Loop-to-Loop Heat-Pump (LOOP-TO-LOOP-HP)

This chiller is attached to a both a chilled-water loop and a hot-water loop (Figure 30). The chiller actively supplies cooling and/or heating to the two loops. A lake/well water loop supplies the necessary heat balance via two heat-exchangers in series with the evaporator and condenser loops.

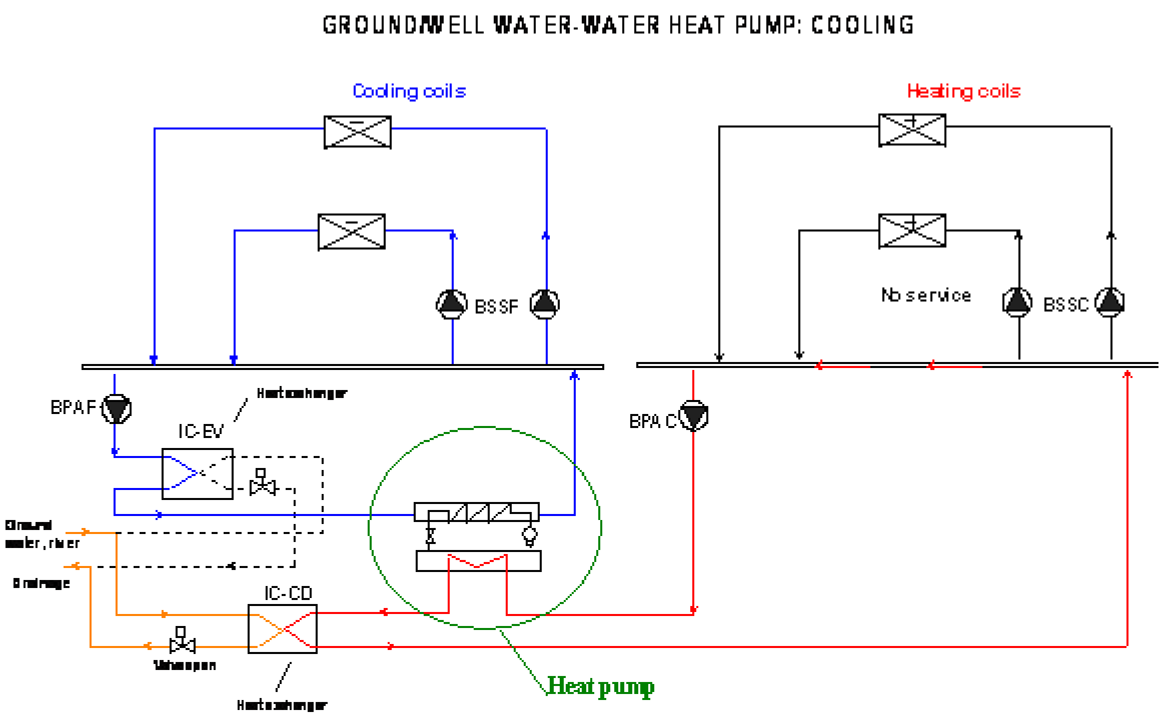

Figure 30. Loop-to-Loop Heat Pump

The chiller requires both evaporator and hot-water pumps, and these pumps must be able to operate independently of the chilled and hot-water loops. For this reason, the chilled-water and hot-water loops must have their own pumps, in addition to the chiller pumps. The evaporator and condenser pumps operate in a constant-flow mode, variable-flow operation is not permitted. However, the circulation-loop chilled-water and hot-water loop pumps may be either constant-flow or variable-flow.

The lake/well-water loop (condenser loop) interfaces with the two heat-exchangers. It can be pumped identically as described for other chillers. Most commonly, the lake/well loop will have its own pump. However, the chiller may have a condenser pump in addition to, or in lieu of, the well pump. If the condenser pump is in lieu of a pump directly attached to the lake/well loop, then it will power the loop. Otherwise it will act only to overcome the head of the chiller's heat-exchangers. The condenser flow may be modulated using either two-way or three-way valves, the default is two-way, resulting in variable –volume condenser flow.

The following describes the four modes of operation. In all four modes, both the evaporator and hot-water pumps must run to circulate fluid through the evaporator and condenser.

1. Cooling only (Figure 31) – In this mode, the chiller tracks the demand of the chilled-water loop. The heat is rejected from the hot-water loop to the well-water loop via heat-exchanger IC-CD. The heat-exchanger is controlled to maintain a leaving hot-water temperature of approximately 85°F (leaving the heat-exchanger; entering the chiller condenser).

