Parallel-Chiller Plants

System Description

Parallel-chiller systems are straightforward to design and operate. They usually have two chillers, although more chillers are possible. Chilled water flow is split through the chillers in a ratio equal to the ratio of the chiller capacities. All chillers see the same return water temperature and therefore see the same percent load.

Chilled Water Loop

The chilled water loop circulates throughout the building. Most traditional parallel chiller designs are constant flow with three-way valves at the terminal units. There can be dedicated chilled water pumps for each chiller or a single main pump for all the chillers (as shown).

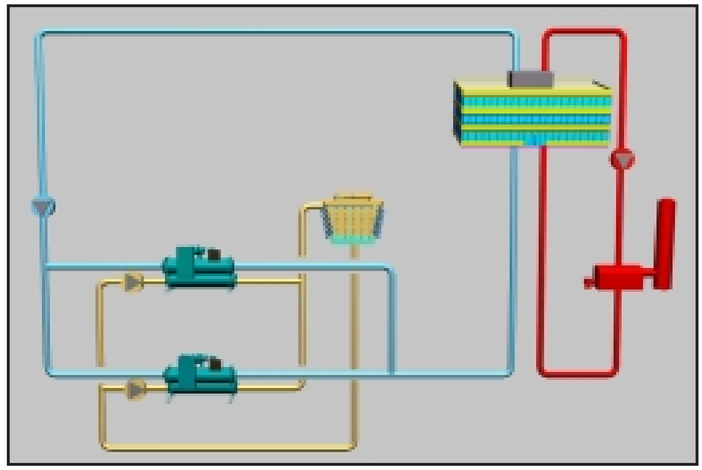
System Parameters

A key issue with parallel chillers is plant operation at light loads. In particular, there is no easy way to operate just one chiller in a constant flow system. Turning off one of the chillers allows return water to flow through it without any change in temperature. This un-cooled water mixes with the cooled water from the other chiller(s), resulting in a raised chilled water supply temperature.

The raised supply water temperature will adversely affect the system operation. Dehumidification will be difficult and maintaining sensible temperature may also be difficult.

There are three options:

1. Lower the setpoint of the operating chiller to balance the supply water temperature, though this will lower the efficiency of the operating chiller and may create a situation where the chiller cannot operate.
2. Let both chillers operate even if the system load is less than the capacity of one chiller.
3. Design the system for variable flow, including chiller isolating valves, variable flow pumps, bypass line and flow meter.



Typical chilled water supply temperatures range from 42 to 45°F, with 44°F being the most common. If a 10°F delta T is used, the chilled water flow is 2.4 U.S. g.p.m. per ton.

Condenser water supply temperatures range from 80 to 90°F, with 85°F being the most common. The condenser water delta T is typically 10°F, which equates to 3.0 U.S. g.p.m. per ton.

Chiller Selection and Sizing

Any kind of chiller can be used. Although the chillers can be different sizes, it is typical for the chillers to have the same capacity. This is beneficial because the pumps, cooling tower, etc., are the same size and can be interchangeable.

Condenser Water Loops

Condenser water loops are required for water cooled chillers only. Each chiller typically gets its own condenser water pump, sized to provide the correct flow for the chiller. Cooling towers are used to reject heat in the condenser water to ambient. Water-cooled chillers are more efficient than air-cooled chillers because they operate with a smaller compressor lift.

Cooling towers may be sized and dedicated to each chiller, or a common cooling tower plant may serve all the chillers.

System Pros

- Straightforward to design and operate.
- Can be modified for variable flow.
- Multiple chillers provide redundancy.
- Chillers can be any size or type.

System Cons

- No easy way to operate with just one chiller during light loads (without variable flow).
- Operating multiple chillers at light loads is inefficient and puts undue wear on equipment.

Energy Considerations

Traditional parallel chillers without variable flow are not very energy efficient when operated below 50% capacity. Variable flow can significantly improve chiller plant performance. The following are some considerations outlined in ASHRAE Std 90.1-1999. The numbers in brackets refer to Std. 90.1-1999 sections.

- Energy efficiency tables for HVAC equipment (6.2.1).
- Equipment must be automatically scheduled off during unoccupied hours (6.2.3.1).
- Air- or water-side economizers are required. There are several exceptions to this rule, particularly when dealing with heat recovery (6.3.1).
- Reheat is allowed if at least 75% of the energy for reheat comes from on-site energy recovery (templifiers).
- Hydronic systems with a system pump power that exceeds 10 hp must employ variable flow and isolation valves at each terminal device. The system must be able to operate down to at least 50% of design flow (6.3.4.1).
- Individual pumps over 50 hp and 100 ft. head must have VFDs and consume no more than 30% design power at 50% design flow (6.3.4.1).
- Supply temperature reset is required for hydronic systems larger than 300 mbh. Temperature reset is not required if it interferes with the proper operation of the system, i.e.: dehumidification (6.3.4.3).
- Fan motors larger than 7½ hp on cooling towers must either have VFDs or be two speed. A control system is required to minimize power usage (6.3.5).
- Hot gas bypass for refrigeration systems is permitted, but has strict limitations (6.3.9).

A thorough explanation of the Standard is beyond the scope of this document. The designer should have access to the Standard and a complete understanding of its contents. The ASHRAE 90.1-1999 Users Manual is also very helpful. ASHRAE considers Standard 90.1-1999 a high-profile standard and continuously updates it.

Typical Applications

Parallel-chiller systems are used in small-to-medium size plants. They were very common in the 1960s and 70s and are often seen in retrofit applications.

Common applications include:

- Office Buildings
- Schools
- Industrial