger and cooling tower into one compact unit. This reduces the complexity of the system by eliminating the need for additional components including piping and valves while enabling the use of a low horsepower spray pump on the open loop side of the fluid cooler (see diagram on page 4 for a typical unit configuration).

**Pumping Power:** Closed loop process fluid pressure drops are generally similar between the two alternatives but can vary depending on the specific equipment selections. The spray pump used on the fluid cooler is often lower horsepower than the pump used on the open loop side of the plate & frame heat exchanger.

**Reduced Cleaning:** The readily accessible external heat transfer surface in a closed circuit cooling tower can be kept clean and effective through a standard water treatment program, eliminating the need to take apart, inspect, and manually clean a plate & frame heat exchanger.

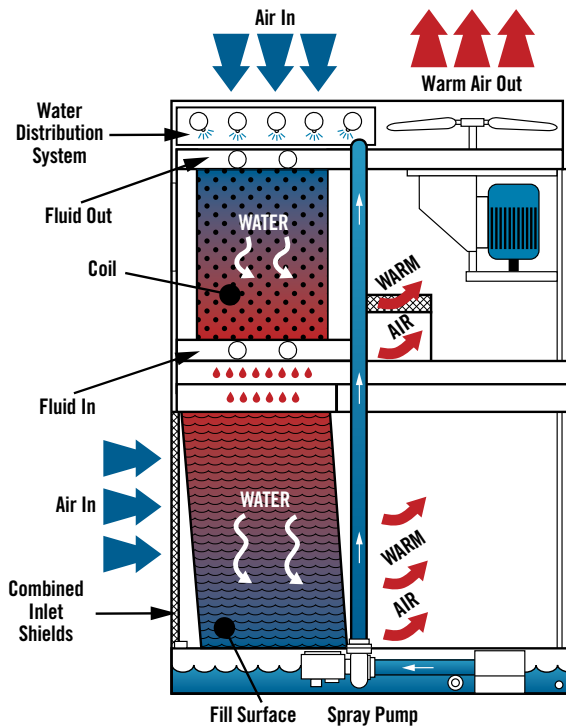
**Installation:** Plate & frame heat exchangers are typically installed indoors in equipment rooms, taking up valuable rentable space in the building, while fluid coolers are heavier, requiring additional steel grillage for support than an open circuit cooling tower sized for the same application.

**Water Treatment:** Fluid coolers can allow up to a 20% reduction in water and water treatment costs due to the reduced open circuit spray water volume, generally higher allowable cycles of concentration, and a reduced need for side-stream filtration versus open circuit cooling towers.

**Freeze Protection:** Fluid coolers operating in sub-freezing weather require some form of freeze protection for the heat exchanger, which can include the use of glycol in the process fluid loop or positive closure dampers. Both types of evaporative units need to follow proper cold weather operating procedures.

**Dry Operation:** Fluid coolers offer the flexibility to operate without water during periods of lower load and / or cooler weather in some climates. This mode saves water while alleviating unit icing concerns on the part of some operators in areas subject to very cold winters.

## Combined Flow Closed Circuit Cooling Tower (Fluid Cooler)



Regardless of the system design chosen, be sure to specify and purchase units with independent thermal performance certification. Evaporative heat rejection equipment should be certified per CTI Standard 201 RS while plate & frame heat exchangers should be certified per AHRI Standard 400. Both certification programs provide assurance of thermal performance as well as pressure drop through the heat exchangers.



*Always specify Independently Certified Thermal Performance*

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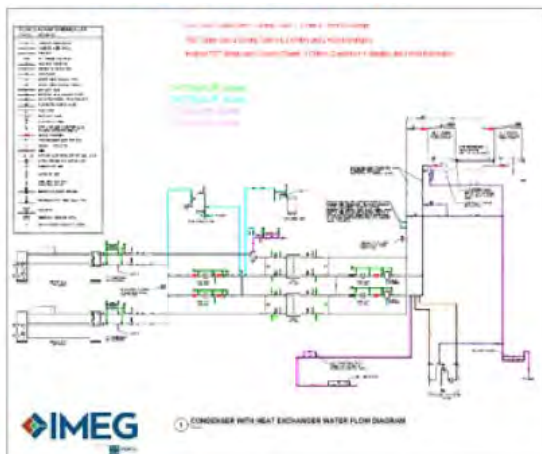
## Total Cost of Installation Study

To supplement the comparison of operational characteristics above, a study was commissioned with the independent engineering consulting firm IMEG (formerly KJWW Engineering) to compare the total installed cost of various cooling systems using two different evaporative heat rejection options - an open circuit cooling tower + plate & frame heat exchanger combination and a fluid cooler. The study, working from detailed system designs like those shown below, evaluated all equipment, material, and labor costs for the heat rejection system. The results of this study were analyzed and key excerpts are presented below to further help guide system designers and operators in making the best heat rejection choice for their systems.