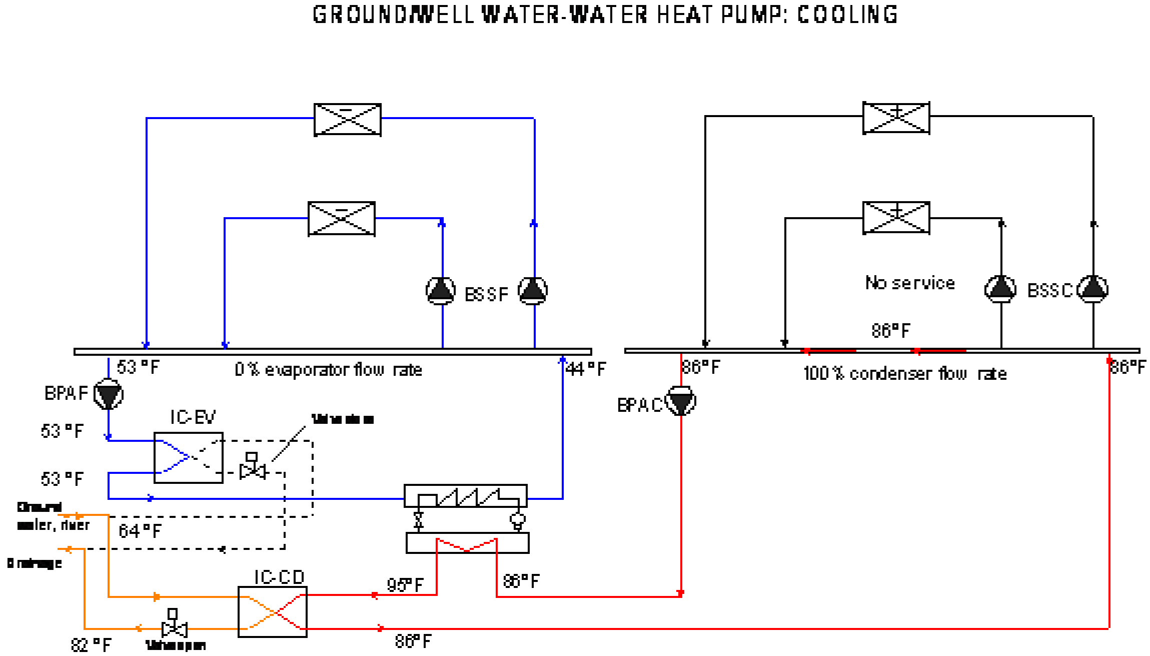

Figure 31. Loop-to-Loop Heat Pump
Cooling Only

2. Heating only (Figure 32) – In this mode, the chiller acts the same as a boiler and tracks the demand of the hot-water loop. Heat is made up from the well-water loop to the evaporator loop via heat-exchanger IC-EV. The heat-exchanger is controlled to maintain a leaving chilled-water temperature of approximately 53°F (leaving the heat-exchanger, entering the evaporator).

