23 64 00 PACKAGED WATER CHILLERS

Delete the following current section in its entirety (deletions are shown struck through).

23 64 00 PACKAGED WATER CHILLERS

~~**.01 Water Chillers (General)**~~

~~A. Discuss chiller selection at conceptual design stage with the University.~~
~~B. Where the cooling load exceeds one hundred tons, consider the feasibility of installing centrifugal chillers.~~
~~C. Basis of design shall include models from a minimum of two reputable manufacturers. Specify maximum acceptable sound levels.~~
~~D. Allow sufficient clear space equal to length and width of machine for tube pull clearance.~~
~~E. Discuss refrigerant selection with the University prior to equipment selection. Chillers using chlorofluorocarbons (CFCs) as a refrigerant are not acceptable.~~
~~F. Provide beam with minimum 4' clearance above chiller or allow sufficient clear space above and around machine for utilizing gantry for compressor replacement.~~
~~G. Refer to 23 05 01.01 for motor inrush current and voltage drop requirements.~~
~~H. Mechanical rooms containing chillers shall be designed to meet the requirements of ASHRAE Standard 15.~~
~~I. Refer to Detail [23 xx xx .xx] for piping. Details are not yet available in WEB-based manual.~~

Replace with following text.

23 64 00 PACKAGED WATER CHILLERS

.01 General Owner Requirements and Design Intent

A. General: Professional shall design each chiller application for optimal operating efficiency, reliability, and flexibility with the lowest life cycle cost. Coordinate and review chillers and chilled water systems with OPP Engineering Services, Chilled Water Services Supervisor (for projects at University Park), Maintenance Superviser at Commonwealth Campuses, and Building Automation System (BAS) Application Engineering Groups.

B. Related Standards Sections: General requirements related to chiller work, include, but are not necessarily limited to, the following:
   1. 23 00 01 Owner General Requirements and Design Intent
   2. 23 05 01.06 Mechanical Identification: Coordinate mechanical identification nomenclature with University Standards.

C. Chiller System Considerations:

Formatted: No bullets or numbering
Formatted
Formatted: Font: (Default) Arial
Formatted: Normal, Indent: Left: 0.25", No bullets or numbering
Formatted: Font: (Default) Arial
Formatted: Normal, Indent: Left: 0.25", No bullets or numbering
Formatted: Font: (Default) Arial
Formatted: Left, Outline numbered + Level: 1 + Numbering Style: A, B, C, ... + Start at: 1 + Alignment: Left + Aligned at: 0.25" + Tab after: 0.5" + Indent at: 0.5"
Formatted: Normal, Indent: Left: 0.75", No bullets or numbering

1. Chiller Selection:
    a. Refer to ASHRAE Systems and Equipment Handbook, Liquid Chilling Systems
    b. Discuss chiller selection at conceptual design stage with the University.
    c. Evaluate centrifugal chillers within commonly available capacity ranges and use whenever that alternative is the lowest life cycle cost for the application.
    d. Carefully evaluate operational full and part load profile and system turndown requirements.
    e. Consider modular, multiple unit configurations where effective and practical for proper low part load operation and to help prevent complete system or building shutdown upon failure of a single chiller. Any applications with a single chiller shall have a minimum of 2 refrigeration circuits to provide redundancy. Single chiller applications with single refrigerant circuit are not acceptable.
    f. Use energy-efficient modulating compressor control technologies that unload input power proportionally to match load. Refer to .02 Product Requirements below.
    g. Try to avoid requiring a central chiller and pump system to operate to serve a relatively small continuous internal load during unoccupied periods or when the chiller system could otherwise be off. But if absolutely unavoidable, be sure chiller has energy-efficient capacity reduction control so it does not excessively cycle during those periods.
    h. Wherever practical, apply water side economizer cooling to supply continuous cooling loads in winter. Options include:
        i. Cooling tower water to chilled water heat exchangers for water cooled chillers
        ii. Integral dry fluid cooler coil in condenser section with associated controls for new packaged air cooled chillers.
        iii. Separate packaged dry fluid coolers for modifications to existing air cooled chiller systems.
    i. Determine any requirements for low ambient operation and specify control options accordingly.
    j. Design for low flow, high temperature differences and variable flow distribution systems to minimize pump energy.
        i. Maintain average overall system water temperature rise of at least12°F.
        ii. Selection of cooling coils in typical HVAC applications is recommended with a 14-16°F rise at peak conditions.
    k. Allow for distribution system heat gains (conduction through pipe insulation, pump heat) in determining the required chiller capacity.
    l. Select chillers for altitude in which installed to achieve minimum performance indicated. Make adjustments to affected chiller components to account for site altitude.
    m. Consider combination chiller-heaters where they can be applied for net energy cost savings to satisfy simultaneous needs for chilled water and hot water.
        i. Options might include:

