15625
Water Chillers

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A. Summary

This section contains design criteria for water chillers.

B. System Design and Performance Requirements

1. Select chillers based on performance, service and maintainability, and life-cycle costing.
2. Specify factory testing for each new chiller, witnessed by the Engineer and Owner with cost of testing and engineer and Owner travel expenses included in Contractor pricing.
3. See Section 00705: General HVAC Design Conditions for chilled water temperatures and ΔT.
4. Provide differential pressure control systems for all chilled water systems over 20 psi that use “commercial” quality valves, or specify control valves based on actual chilled water system pressure.
5. The Central and Science area chilled water systems are designed to be variable volume, constant pressure, all-primary design systems.
6. All new work must be consistent with variable-volume, all-primary design chilled water systems.

7. The primary pumps in the plant provide a constant-pressure differential to a control point in the system. At any point in the system, the pressure differential remains relatively constant.
8. In general, the Yale University Facilities group extends service to the "project boundary line" of the project to be served. Building projects are generally designed to connect to the distribution at that point. The exact boundary will vary, and is determined on a case-by-case basis. Contact the Yale University Facilities group.
9. Most building systems can use the primary system pressure differential by a direct connection to the chilled water supply and return mains.
10. Remote points in the system might have a low pressure differential requiring a booster pump. The use of building circulation or booster pumps must be reviewed and approved in advance by Yale university before including them in the design.
11. Secondary loops, bridge circuits, bypasses, or any other system that allows the chilled water supply to shunt to the return are not allowed.
12. Use of the chilled water supply for condenser water in direct expansion refrigeration equipment is not allowed. The chilled water return may be used for condensing and returned to the chilled water return piping. A circulation pump is required.
13. The project manager, in consultation with the Yale University Facilities group will supply the following information to the designer.
    a. The location of interconnections to the chilled water distribution system.
    b. The supply pressure at the point of interconnection.
    c. The pressure differential available across the mains at the point of interconnection (determined by the hydraulic model or empirical data).
    d. Supply temperature range

14. The building control system must include controls to perform the following functions.
    a. Maintain design temperature drop at full-load conditions.
    b. When necessary, operate booster pumps to maintain design flow and prevent over-pressurization of the return main when pumps are running.
    c. Maintain the flow rate within design conditions.
    d. The use of balancing valves on the chilled water distribution system is not usually necessary. Distribution mains are sized to supply chilled water to all areas of campus at a pressure differential usable by the building system. Within building systems, particularly retrofit installations, balancing valves might be necessary.
15. All chilled water service is metered by the Central Building Utilities Metering System. See Section 01350: Special Project Procedures.
16. Equip all chillers with flow proving switches wired to prevent the compressor from starting until chilled water and condenser water flow have been established. Differential pressure switches are preferred. If flow switches are used, piping must be large enough to permit paddle installation without trimming.
17. Energy-efficient centrifugal chillers should be selected at 0.50-.60 kw/ton at full load and approximately 0.4 kw/ton at partial load. Screw chillers should be selected at 0.62-0.72 kw/ton and air cooled chillers at 0.7-0.78 kw/ton.
18. Size two chillers for 70% of the load and pipe them to cross feed with their own and the other chiller's tower.
19. Verify with the structural engineer that a lift beam and winch has been specified to lift chiller motors and compressors.
20. Maintain ambient temperatures in chiller mechanical rooms within 13°F of outdoor ambient design.
21. Verify that the system design can accommodate minimum and maximum loads.
22. On larger chillers, specify the installation of davits with marine boxes and flanged piping to simplify the removal of the heads.
23. Design chiller condensing piping to facilitate the future installation of a brush cleaning system.