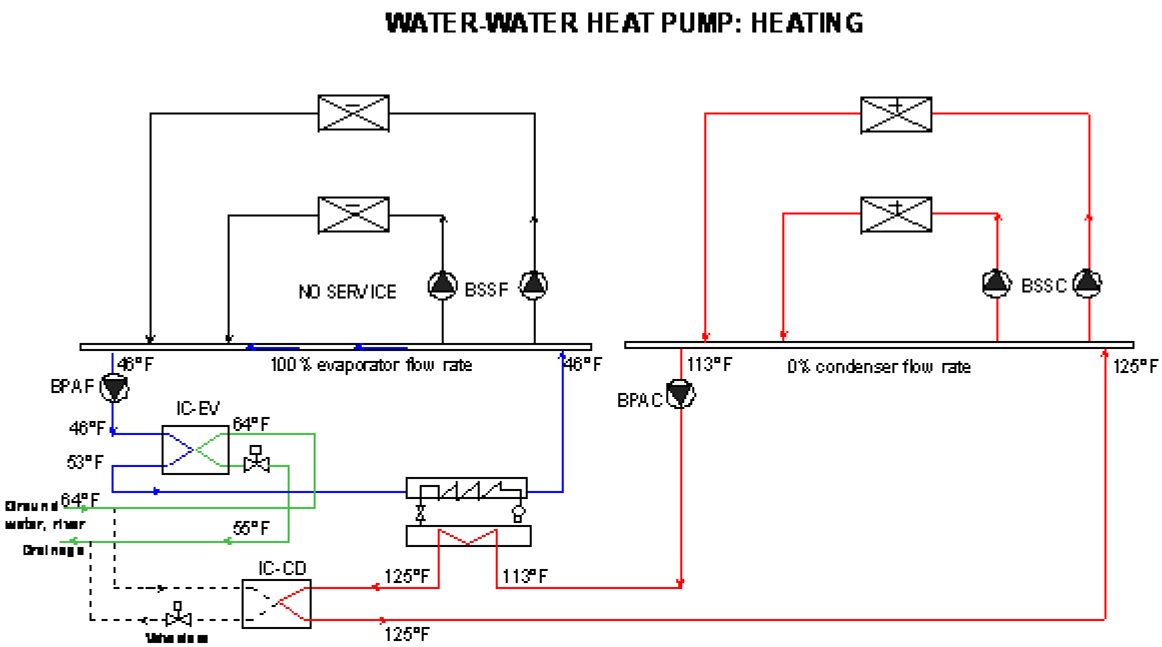

Figure 32. Loop-to-Loop Heat-Pump
Heating Only

3. Cooling dominated (Figure 33) – Simultaneous heating and cooling loads exist, with cooling being the dominant load. Excess heat is rejected from the hot-water loop via heat-exchanger IC-CD. The heat-exchanger is controlled to maintain the supply temperature of the hot-water loop. Since the temperature returning from the hot-water loop and entering the condenser may be substantially higher than in the cooling-only mode, the capacity and energy efficiency of the chiller are reduced.

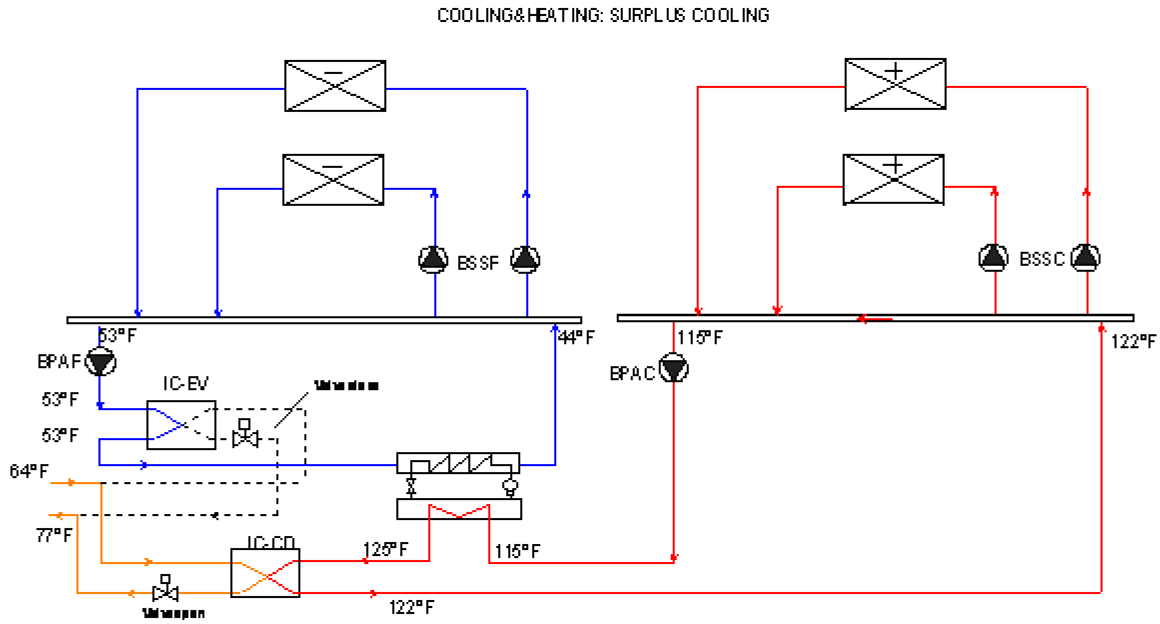

Figure 33. Loop-to-Loop Heat-Pump
Cooling Dominated

4. <u>Heating dominated (Figure 34)</u> – Simultaneous heating and cooling loads exist, with heating being the dominant load. Additional heat from the well loop is made up to the evaporator loop via heat-exchanger IC-EV. The heat-exchanger is controlled to maintain the supply temperature of the chilled-water loop. Since the temperature leaving the evaporator may be substantially lower than in the heating-only mode, the capacity and energy efficiency of the chiller are reduced.