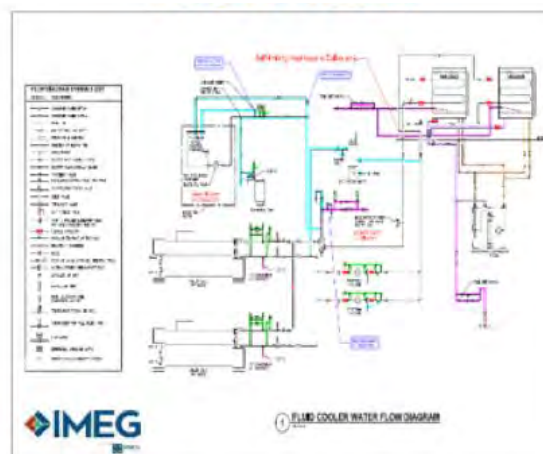


IMEG evaluated the total material and labor costs for each heat rejection alternative in ASHRAE Climate Zones 3A and 5A, using the cities of Dallas, Texas and Chicago, Illinois respectively. The study used several building types including Offices, Condominiums, Hotels, and Hospitals, ranging from 250 tons to 750 tons, with typical design conditions for each region and building type. Costs were established using supplier quotes and RS Means data, adjusted for the specific city design conditions as well as cost and labor rate multipliers. An evaluation of fan and pump motors found similar total connected horsepower for the two alternatives. Process fluid pressure drops were also similar for each system that was evaluated.

### *Open Circuit Cooling Tower + Heat Exchanger*



### *Fluid Cooler*

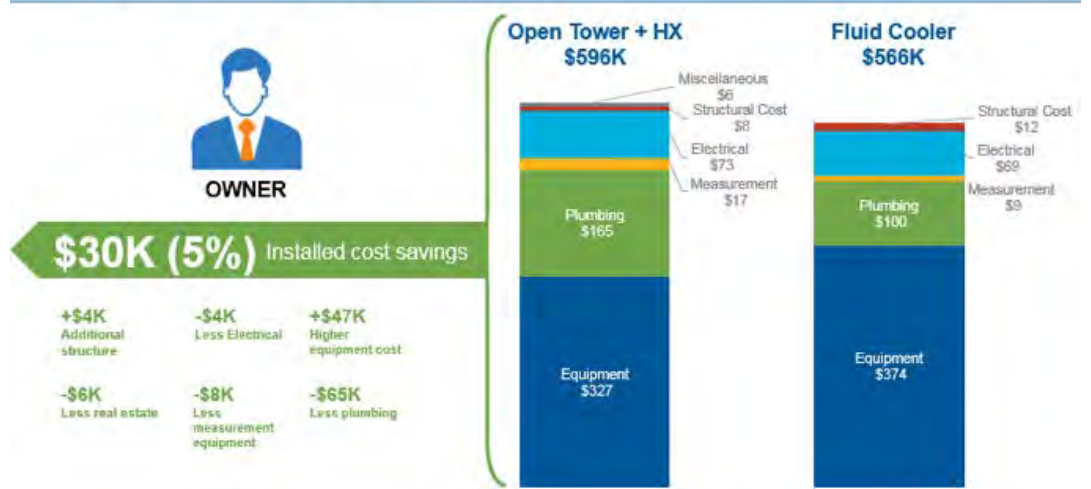


*Detailed system diagrams with all required components were created for each alternative*

# CHILLER SYSTEM

250 TON OFFICE CHICAGO (50% Ethylene Glycol)

Figure 1  
Heat Rejection System  
Detailed Cost Breakdown  
for 250 Ton Chicago  
Office Building with  
Water Cooled Chiller