Formatted: Outline numbered + Level: 2 + Numbering Style: 1, 2, 3, … + Start at: 1 + Alignment: Left + Aligned at: 0.75" + Tab after: 1" + Indent at: 1"

Formatted

Formatted: Outline numbered + Level: 3 + Numbering Style: a, b, c, … + Start at: 1 + Alignment: Left + Aligned at: 1.25" + Tab after: 1.5" + Indent at: 1.5"

Formatted: Font: 11 pt

Formatted: Font: 11 pt

Formatted: Outline numbered + Level: 3 + Numbering Style: a, b, c, … + Start at: 1 + Alignment: Left + Aligned at: 1.25" + Tab after: 1.5" + Indent at: 1.5"

Formatted

Formatted

Formatted

Formatted: Space After: 0 pt

Formatted: Font: (Default) Arial

Formatted: Space After: 0 pt

a) Water to water heat pumps
b) Dedicated Heat Recovery Chillers
c) Air to Water Heat Pump

ii. Resources:

a) ASHRAE Systems and Equipment Volume, Applied Heat Pump and Heat Recovery Systems
b) "Dedicated Heat Recovery", ASHRAE Journal article, October 2003.
c) Manufacturer's Literature: http://www.multistack.com/products/chiller_heaters.aspx

2. Distribution Systems:

a. Provide minimum system fluid volume in circulation to provide sufficient thermal mass in system as required to avoid excessive cycling of compressors, poor temperature control, and/or erratic system operation.
   i. Chiller systems require adequate time to recognize a load change, respond to the change and stabilize to avoid undesirable short cycling of the compressors or loss of temperature control. In air conditioning systems, the potential for short cycling usually exists when the building load falls below the minimum chiller plant capacity or on close-coupled systems with very small water volumes.
   ii. To determine the minimum system fluid volume in circulation, the designer shall consider the type of application, the allowable system temperature control swing, the minimum cooling load, the minimum chiller plant capacity during the low load period and the desired cycle time for the compressors. Consult with chiller manufacturers and comply with their application recommendations.
   iii. Volume calculations for fluid volume in circulation shall exclude any dead leg piping and equipment beyond any control valves.
   iv. A "buffer" tank specifically designed for this application may have to be added to the system to reach the recommended system volume. Refer to Product Requirements and Execution for additional details.

b. Typically design chilled water and condenser water systems to pump into the chiller. Review exceptions with OPP.
   i. Exception: On hi-rise applications in which the static pressure is great, installing the primary pump on the outlet of the chiller might be advantageous to reduce the total pressure on the evaporator.

c. Ensure chillers are circuited and piping system is arranged to achieve maximum efficiency.
   i. Ensure the manufacturer's required water flow through evaporator is maintained.
   ii. Connect piping so that all return water and any water from a bypass are thoroughly mixed before any of the water enters a chiller. After the tee, there should be at least 10 pipe diameters to

