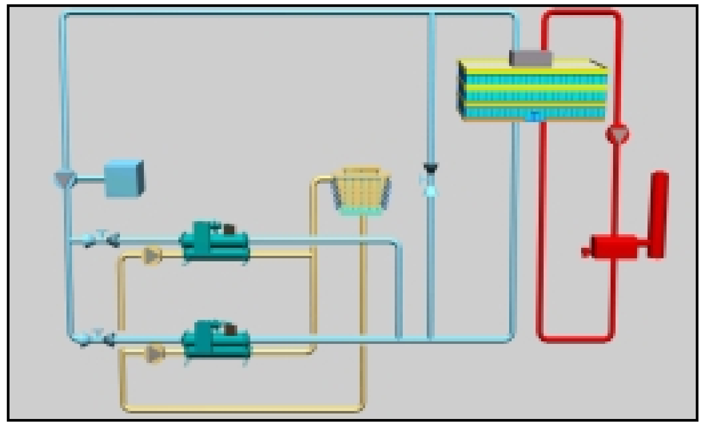
Variable Flow Chiller Plants



System Description

To reduce installation and operating costs, it is best to vary the chilled water flow throughout the building. Doing this allows the chilled water delta T to remain constant during partial load conditions and chilled water flow to vary in proportion with the load. By varying the flow, smaller pumps and piping can be used.

Usually this is done using primary/secondary systems. Variable flow chiller plants also provide variable flow pumping using only a single set of pumps. Chilled water pumps vary the flow both through the chillers and the building.

Chilled Water Loop

Variable flow chiller systems have only one loop that circulates chilled water through the chillers and building. The flow can be varied to meet the needs of the building cooling load. With only one loop, the flow through the chillers also varies. The flow variation is accomplished by using two-way control valves at the loads.

The main circulating pumps must be variable flow. Multiple pumps can be staged on, but VFDs are more commonly used. During periods of low flow, a bypass line is used to maintain minimum chilled water flow through the chillers.

Multiple chillers can be isolated during low loads by automated isolation valves. A flow meter is used to measure chilled water flow and control chiller isolation and the bypass line.

System Parameters

The key parameter for variable flow systems is the chilled water delta T. It can be any temperature (typically 10 to 16°F). Once the temperature is selected, all equipment must be designed to operate within that range. This includes the chillers, air handling unit coils, and especially the control valves.

Chilled water supply temperatures typically 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 in variable flow systems. The most common are water-cooled screw, centrifugal and absorption chillers. Centrifugal chillers are the most efficient. Absorption chillers can operate using either natural gas or steam, which allows peak shaving and avoids ratchet charges. This is very important where electrical demand charges are high.

Since the flow is designed to vary through the chillers, it is important that the minimum and maximum flow rates are not exceeded. The fluid velocity in the chiller tubes should be between 3 and 12 fps. Most chillers are designed around 6-7 fps, meaning the flow can be reduced to 50%.

It is possible to select a chiller with higher design velocities and provide a 3:1 turndown; however, the design water pressure drop will be higher and the pumps will have to be sized accordingly.

Condenser Water Loops

Condenser water loops are required for water-cooled chillers only. Each chiller 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 from the building. Water-cooled chillers are more efficient than air-cooled chillers because they operate with a smaller compressor lift.

A cooling tower may be matched to each chiller or a common cooling tower plant can serve all of the chillers.

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System Pros

- Variable flow throughout the building reduces pump and pipe size (capital savings) and pump work (operating savings).
- Only one set of pumps is needed.
- Multiple chillers provide redundancy.
- Chillers can be any size or type.

System Cons

- Can be more involved to design and operate.
- May require modern chiller controllers (not suggested for older chillers).
- A bypass and flow meter may be needed.
- DDC chiller plant controls may be needed.

Energy Considerations

Variable flow systems save pump work during part load operation. Std 90.1-1999 promotes variable flow unless it conflicts with proper system operation. 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

Variable flow chiller plants offer a money-saving way to have variable flow through small-to- medium sized buildings. It is an excellent choice when retrofitting existing parallel chiller plant designs.

Common applications include:

- Office Buildings
- Schools

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