Well-Water-to-Water Heat-Pump (HEAT-PUMP, WATER-COOLED)

A water-to-water heat pump serving a 2-pipe fan coil system is simulated using a chiller of TYPE = HEAT-PUMP and CONDENSER-TYPE = WATER-COOLED. When the 2-pipe circulation-loop is in the cooling mode, the unit acts identically to an water-cooled electric chiller. When the loop is in the heating mode, a changeover valve causes chiller to act as a heat pump, heating the loop by absorbing heat from a ground-water loop. In the heating mode, the chiller can deliver water as hot as 130°F. Note, however, that the maximum temperature varies with ground-water temperature.

In the cooling mode, the unit acts identically to an water-cooled electric chiller, and all keywords applicable to an electric chiller apply to this chiller type, with the following exceptions:

- <u>Condenser type</u> – The CONDENSER-TYPE should be specified as WATER-COOLED. You may also specify AIR-COOLED, which is covered in a separate section. No other condenser types are acceptable. 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.

- <u>Attachment to lake/well loop</u> - 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. In the heating mode, the condenser reverses its function and becomes the evaporator; drawing heat from the lake/well loop.

- <u>Heat recovery</u> – This chiller is offered as a packaged self-contained unit, and heat recovery in the cooling mode is not available.

In the heating mode, the unit acts as a heat pump, and its performance may be significantly different than in the cooling mode. The following keywords define the unit's performance when heating. Note that, for the sake of consistency with other chillers, references to "condenser" in the following keywords refer to the heat-exchanger that rejects heat when in the cooling mode (the well-side heat-exchanger. This heat-exchanger is actually the evaporator in the heating mode, however the keywords still refer to it as a condenser, as this is the heat-exchanger coupled to the CW-LOOP.

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:

- HEAT-CAP-FT
- HEAT-EIR
- HEAT-EIR-FT
- HEAT-EIR-FPLR

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 2-pipe loop to which this chiller is attached.

DESIGN-COND-T-HT

The entering lake/well temperature at the design heating conditions. The default is the DESIGN-HEAT-T of the lake/well loop.

CW-DT

The design temperature change of the lake/well water when in the cooling mode. The default is 90°F (32°C) minus the CW-LOOP:DESIGN-COOL-T. For example, if the design cooling temperature of the lake/well loop is 60°F, then the design temperature change will be 30°F.

The expansion valve of the heat pump is sized for the high pressure differential that normally exists in the heating mode. In the cooling mode, if 60°F water were to enter the heat pump with only a 10°F rise, then the condensing pressure would be too low to maintain refrigerant flow through the expansion valve. For this reason, flow is normally reduced through the condenser when in the cooling mode. This is accomplished via a solenoid valve in parallel with a restricting valve. During cooling, the solenoid valve is closed, and condenser flow is restricted through the balance valve (thereby achieving the CW-DT). During heating, the solenoid valve is open, allowing full flow.

CW-DT-HT

The design temperature change of the lake/well water when in the heating mode. The default is 9°F (5°C).

The expansion valve of the heat pump is sized for the high pressure differential that normally exists in the heating mode. In the cooling mode, if 60°F water were to enter the heat pump with only a 10°F rise, then the condensing pressure would be too low to maintain refrigerant flow through the expansion valve. For this reason, flow is normally reduced through the condenser when in the cooling mode. This is accomplished via a solenoid valve in parallel with a restricting valve. During cooling, the solenoid valve is closed, and condenser flow is restricted through the balance valve (thereby achieving the CW-DT). During heating, the solenoid valve is open, allowing full flow.

RATED-HW-T

specifies the leaving hot-water temperature at the rated conditions, either ARI or Eurovent (The default is for Eurovent). This is the value at which the heating mode performance curves are normalized. Normally, you should not change the default value of this keyword unless you are also specifying the heat-pump performance curves, and the curves are normalized to a different value.

RATED-COND-T-HT

The entering lake/well temperature when in the heating mode, at the rated heating conditions. This is the value at which the heating mode performance curves are normalized. Normally, you should not change the default value of this keyword unless you are also specifying the heat-pump performance curves, and the curves are normalized to a different value.

RATED-HT/CL-FLOW

specifies the ratio of the flow during heating to the flow during cooling at the rated conditions. Heating and cooling performance is usually rated at a constant CW-LOOP temperature change of 9°F (5°C). However, because the heat taken or rejected to the CW-LOOP is not the same in both modes, the rated flow used to develop the performance curves is different in each case; usually with the heating flow smaller than the cooling flow.

Normally, you should not change the default value of this keyword unless you are also specifying the heat-pump performance curves, and the curves are normalized to a different value.

HEAT/COOL-CAP

Is the ratio of the heating capacity to the cooling capacity at the standard rating conditions.

The chiller's CAPACITY is the cooling capacity at the standard cooling rating conditions (SPECIFIED-AT = RATED-CONDITIONS). At the standard heating rating conditions, the heating capacity is usually very close to the cooling CAPACITY. If, however, the heating capacity was only 80% of the cooling capacity, then this keyword would have a value of 0.8

When the CAPACITY is allowed to default:

- Cooling capacity - The program looks at the peak cooling requirement at the actual peak conditions, calculates the capacity at these conditions, and translates the capacity to the rated conditions.

- Heating capacity – The program looks at the peak heating requirements at the actual peak heating conditions, calculates the heating capacity at these conditions, and translates the capacity to the rated condtions.

- Greater of the two – The program takes the rated heating capacity and calculates an equivalent cooling capacity by dividing by the HEAT/COOL-CAP. The CAPACITY is the greater of the rated cooling capacity, or the equivalent cooling capacity required for heating.

HEAT-CAP-FT

Takes the U-name of a curve the gives the heating capacity of the chiller as a function of the leaving hot water temperature and the entering lake/well temperature. This curve should be normalized to 1.0 at the ARI or Eurovent rating point.

HEAT-EIR

The ratio of electric input power to heating capcacity at the standard heating rating conditions. The HEAT-EIR is dimensionless, so that the same units for electric input and capacity must be used when calculating it.

The program uses the following relationship to calculate the electricity input to the chiller each hour when heating:

Cap_{hour} = Capacity * Heat/Cool Ratio * Cap f(Thws,Twws)
dT = Thws - Twws
$Elec_{hour}$ = Cap_{hour} * EIR * EIR f(PLR,dT) * EIR f(Thws,Twws)

where

Thws	leaving hot-water temperature
Twws	entering lake/well water temperature
Cap_{hour}	hourly heating capacity
Capacity	rated cooling capacity, CAPACITY
Heat/Cool Ratio	ratio of rated heating capacity to rated cooling capacity, HEAT/COOL-CAP
Cap f(Thws,Twws)	correction to capacity for temperatures, curve HEAT-CAP-FT
$Elec_{hour}$	electric input to the chiller
EIR	rated electric input ratio, HEAT-EIR
EIR f(PLR,dT)	correction to EIR for part-load ratio, curve HEAT-EIR-FPLR
EIR f(Thws,Twws)	correction to EIR for temperatures, curve HEAT-EIR-FT

If you change any one of the above curves you should either change the others or verify that they are reasonable over the expected range of operating conditions.

HEAT-EIR-FT

Takes the U-name of a curve that adjusts the HEAT-EIR as a function of the leaving hot water temperature and the entering lake/well temperature. This curve should be normalized to 1.0 at the ARI or Eurovent rating point.

HEAT-EIR-FPLR

Takes the U-name of a curve that adjusts the HEAT-EIR as a function of the heating part load ratio. The curve must be normalized to 1.0 at full load.