Formatted: Space After: 0 pt
Formatted: Space After: 0 pt
Formatted: Space After: 0 pt
Formatted: Font: (Default) Arial
Formatted: Normal, Indent: Left: 0.75", No bullets or numbering
Formatted: Outline numbered + Level: 2 + Numbering Style: 1, 2, 3, … + Start at: 1 + Alignment: Left + Aligned at: 0.75" + Tab after: 1" + Indent at: 1"
Formatted: Outline numbered + Level: 3 + Numbering Style: a, b, c, … + Start at: 1 + Alignment: Left + Aligned at: 1.25" + Tab after: 1.5" + Indent at: 1.5"
Formatted: Not Highlight
Formatted: Outline numbered + Level: 4 + Numbering Style: i, ii, iii, … + Start at: 1 + Alignment: Left + Aligned at: 1.75" + Tab after: 2" + Indent at: 2", Don't adjust space between Latin and Asian text, Don't adjust space between Asian text and numbers
Formatted: Font: (Default) Arial, 11 pt
Formatted: Font: (Default) Arial, 11 pt
Formatted: Underline
Formatted: Font: (Default) Arial, 11 pt
Formatted: Font: (Default) Arial, 11 pt
Formatted: Font: (Default) Arial, 11 pt
Formatted: Normal, Left, No bullets or numbering, Don't adjust space between Latin and Asian text, Don't adjust space between Asian text and numbers
Formatted
Formatted
Formatted
Formatted

the nearest chiller. This is to help avoid the possibility of having stratification in the primary return line, which can lead to unmixed water to the nearest chiller. This can lead to chiller cycling.

iii. Arrange piping such that all chillers obtain equal return water temperature.

a) Exception: in systems where "backloading" or "preferential" loading of chillers is advantageous by design to maximize the operating performance of different types of chillers.

iv. For primary-secondary systems, the system must be piped and controlled so that water never flows in the reverse direction in the decoupler bypass during normal operation.

a) The supply tee connecting the building supply distribution loop to the chiller loop shall be arranged such that the secondary loop is the side branch and the bypass is the straight through direction. This directs the primary loop water's energy into the decoupler bypass and requires the secondary loop to pull the water out of the tee.

b) The return tee connecting the secondary return loop to the primary chiller return shall be arranged such that the bypass is the side branch and the secondary return to the primary chiller return loop is the straight through direction.

c) The secondary loop return must not be connected too closely to the supply pipe with a bullhead tee in which the velocity head rams into the decoupler bypass which can encourage migration.

d) Although in theory there should be no pressure drop in the decoupler, in order to avoid thermal contamination in actual systems the decoupler should be at least 10 pipe diameters in length (per 2008 ASHRAE Systems Handbook, p. 12.22). Longer decouplers tend to increase the pressure drop.

e) Size decouplers for the flow rate of the largest primary pump. This may be more than the design flow rate of the largest chiller if overpumping is being considered. The pressure drop should not exceed 1.5 ft. As the pressure drop through the decoupler increases, it tends to make the primary and secondary pumps behave like they are in series.

3. Controls:

a. Include reliable safety flow proving switches to protect chiller.

b. Include accurate and reliable flow meter(s) to monitor system GPM flow through BAS and to ensure minimum flow is maintained through chiller evaporators whenever operating chiller(s) in variable primary flow applications.

c. Apply energy saving control strategies, including:

i. Enable chiller on actual cooling requests rather than just outside air temperature.

ii. Chilled water temperature reset optimization. Control to minimize combined chiller and pump energy that always just satisfies the

Formatted

Formatted

Formatted

Formatted: Don't adjust space between Latin and Asian text, Don't adjust space between Asian text and numbers

Formatted

Formatted: Not Highlight

Formatted: Font: (Default) Arial, 11 pt

Formatted: Don't adjust space between Latin and Asian text, Don't adjust space between Asian text and numbers

Formatted: Font: (Default) Arial

Formatted: Outline numbered + Level: 2 + Numbering Style: 1, 2, 3, … + Start at: 1 + Alignment: Left + Aligned at: 0.75" + Tab after: 1" + Indent at: 1"

Formatted: Outline numbered + Level: 3 + Numbering Style: a, b, c, … + Start at: 1 + Alignment: Left + Aligned at: 1.25" + Tab after: 1.5" + Indent at: 1.5"

Formatted

control zone cooling and dehumidification demands. Optimization shall be based on the following:

a) Zone cooling/dehumidification requests
b) Pump Speed
c) Chiller efficiency operating curve
d) Maintaining minimum flow requirements through chiller
e) Limiting temperature reset range to a lower upper limit when OA enthalpy is higher to ensure better dehumidification is available when needed.

iii. Condenser water temperature reset based on constant approach with respect to ambient wet bulb.

d. Controls must not be placed in public areas.