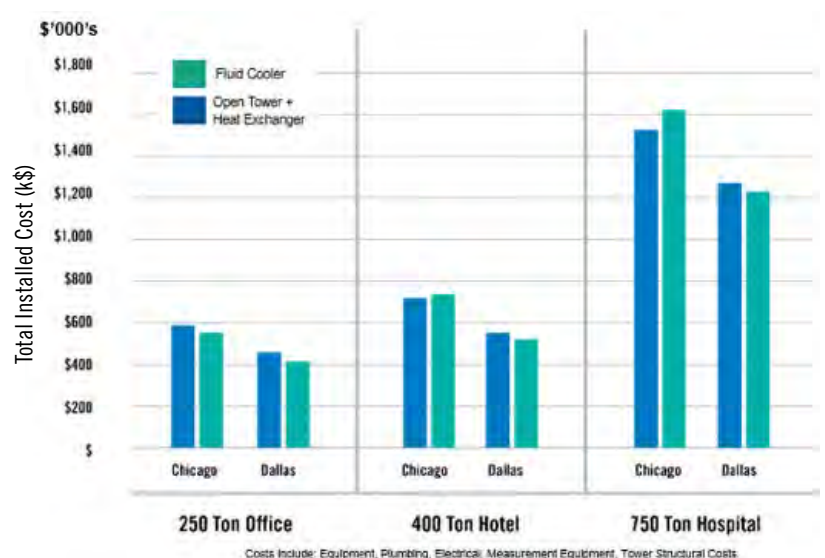


## Total Cost of Installation Study (Cont.)

An example of this cost breakdown is shown above in Figure 1 for an Office Building with a water cooled chilled water system. The equipment cost for the fluid cooler option was more than that for the tower + heat exchanger, yet when all of the other costs for piping, electrical, instrumentation, etc. are included, the installed cost favors the fluid cooler version. Note that while the structural cost for mounting the unit was less with the lighter weight open circuit cooling tower, the larger equipment room to accommodate the plate & frame heat exchanger and loss of rentable space more than offsets this added cost.

The summary results for all water cooled chiller systems studied are shown in Figure 2. While installed costs were similar, fluid cooler based designs were lower cost in most cases, except for the 400 ton Hotel and 750 ton Hospital cases in Chicago, due to the simpler, more compact nature of the fluid cooler based system (versus having to design, layout, and pipe an open circuit cooling tower + heat exchanger system). Note that the Chicago designs all called for glycol in the condenser loop for freeze protection, which also necessitated the use of a larger fluid cooler. However, the 250 ton Chicago Office case still offered savings despite the use of glycol.

Figure 2 Closed Loop Chiller Systems

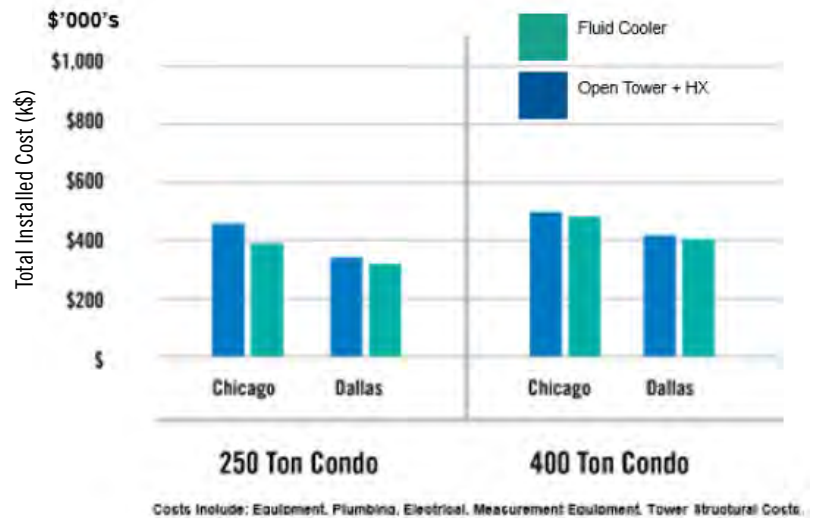


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## Total Cost of Installation Study (Cont.)

Results for 250 ton and 400 ton water source heat pump systems, often used in condominium buildings, are shown in Figure 3. In both cases, the equipment costs for the open circuit cooling tower + heat exchanger were again less than the fluid cooler. However, in all cases, the installed cost of the fluid cooler based system was less than the alternative, despite the use of both glycol and positive closure damper hoods (required by Code to minimize heat loss when the system is in boiler mode) with the fluid coolers located in Chicago.

Figure 3 Water Source Heat Pump Systems



Costs Include: Equipment, Plumbing, Electrical, Measurement Equipment, Tower Structural Costs

In addition to the total installed cost, the fluid cooler option benefits from the flexibility of dry operation and other water related efficiencies not offered by an open circuit cooling tower + heat exchanger. As mentioned earlier, this option also saves space within the building by eliminating the need for a larger mechanical room to accommodate the heat exchanger.

## Conclusion

Closed loop cooling systems offer many advantages over traditional open loop cooling systems in terms of maintaining high system efficiency over time, ongoing maintenance requirements, and application flexibility. The use of energy efficient evaporative heat rejection, whether open or closed circuit, offers the highest overall system efficiency compared to air cooled alternatives. When choosing between an open circuit cooling tower + heat exchanger combination and a fluid cooler, be sure to evaluate the space available in the equipment room, the availability of maintenance staff, water treatment requirements, and other installation and operational considerations. Lastly, be sure to compare the total installed cost, rather than simply the initial heat rejection equipment cost, of these two alternatives. Often the fluid cooler based system will offer the lowest total installed cost for the Owner thanks to the simpler system design while allowing more usable space in the building.