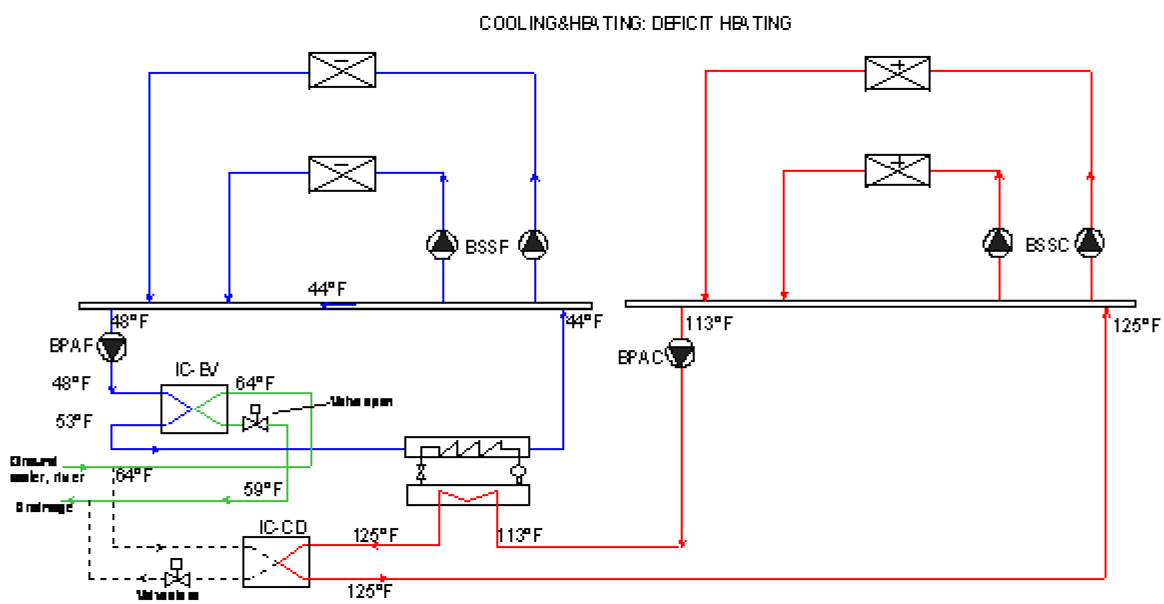

Figure 34. Loop-to-Loop Heat-Pump
Heating dominated

Most of the keywords for this chiller are identical to the keywords used for conventional electric chillers. The following summarizes the differences:

- <u>Condenser type</u> – The CONDENSER-TYPE is not used, as the condenser is always water-cooled. While the condenser of a conventional chiller can attach to loops of TYPE = CW, WLHP, or

LAKE/WELL, this chiller can attach only to a loop of TYPE = LAKE/WELL.

- Attachment to lake/well loop- The condenser keywords (CW-LOOP, CW-PUMP, CW-HEAD, etc.) are used in the same manner as for conventional chillers, and describe the attachment to the lake/well loop. The chiller may either draw heat from or reject heat to the lake/well loop, depending on whether the chiller is cooling or heating dominated.

- Hot and chilled-water pumps – As described previously, this chiller must have dedicated evaporator and condenser-water pumps, which operate in either a constant-flow mode. The loops they serve must have their own pumps, which may be either constant-flow or variable-flow. The well-water attachment (CW-LOOP, etc.), may optionally have a condenser pump, which may be in lieu of the well loop pump, and by default is variable-flow.

- Heat-recovery loop – This chiller actively heats a HW loop, similar to a boiler. Therefore, the heat-recovery keywords (HTREC-LOOP, etc.) are not valid.

- Performance data – Unlike the two-pipe heat-pump chiller (HEAT-PUMP), this chiller does not have a reversing valve; all heating/cooling effects are controlled via the two well-water heat-exchangers. For this reason, the program can use the cooling performance curves that describe the evaporator and compressor motor performance to calculate the resulting heating performance. In other words, there is no separate set of keywords that describe the chiller performance when in the heating mode. It is critical that the performance curves be valid over the entire range of evaporator and hot-water temperatures which may be encountered.

