Primary/Secondary Chiller Plants

System Description

For large chillers or where more than two chillers are needed, primary/secondary (decoupled) piping systems are often used. To reduce installation and operating costs, it is best to vary the system flow so that the chilled water delta T remains constant during partial load conditions and chilled water flow varies in proportion with the load. By varying the flow, smaller pumps and piping can be used.

Also, primary/secondary systems provide constant flow through the chillers to maintain chiller stability.

Secondary Loop

The chilled water loop that circulates through the building is called the secondary loop. Two-way control valves installed at the loads (fancoils, air-handling units, etc.) make the loop variable flow.

The secondary pumps must be variable flow. Multiple pumps can be staged on, but VFDs are more commonly used.

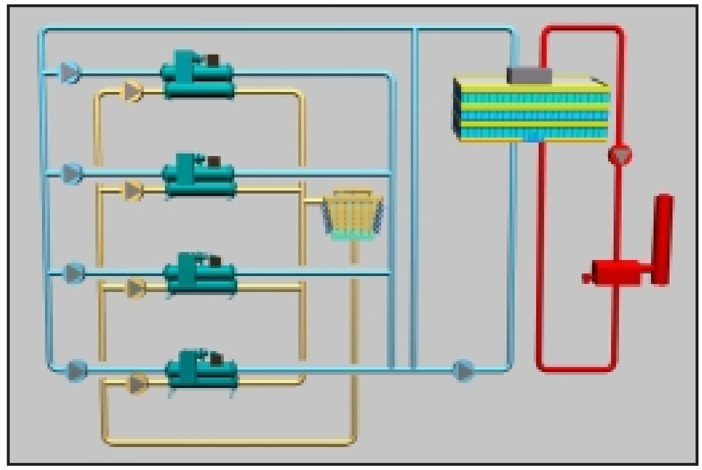
The system head pressure for the secondary pump represents all the pressure drops seen "outside the mechanical room".

Primary Loop

The primary loop is located in the room where the chillers reside. Each chiller typically has its own pump. The pump is a fixed-speed type sized for the flow rate of the chiller it serves. The head pressure the primary pump sees is only the pressure drop in the mechanical room and is dominated by the pressure drop inside the chiller.

System Parameters

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



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

Any kind of chiller can be used in primary/secondary systems. The most common are water-cooled centrifugals and absorption chillers. Centrifugal chillers are the most efficient. Absorption chillers can operate either on natural gas or steam, which allows peak shaving and avoids ratchet charges. This can be very important where electrical demand charges are high.

A small air-cooled chiller is sometimes used for winter operation where there is a small chilled water load (such as with process equipment).

Chiller Sizing

Varying chiller sizes can help meet intermediate loads more efficiently. For example, splitting the chiller sizes 1/3 – 2/3 lets the chiller sized for 2/3 of plant capacity be used on days where the load is not expected to exceed 2/3 of design. The benefits are:

- One chiller operates near its most efficient point.
- Only one primary pump, condenser pump, and tower fan are required.

Condenser Water Loops

Condenser water loops are required for water-cooled chillers only. Each chiller has 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 air. 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 tower plant can serve all the chillers.

System Pros

- Variable flow on the secondary loop reduces pipe size (capital savings) and pump work (operating savings).
- Fixed flow for each chiller provides control stability. Flow is only required when chiller is operating.
- Dedicated condenser flow for each chiller is required only when it operates.
- Chillers can be any size or type.

System Cons

- May require a large mechanical room.
- More complicated to design and operate.
- If the system delta T is not maintained (control valves problems, dirty coils, etc.) the system does not function properly and operating costs can rise.

Energy Considerations

Primary/secondary systems are energy efficient because they provide variable flow in the secondary loop. ASHRAE STD 90.1-1999 has several requirements that affect primary/secondary system design. 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 scheduled off automatically during unoccupied hours (6.2.3.1).
- Air- or water-side economizers are required. There are exceptions, 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 over 10 hp must use variable flow and isolation valves at each terminal device. The system must be able to operate 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 needed 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 lower power use (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

Primary/secondary systems are used for the largest chiller plants.

Common applications include:

- Office Buildings
- Institutions
- Health Care
- Industrial