

SECTION 236000 – CENTRAL COOLING EQUIPMENT

- 1.0 ASHRAE 90.1 Compliance: University of Pennsylvania buildings shall comply with the Commercial Energy Efficiency Requirements of ASHRAE Standard 90.1-2016. The ASHRAE 90.1-2016 compliance paths shall be followed instead of the International Energy Conservation Code (IECC) requirements as permitted by 2018 IECC Section 401.2 Application.
- 2.0 This Section pertains to:
 - A. Local building chillers to maintain cooling capacity during a site chilled water plant shutdown, process chillers or chillers that supplement the site chilled water capacity at the building.
 - B. Central Utility Plant Chillers.
- 3.0 The use of refrigerant R-134A is preferred. The use of refrigerant R-407C or R-410 is limited to local air-cooled or water-cooled chiller systems up to 300 tons. The use of equipment utilizing low-pressure refrigerants is prohibited due to the additional maintenance associated with those machines.
- 4.0 The design of all refrigeration equipment must include an analysis addressing the noise impact upon surrounding areas and the aesthetic impact if located on the exterior of the building. Refer to Section 230000 for noise criteria that apply to mechanical equipment rooms. On a project by project basis, exterior installations of air cooled equipment shall be evaluated against local site noise level goals and criteria. Refer to Part I, General Section XI.
- 5.0 Spaces which require cooling during chiller plant shut-down periods, and use individual units for such, must be designed to interface and utilize the central chilled water source as a primary source of cooling. An automatic changeover system shall be designed to energize the local system during central plant shut-downs via the site monitoring and control system. This requirement shall be followed independent of central chilled water availability unless prior approval for deviation from this standard has been granted by the University Representative.
- 6.0 Prior to the selection of compressor unit, i.e., reciprocating, centrifugal, screw or scroll, the Engineer of Record must submit an analysis of the various compressor types, conclusions and recommendations to the University's Representative for approval. The analysis shall address operating efficiency, costs associated with noise control implementations, minimizing maintenance costs associated with the training of staff and stocking of parts, maintenance, service, availability from manufacturer, refrigerant type, part load performance, electrical characteristics, and estimated installation cost.
- 7.0 All chillers above 300 tons shall be of the centrifugal or screw type.
- 8.0 Compressors may be of the high-speed open drive or hermetic type. Magnetic bearing oilless compressors will be considered.
- 9.0 ASHRAE 90.1-2016 Compliance Requirements:
 - A. The Minimum Efficiency Requirements for water chiller packages, when rated at AHRI 550/590 standard test conditions of 44°F leaving and 54.00°F entering chilled fluid temperatures, and with 85.00°F entering and 94.30°F leaving condenser-fluid temperatures shall be as indicated in the following table 6.8.1-3 from ASHRAE 90.1-2016:

Table 6.8.1-3 Water-Chilling Packages—Minimum Efficiency Requirements^{a,b,e}

Equipment Type	Size Category	Units	Path A	Path B	Test Procedure ^c
Air-cooled chillers	<150 tons	EER (Btu/Wh)	≥10.100 FL	≥9.700 FL	AHRI 550/590
			≥13.700 IPLV.IP	≥15.800 IPLV.IP	
	≥150 tons		≥10.100 FL	≥9.700 FL	
	≥14.000 IPLV.IP		≥16.100 IPLV.IP		
Air-cooled without condenser, electrically operated	All capacities	EER (Btu/Wh)	Air-cooled chillers without condenser must be rated with matching condensers and comply with air-cooled chiller efficiency requirements		AHRI 550/590
Water-cooled, electrically operated positive displacement	<75 tons	kW/ton	≤0.750 FL	≤0.780 FL	AHRI 550/590
	≥75 tons and <150 tons		≤0.600 IPLV.IP	≤0.500 IPLV.IP	
			≤0.720 FL	≤0.750 FL	
	≥150 tons and <300 tons		≤0.560 IPLV.IP	≤0.490 IPLV.IP	
			≤0.660 FL	≤0.680 FL	
	≥300 tons and <600 tons		≤0.540 IPLV.IP	≤0.440 IPLV.IP	
≥600 tons	≤0.610 FL	≤0.625 FL			
Water cooled, electrically operated centrifugal	<150 tons	kW/ton	≤0.610 FL	≤0.695 FL	AHRI 550/590
			≤0.550 IPLV.IP	≤0.440 IPLV.IP	
	≥150 tons and <300 tons		≤0.610 FL	≤0.635 FL	
	≥300 tons and <400 tons		≤0.550 IPLV.IP	≤0.400 IPLV.IP	
			≤0.560 FL	≤0.595 FL	
	≥400 tons and <600 tons		≤0.520 IPLV.IP	≤0.390 IPLV.IP	
			≤0.560 FL	≤0.585 FL	
	≥600 tons		≤0.500 IPLV.IP	≤0.380 IPLV.IP	
			≤0.560 FL	≤0.585 FL	
	≤0.500 IPLV.IP		≤0.380 IPLV.IP		
Air-cooled absorption, single effect	All capacities	COP (W/W)	≥0.600 FL	NA ^d	AHRI 560
Water-cooled absorption, single effect	All capacities	COP (W/W)	≥0.700 FL	NA ^d	AHRI 560
Absorption double effect, indirect fired	All capacities	COP (W/W)	≥1.000 FL	NA ^d	AHRI 560
			≥1.050 IPLV.IP		
Absorption double effect, direct fired	All capacities	COP (W/W)	≥1.000 FL	NA ^d	AHRI 560
			≥1.000 IPLV		

a. The requirements for centrifugal chillers shall be adjusted for nonstandard rating conditions per Section 6.4.1.2.1 and are only applicable for the range of conditions listed there. The requirements for air-cooled, water-cooled positive displacement and absorption chillers are at standard rating conditions defined in the reference test procedure.

b. Both the full-load and IPLV.IP requirements must be met or exceeded to comply with this standard. When there is a Path B, compliance can be with either Path A or Path B for any application.

c. Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

d. NA means the requirements are not applicable for Path B, and only Path A can be used for compliance.

e. FL is the full-load performance requirements, and IPLV.IP is for the part-load performance requirements.

- B. Equipment not designed for operation at AHRI 550/590 standard test conditions of 44°F leaving and 54.00°F entering chilled fluid temperatures, with 85.00°F entering and 94.30°F leaving condenser-fluid temperatures shall have maximum full-load kW/ton (FL) and part-load rating requirements adjusted using the calculation method provided in Section 6.4.1.2.1 of ASHRAE 90.1-2016.
 - C. Chilled Water Plant Monitoring shall be provided in accordance with Section 6.4.3.11.1 of ASHRAE 90.1-2016.
- 10.0 Drawings shall indicate routing of refrigerant relief piping. Relief piping shall be sized per ASHRAE Standard 15. Each chiller location (single chiller installation or multiple chillers in one location) shall be designed with a refrigerant recovery system.
- 11.0 Consideration should be given to the use of speed controls on chillers to improve part load performance or enhance the life of the equipment. Variable speed controls shall be required for chillers above 300 tons.
- 12.0 The A/E will analyze various water-cooled chiller selections based upon energy efficiency and cost, and consider single pass units to reduce condenser and chilled water pumping system costs (operating and first cost). Units should be analyzed based upon 100% cooling tower(s) operation to minimize tower supply water temperatures. A/E shall prepare annual operating level table that bidding manufacturers can complete with actual part-load energy usage data to aid in the selection of chiller equipment for all chillers greater than 300 tons. Table will have (3) columns: Load level; hours during year at that load; and energy usage at that load (to be completed by manufacturer).
- 13.0 All water cooled chillers must be capable of operation with 55°F entering condenser water temperature, at full and all part load conditions, without the use of flow control or by-pass flow. Marine boxes shall be specified on water cooled condensers.
- 14.0 PLC based controls shall be furnished for chillers with a capacity of 300 tons or greater. The controls shall include a communication interface to communicate directly with the Operations and Control Center (OCC). Sequences for activation of supplemental or back-up chilled water systems shall be reviewed closely with the University Representative.
- 15.0 Chillers up to 500 tons capacity shall be furnished with 480 volt motors. Chillers greater than 500 tons capacity shall be furnished with 4,160 volt motors.
- 16.0 Chiller Warranty:
- A. Specify written warranty period of two (2) years (one year standard plus one year additional). The warrantee shall provide unconditional service for parts, labor, refrigerant and materials to assure that each chiller will perform to the requirements of this specification.
 - B. The warranty period shall commence following University's acceptance of the chiller field performance test and at the completion of the commissioning efforts.
 - C. Specify that at no cost to the University, all refrigerant and lubrication oil lost from each system will be replaced during the warranty period.
- 17.0 Specify chillers with factory-applied anti-sweat insulation of the flexible, closed-cell elastomer type, 3/4 inch thick, attached with vaporproof cement to the cooler shell, flow chamber, tubesheets, suction connection and as necessary to the auxiliary tubing, and all other surfaces subject to sweating. The insulation of the water boxes will be furnished and field installed by the Mechanical