  For example, consider a chiller attached to a lake, operating in the heating mode in the winter. If the entering lake-water temperature is 45°F, then the leaving evaporator temperature may be on the order of 35°F. Simultaneously, the hot-water return temperature (entering condenser-water temperature) may be on the order of 120°F. The performance curves must be valid for this extreme range.

Since this type of chiller is common in Europe, but not in the United States, the performance curves are normalized at the Eurovent rating conditions, rather than ARI.

Subtopic help for this Topic:

DESIGN-HW-T

The leaving hot-water temperature at the heating design conditions. The default is the same as the DESIGN-HEAT-T of the hot-water loop to which this chiller is attached.

DESIGN-COND-T

The entering condenser temperature at the design *cooling* conditions. This is the temperature leaving the condenser-side heat-exchanger and entering the chiller condenser. The default is the DESIGN-COOL-T of the lake/well water loop, plus 5°F.

When autosizing a chiller, the default assumes that heating does not occur simultaneously with peak cooling. If heating does occur simultaneously with peak cooling, change this value to approximate the hot-water return temperature at the peak cooling conditions.

The following keywords describe the properties of the heat-exchangers. The heat-exchangers are assumed to be counterflow.

EVAP-HX-DESIGN-T

The design temperature of the water leaving the evaporator-side heat-exchanger (heating mode). The default is the DESIGN-HEAT-T of the lake/well loop, minus 5°F. This value is used in the design heating calculations.

EVAP-HX-SETPT-T

When the chiller is in the heating-only mode and heat-exchanger IC-EV is adding heat to the evaporator loop, specifies the temperature setpoint of the chilled-water *leaving* the heat-exchanger and entering the evaporator. The default is the same as the EVAP-HX-DESIGN-T.

The program uses this setpoint, together with the hourly load, UA product and chilled-water flow, to calculate the chilled-water temperature and required well-water flow. Note that this setpoint may not be maintained if the well-water is too cold. For example, if the setpoint is 60°F but the well-water is only 50°F, then it will be impossible to meet the setpoint, and the evaporator temperature will float somewhere below 50°F.

This keyword applies to the *heating-only* mode. In all other modes involving cooling, the heat-exchanger is controlled so that the temperature requirement of the chilled-water loop (chilled-water supply temperature) is met.

EVAP-HX-TD

is the design temperature differential between the chilled-water and well-water streams *entering* the evaporator-side heat-exchanger (IC-EV in the diagrams). The differential is the differential when the chiller is operating in the heating-only mode, which represents maximum heat-exchanger loading. The program uses this value, together with the design evaporator load in the heating mode, and the design chilled-water and well-water flows, to calculate the UA product of the heat-exchanger.

The default is calculated as

TD = Twell – (Tsetpt+dTchw)

where

TD the design entering temperature differential
Twell the DESIGN-HEAT-T of the well water loop
Tsetpt the EVAP-HX-SETPT-T
dTchw the design chilled water temperature rise, CHW-DT

COND-HX-SETPT-T

When the chiller is in the cooling-only mode and heat-exchanger IC-CD is removing heat from the hot-water loop, specifies the temperature setpoint of the hot-water *leaving* the heat-exchanger and entering the condenser. The default is the same as the DESIGN-COND-T.

The program uses this setpoint, together with the hourly load, UA product and chilled-water flow, to calculate the condenser-water temperature and required well-water flow. Note that this temperature may not be maintained if the lake/well-water is too warm. For example, if the setpoint is 75°F but the chiller is attached to a lake that peaks at 80°F, then it will be impossible to meet the setpoint.

This keyword applies to the *cooling-only* mode. In all other modes involving heating, the heat-exchanger is controlled so that the temperature requirement of the hot-water loop (hot-water supply temperature) is met.

COND-HX-TD

is the design temperature differential between the hot-water and well-water streams *entering* the condenser-side heat-exchanger (IC-CD in the diagrams). The differential is the differential when the chiller is operating in the cooling-only mode, which represents maximum heat-exchanger loading. The program uses this value, together with the design condenser load in the cooling mode, and the design hot-water and well-water flows, to calculate the UA product of the heat-exchanger.

The default is calculated as

TD = Tsetpt+dTcw - Twell

where

TD the design entering temperature differential
Tsetpt the CO ND-HX-SETPT-T
dTcw the design condenser-water temperature rise, CW-DT
Twell the DESIGN-COOL-T of the well water loop