4. Sound and Vibration Control: Comply with requirements Section 23 05 01 Mechanical General Requirements, .04 Sound and Vibration Control

a. Refer to ASHRAE Applications, Sound and Vibration Control and comply with guidelines and recommendations therein.
b. Chiller systems produce significant and often objectionable amounts of sound power levels as both average noise level overall and as strong peaks within certain octave bands. These specific characteristics are dependent on the chiller type and must be accounted for in the overall application and design.
c. Historically screw type chillers have been the source of many noise complaints. Therefore they require extra careful attention regarding their relative location with respect to noise sensitive areas and subsequent noise and vibration control design.
d. Coordinate with Architect to locate chillers away from noise sensitive areas and to provide adequate general construction sound barrier assemblies as needed.
e. Minimize objectionable noise to nearby buildings or sensitive neighboring areas.
f. Include sound performance criteria in equipment schedules.

5. Coordination for indoor chillers:
a. Mechanical rooms containing refrigeration machinery shall be designed to meet the requirements of Chapter 11, Refrigeration of the International Mechanical Code and ASHRAE Standard 15.
b. Indicate location on drawings of all required refrigeration machine room safety equipment (refrigerant leak detection, self-contained breathing apparatus, emergency exhaust systems, refrigerant relief piping, etc.) as required by building code.
c. Locate refrigerant pumpdown, pumpout and storage devices if they are required for application.
d. Mechanical room locations and placement must take into account how equipment and largest replacement parts can be moved into and out of the building during installation and future major repair/replacement.
e. Make sure that all clearances are maintained, including:
i. Minimum as required by manufacturer.

Formatted: Font: (Default) Arial

Formatted

Formatted: Font: (Default) Arial

Formatted

Formatted: List Paragraph

Formatted: Font: (Default) Arial

Formatted: Normal, Indent: Left: 0.75", No bullets or numbering

Formatted: Outline numbered + Level: 2 + Numbering Style: 1, 2, 3, … + Start at: 1 + Alignment: Left + Aligned at: 0.75" + Tab after: 1" + Indent at: 1"

Formatted: Outline numbered + Level: 3 + Numbering Style: a, b, c, … + Start at: 1 + Alignment: Left + Aligned at: 1.25" + Tab after: 1.5" + Indent at: 1.5"

Formatted: Outline numbered + Level: 2 + Numbering Style: 1, 2, 3, … + Start at: 1 + Alignment: Left + Aligned at: 0.75" + Tab after: 1" + Indent at: 1"

Formatted: Outline numbered + Level: 3 + Numbering Style: a, b, c, … + Start at: 1 + Alignment: Left + Aligned at: 1.25" + Tab after: 1.5" + Indent at: 1.5"

Formatted: Outline numbered + Level: 4 + Numbering Style: i, ii, iii, … + Start at: 1 + Alignment: Left + Aligned at: 1.75" + Tab after: 2" + Indent at: 2"

ii. Allow at least three feet between all service sides of equipment and obstructions.
iii. Allow sufficient clear space equal to length and width of machine for tube pull clearance. Show tube pull clearances and locations on drawings.
iv. Maintain minimum electrical clearances required by NEC.

f. Coordinate height of chiller with overhead obstructions. Provide beam with minimum 4' clearance above chiller or allow sufficient clear space above and around machine for utilizing gantry for compressor replacement.

D. Quality Assurance and Uniformity:

1. ARI Compliance: Rate and certify chiller performance according to requirements in ARI.
2. ASHRAE Compliance:
   a. ASHRAE 15 for safety code for mechanical refrigeration.
   b. ASHRAE 147 for refrigerant leaks, recovery, and handling and storage requirements.
   c. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1 or ASHRAE 189.1 as required in 01 80 00 PERFORMANCE REQUIREMENTS
3. ASME Compliance: Fabricate and label chiller to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, and include an ASME U-stamp and nameplate certifying compliance.
4. Comply with NFPA 70.
5. Comply with requirements of UL and include label by a qualified testing agency showing compliance.
6. Equipment manufacturer shall be ISO-9001 certified.
7. Equipment shall be of U.S. manufacturer.
8. Provide equipment of same type by same manufacturer.
9. Perform functional run tests of chillers before shipping. (Note: Not all manufacturers "run test" chillers. Consult manufacturers for availability.)