24. Pipe chilled water circuits for complete functional flexibility. Provide cross-connection for chilled water pumps, suctions, and discharges. Provide automatic on/off valves where necessary to avoid pumping through an inoperative chiller.
25. Provide a chilled water filter, connected from the pump discharge back to the suction, for 1% to 2% of total flow with a constant flow device in the branch piping, for new or existing systems. Include the filter gpm in the chilled water pump capacity.
26. Typical critical systems include:
    - Laboratories
    - Medical areas
    - Administrative areas
    - Libraries
    - Museums
27. Typical comfort cooling systems include:
    - Master's offices
    - Master's houses
    - Dean and Fellow's suites
    - Dean's offices
    - Faculty offices
    - Seminar rooms
28. Some units on campus (in computer rooms) are completely stand-alone with their own condensing units. Those units that cannot stand alone should be connected to the chilled water return from the central plant as a condensing medium.
29. Do not purchase R11 and R12 units. Alternative refrigerants of low toxicity and pressure are the desired refrigerants for the stand-alone systems.
30. Isolate the water systems in such a way that no chiller water could pass into the domestic water system.
31. As a minimum, safety devices are required for protection against high head pressure, oil failure, and electrical malfunctions. They will be reset manually. Any rupture disc should vent outside to a safe location.

32. Pumps and compressors, as they are located in individual buildings, must take into account the seismic restrictions for people in the adjacent areas. Noise and vibration has been a problem in some Yale University facilities.

33. Central air conditioning systems for a building or group of buildings must be served by two or more chillers. The size of the various chillers should be such that the load profile of the facility is matched as close as practicable through the sequential use of the selected chillers. A load profile analysis may indicate the beneficial use of two or more chillers of different size.

34. Base the selection of refrigeration equipment for system capacity over 100 tons on an economic life-cycle cost analysis. The analysis must consider the hours of operation at various loads and the life expectancy of each piece of equipment. Apply relevant Yale University guidelines for an engineering economic analysis.

35. The selection of the most appropriate equipment must be made by comparing three alternatives from the following types:
    - Chiller size less than 200 tons
      - Electric driven reciprocating chiller
      - Electric driven centrifugal chiller
      - Electric driven screw chiller
      - Steam absorption (single stage) chiller
    - Chiller size from 200 tons to 1,000 tons
      - Electric driven constant speed centrifugal chiller
      - Electric driven variable speed centrifugal chiller
      - Electric driven screw chiller
      - Steam absorption (single or double stage) chiller
      - Turbine driven centrifugal chiller-(steam or gas turbine)
    - Chiller size over 1,000 tons—give special consideration to combined solutions such as:
      - Steam turbine driven centrifugal combined with absorption
      - Gas turbine driven centrifugal with waste beat boiler and absorption
      - Electric driven centrifugal powered by engine driven generator with waste heat boiler and absorption

36. Refrigeration equipment for small air conditioning systems with capacity less than 100 tons does not need a life-cycle analysis and the comparison of three alternatives. For smaller sizes, air-cooled, direct expansion units may be used. For larger sizes, air-cooled chillers may be used.

C. Installation

1. The contractor is responsible for the notification of all sections or individuals identified by the project manager at least three days prior to disruption of utilities.
2. The contractor will provide a 24-hour emergency telephone number that will be maintained at the Physical Plant Control Center or the Yale University Utilities Department.
3. During installation, the contractor must have personnel available for immediate response in case of emergency (for example, broken pipes or interrupted electricity).
4. Testing of the chilled water system must be accomplished with the Physical Plant mechanics, and when specified, requires certification from an independent testing company.

D. Submittals

Submit the following design, testing, and certification documentation.

1. Designer Submittals

a. See Section 01330: Designer Submittals.

b. Submit calculations for:

- Chilled water tonnage
- Chilled water gpm
- Chilled water temperature requirements
- Chilled water temperature differential

2. Contractor Submittals

Submit a factory test report.

3. Product Certificates Signed by Manufacturer

Specify that chillers be inspected by the manufacturer's authorized representative who shall submit a written report to the engineer with copy to Yale University stating that the chillers have been properly installed, are operating correctly, and the installation is acceptable to the manufacturer in every respect.