Contractor in accordance with the requirements of Section 230700.

- 18.0 All refrigeration system specifications must be specified to include manufacturer's start-up and servicing. The factory start-up shall include the check-out of all controls, safety components and performance characteristics. The University Representative shall actively observe the testing and start-up of the systems. The manufacturer is to submit the start-up report to the University Engineering Department. Start-up report shall include how much refrigerant is installed in the chiller.
- 19.0 When drafting the specifications, the A/E shall consider the requirement for factory and/or field testing of chillers with respect to the application.
- A. Components of factory testing to be considered are:
1. Factory Leak Test.
 2. Insulation Resistance Test.
 3. Chiller Performance Test.
 4. Chiller Functional Test.
 5. Eddy current Test (Provide report for baseline data).
- B. Components of field testing and commissioning to be considered are:
1. Capacity Testing.
 2. Interface to the Site Monitoring and Control System.
 3. Sequence of Operation.
 4. Instrumentation including Safety Controls.
- C. If the chillers fail the Field Performance Test, the chiller manufacturer will have ten (10) working days to correct any deficiencies and retest the chillers. Should the chillers still be unable to pass the field performance test after this period of time, the chiller manufacturer shall remove the chiller or chillers and replace them with chillers that do meet the specified performance in all aspects. Such replacement shall be at no cost to the Owner or Mechanical Contractor, and all costs of labor, material, freight, rigging, repiping, reconnecting and retesting plus any structural changes for access shall be borne by the chiller manufacturer.
- 20.0 All refrigerant compressors and chilled water tube bundles must be installed within a mechanical room. Packaged air cooled chillers are not acceptable unless a glycol based system is utilized. All glycol applications must be approved by the University's Representative.
- 21.0 Small individual packaged split systems are inevitable but must be kept to an absolute minimum. Prior approval for the use of such must be obtained from the University's Representative.
- 22.0 All air-cooled condensers must contain condenser fan modulation and staging controls based on compressor discharge pressure as a means of capacity control for low ambient operation. Condenser fan dampers are prohibited.
- 23.0 All critical process equipment cooling, including computer systems, should be designed with a separate back-up cooling source independent of the central utility system.
- 24.0 All communication room cooling and other backup or process cooling systems shall be provided with an independent source of cooling operating on standby power.
- 25.0 For local winter cooling applications a waterside economizer system is preferred, where possible, to avoid the addition of chilled water generation or direct expansion equipment.

- 26.0 The University is responsible to maintain an inventory of refrigerants. As part of the project specifications, the A/E shall require the installing contractor to provide data to the University on the type and quantity of refrigerant utilized for each piece of equipment on the project. The University will provide project closeout data required.