E. Submittals: Documents shall require the following:

1. Product Data: Submit manufacturer's technical product data for chillers, including:
   a. Selection characteristics and rated capacities.
   b. Performance curves with system operating conditions indicated.
   c. Sound pressure levels per ARI Standard 575 for indoor chillers and ARI Standard 370 for outdoor chillers.
   d. General specifications: type description, material of construction, thicknesses and finishes,
   e. Motor type, ratings and electrical characteristics
   f. Accessories furnished
2. Shop Drawings: Include the following:
   a. Plans, elevations, sections, and attachment details.
   b. Details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

Formatted: Outline numbered + Level: 3 + Numbering Style: a, b, c, ... + Start at: 1 + Alignment: Left + Aligned at: 1.25" + Tab after: 1.5" + Indent at: 1.5"

Formatted: Font: (Default) Arial

Formatted: Normal, Indent: Left: 0.25", No bullets or numbering

Formatted: Outline numbered + Level: 1 + Numbering Style: A, B, C, ... + Start at: 1 + Alignment: Left + Aligned at: 0.25" + Tab after: 0.5" + Indent at: 0.5"

Formatted: Outline numbered + Level: 2 + Numbering Style: 1, 2, 3, ... + Start at: 1 + Alignment: Left + Aligned at: 0.75" + Tab after: 1" + Indent at: 1"

Formatted: Font: (Default) Arial

Formatted: Font: (Default) Arial

Formatted: Outline numbered + Level: 3 + Numbering Style: a, b, c, ... + Start at: 1 + Alignment: Left + Aligned at: 1.25" + Tab after: 1.5" + Indent at: 1.5"

Formatted: Font: (Default) Arial

Formatted: Outline numbered + Level: 2 + Numbering Style: 1, 2, 3, ... + Start at: 1 + Alignment: Left + Aligned at: 0.75" + Tab after: 1" + Indent at: 1"

Formatted: Font: (Default) Arial

Formatted: Font: (Default) Arial

Formatted: Font: Not Bold

Formatted: Font:

Formatted: Indent: Left: 0.25", No bullets or numbering

Formatted: Outline numbered + Level: 1 + Numbering Style: A, B, C, ... + Start at: 1 + Alignment: Left + Aligned at: 0.25" + Tab after: 0.5" + Indent at: 0.5"

Formatted: Outline numbered + Level: 2 + Numbering Style: 1, 2, 3, ... + Start at: 1 + Alignment: Left + Aligned at: 0.75" + Tab after: 1" + Indent at: 1"

Formatted: Outline numbered + Level: 3 + Numbering Style: a, b, c, ... + Start at: 1 + Alignment: Left + Aligned at: 1.25" + Tab after: 1.5" + Indent at: 1.5"

Formatted: Outline numbered + Level: 2 + Numbering Style: 1, 2, 3, ... + Start at: 1 + Alignment: Left + Aligned at: 0.75" + Tab after: 1" + Indent at: 1"

Formatted: Outline numbered + Level: 3 + Numbering Style: a, b, c, ... + Start at: 1 + Alignment: Left + Aligned at: 1.25" + Tab after: 1.5" + Indent at: 1.5"

c. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

3. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to chiller units. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
4. Coordination Drawings: As required to meet project complexity, show chiller room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.
5. Maintenance Data: Submit operation and maintenance instructions, including lubrication instructions, motor and drive replacement, and spare parts lists. Include this data, product data, shop drawings, and wiring diagrams in maintenance manuals; in accordance with requirements of Section 23 01 00 OPERATION AND MAINTENANCE OF HVAC SYSTEMS.
6. Manufacturer's functional run test report.
7. Field quality-control reports.