E. Manufacturers

Subject to compliance with the design requirements, manufacturers offering products that may be incorporated in the work include, but are not limited to, the following:

- Carrier
- York
- McQuay
- Trane

F. Accessories or Special Features

1. Flow Proving Switches

Equip all chillers with flow proving switches wired to prevent the compressor from starting until chilled water flow has been established. Differential pressure switches are preferred. If flow switches are used, piping must be large enough to permit paddle installation without trimming.

2. Safety Cut-Outs

All safety cut-outs must be manual reset types. Provide time delay for all machines.

3. Required Devices

1. Provide a thermostat to prevent the unit from attempting to start when the ambient temperature is too low.
2. Provide a head pressure controller for cooling tower applications.

G. Quality Control Testing

Specify a factory test with the engineer and a Yale University witness to verify performance kw/ton at design operating conditions and at integrated part load value (IPLV).

H. Installation Guidelines

1. Allow sufficient clearance and access in building construction for replacement chillers and parts, and for normal chiller maintenance.
2. In new construction, the equipment room layout must provide designated space for a future machine and accessories equal in size to the largest machine being furnished. In existing buildings or plants, it is sufficient to dot-in future building expansion, if necessary, to provide the space for the future machine. In either case, space must be designated for the future starter, pumps, and cooling tower.
3. Locate chiller plants at grade level for ease of servicing. Size, arrange, and valve the plant piping for installation of the future chiller, pumps, cooling tower, and other equipment.
4. Allow sufficient clearance for tube bundle pulling and cleaning.
5. Provide marine boxes and piping to facilitate head removal.
6. Do not install chillers in the same space as fuel-firing equipment, such as boilers and water heaters.
7. Arrange chilled and condenser water piping with offsets for flexibility. Adequately support and brace the piping independently of the chiller to avoid strain on the unit.
8. Install each water pipe connected to a chiller with a flexible connection, as necessary for seismic conditions. See Section 00200: Information Available to Designers for seismic requirements.
9. Use a flexible connection at least 24" long to make all water chiller electrical connections.
10. Use vibration elimination hangers to hang all piping connected to chillers.

I. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.

End of Section

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Refrigerant Monitoring and Safety Equipment

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A. Summary
B. System Design and Performance Requirements
C. Quality Control

A. Summary

This section contains design criteria for refrigerant monitoring and safety equipment.

B. System Design and Performance Requirements

1. General requirements include showing the locations of utility service connection points, verifying the capacity of these connection points, and installing equipment in a safe, well-lit, and accessible location.
2. Verify emergency power for refrigerant monitoring and ventilation equipment.

C. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.

End of Section

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Open-Circuit, Mechanical Draft Cooling Towers

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F. Installation Guidelines
G. Quality Control

A. Summary

This section contains design criteria for open-circuit, mechanical draft cooling towers.

B. System Design and Performance Requirements

1. General requirements include showing the locations of utility service connection points, verifying the capacity of these connection points, and installing equipment in a safe, well-lit, and accessible location.
2. Size towers for 70 percent of the load, and pipe them to cross-feed with the other towers.
3. Locate the cooling tower so that spray or plume, which can be a source of Legionella, cannot enter outdoor air intakes.
4. Consult the tower manufacturer for the octave band sound power ratings of the tower and for assistance in sound evaluations. An analysis of the proposed cooling tower relative to adjacent occupancies must be made considering noise, fan horsepower, and the cost of alternative cooling tower selections. The 60 dBA requirement at 120 feet in Section 00700: General Design Conditions, may be changed for particular projects (lower for critical locations, which may also require attenuation, and higher for non-critical locations).
5. Verify that the tower is located such that condenser pumps have sufficient net positive suction head (NPSH).

6. Provide water treatment for cooling towers, and show the location of the equipment on the drawings.
7. Treatment chemicals may be put into the return piping if the feed pump is interlocked with cooling water flow.
8. Cooling towers for systems that are not to be drained in winter must be winterized for automatic winter operation.
9. If a cooling tower by-pass is provided, the by-pass must discharge to the cooling tower basin(s) rather than to the outlet piping.
10. Provide for hoist beams overhead so that the condenser and chiller heads can be removed.
11. Piping to refrigeration equipment must be supported independently. Piping to chillers must include offsets and mechanical couplings or flanges to permit removal of heads and tubes.

C. Product Certificates Signed by Manufacturer

Specify that cooling towers be inspected by the manufacturer's authorized representative who shall submit a written report to the engineer with copy to Yale University stating that the cooling towers have been properly installed, are operating correctly, and the installation is acceptable to the manufacturer in every respect.

D. Manufacturers

- Marley
- Baltimore Air Coil

E. Materials

Use stainless steel drain pans for long service life and to help in restricting microbial growth.

F. Installation Guidelines

1. Install davits, beams, or other means for assisting in the removal and replacement of tower motors larger than 15 hp.
2. For multiple tower installations, provide for equalizing pipe, and provide balancing valves in the supply and return piping.
3. Valve each tower separately for servicing.
4. Provide for sufficient free and unobstructed space around the tower per manufacturer recommendations to ensure adequate air supply.
5. Do not locate towers downstream of boiler stacks or upstream and near to outdoor air intakes.
6. Install tower piping to allow for expansion and contraction flexibility between the tower and piping.
7. The cooling tower must be located to avoid problems with noise, vibration, air recirculation or drift.
8. Provide security and maintenance lights and receptacles for maintenance at the cooling tower. When access to the tower is greater than 7 feet above grade, provide structural ladder and platform to enable access to the access doors in the cooling tower sidewalls.
9. At stations where cottonwood or similar types of trees are likely to interfere with cooling tower operation, provide easily-cleaned screens or roughing filters at the air inlets.
10. Consider how several drums of chemicals with spares might be moved to and from the point of use

G. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.

End of Section

15672
Air-Cooled Condensers

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A. Summary
B. System Design and Performance Requirements
C. Installation Guidelines
D. Quality Control

A. Summary

This section contains design criteria for air-cooled condensers and condensing units.

B. System Design and Performance Requirements

1. Units must consist of coils with integral sub-cooling, and casings with stands.
2. Coil must be aluminum plate fins on mechanically-expanded copper tubes. Coils must be cleaned, dehydrated, sealed, leak tested at 150 psig, and pressure tested at 420 psig.
3. Fans must be direct-drive, propeller fans protected with guards.
4. Condensers must have two, 3-phase motors and one permanent split capacitor motor for use with accessory speed controls suitable for reduced-voltage starting. Motors must be pre-lubricated, with built-in overload protection.
5. Fan shafts must be corrosion-protected. Fan blades must have an irradiate or aluminum finish. Magnetic contactors must be field-supplied. Provide magnetic contractors in accessory fan cycling control packages to cycle fans in response to the outdoor ambient temperature.
6. Casings must have baked enamel finishes. Provide access panels for electrical connections.
7. Provide openings for power and refrigerant connections.

C. Installation Guidelines

1. Locate the condenser or condensing unit away from side and overhead restrictions. Maintain at least a one-half length or full-width distance from side restrictions, or as directed by the manufacturer. Overhead clearance should not restrict the full discharge of hot air.
2. Do not locate the discharge near outdoor air intakes.
3. Mount air-cooled condensers on grade on a concrete pad that is 6" larger all around than the condenser. The bottom of the pad should be carried below the frost line.
4. When mounted on the roof, a steel framework should be erected. Install vibration pads between the structural framework and the condenser supports.
5. Do not install the condenser or condensing unit in locations where the coils can become plugged, such as near cottonwood trees or in locations where construction is to take place in the near future. When not possible, provide easily-cleaned screens or roughing filters at the air inlets.

D. Quality Control

If this portion of the project includes commissioning, verify that insertions in the project specifications have been made that refer to the commissioning procedures in the commissioning specification section. Verify that the systems and equipment identified in this section of the standards, and listed in the project specifications, do not conflict with commissioning procedures for testing and training.

End of Section