F. Warranty

1. Standard Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of chillers that fail in materials or workmanship within specified warranty period of minimum of 2 years from date of Substantial Completion.
2. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of chillers that fail in materials or workmanship within specified warranty period. Extended warranties include, but are not limited to, the following:
   a. Complete chiller including refrigerant and oil charge. Warranty Period: minimum of 2 years from date of Substantial Completion.
   b. Complete compressor and drive assembly including refrigerant and oil charge. Extended Warranty Period: minimum of 5 years from date of Substantial Completion.

.02 Product Requirements

A. General:

1. Discuss refrigerant selection with the University prior to equipment selection.
   a. Select with respect to current EPA regulations regarding phaseout of Ozone-Depleting Substances. http://www.epa.gov/ozone/title6/phaseout/index.html
   b. At University Park, chillers for central plants shall match existing refrigerant (R-134a).
   c. In general, OPP prefers not to use R-123, but may consider for special applications.
2. Statically and dynamically balance rotating parts.
3. Serviceability: All components shall be easily accessible for inspection and service.

B. Basis of design shall include models from a minimum of two reputable manufacturers.

Formatted: Outline numbered + Level: 2 + Numbering Style: 1, 2, 3, … + Start at: 1 + Alignment: Left + Aligned at: 0.75" + Tab after: 1" + Indent at: 1"

Formatted: Font: (Default) Arial

Formatted: Font: (Default) Arial

Formatted: Indent: Left: 0.25", No bullets or numbering

Formatted: Outline numbered + Level: 1 + Numbering Style: A, B, C, … + Start at: 1 + Alignment: Left + Aligned at: 0.25" + Tab after: 0.5" + Indent at: 0.5"

Formatted: Font: (Default) Arial

Formatted: Outline numbered + Level: 2 + Numbering Style: 1, 2, 3, … + Start at: 1 + Alignment: Left + Aligned at: 0.75" + Tab after: 1" + Indent at: 1"

Formatted: Font: (Default) Arial

Formatted: Outline numbered + Level: 3 + Numbering Style: a, b, c, … + Start at: 1 + Alignment: Left + Aligned at: 1.25" + Tab after: 1.5" + Indent at: 1.5"

Formatted: Font: (Default) Arial

Formatted: Font: (Default) Arial

Formatted: Normal, No bullets or numbering

Formatted: Font: 11 pt

Formatted: Not Highlight

Formatted: Outline numbered + Level: 1 + Numbering Style: A, B, C, … + Start at: 1 + Alignment: Left + Aligned at: 0.25" + Tab after: 0.5" + Indent at: 0.5"

Formatted

Formatted: Font: 11 pt

Formatted

Formatted: PR2, Outline numbered + Level: 1 + Numbering Style: A, B, C, … + Start at: 1 + Alignment: Left + Aligned at: 0.25" + Tab after: 0.5" + Indent at: 0.5"

C. Capacity Control: Chillers shall be configured to achieve most energy-efficient, reliable, and stable operation throughout expected service conditions. Options shall include combination of:

1. Multiple refrigerant circuits
2. Multiple compressors
3. Modulating, power unloading compressor technologies such as variable speed drives or time averaged pulsed loading and unloading with digital scroll type compressors in lieu of energy-wasteful hot gas bypass.
    a. Digital (Pulse Width Modulation) Scroll Compressors: http://www.digitalscroll.com/sb300/portal/home/normal/1
    b. VFD Driven Compressors:
        i. Scroll: http://www.danfoss.com/NR/rdonlyres/ED489694-517C-4A3D-BE71-0586F73B20A3/0/Apexx_Brochure.pdf
        ii. Screw
        iii. Centrifugal
4. If hot-gas bypass is only available option, use only on smallest stage(s). Review with OPP Engineering Services.

D. Compressors:

1. Shall be factory mounted, aligned, and balanced as part of compressor assembly before shipping.
2. Vibration Balance: Balance chiller compressor and drive assembly to provide a precision balance that is free of noticeable vibration over the entire operating range.
3. Provide lifting lugs or eyebolts attached to casing.

E. Refrigeration Circuits: Shall include the following:

1. Compatibility: Chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
2. Full operating charge of refrigerant and oil.
3. Refrigerant filter drier (replaceable core type) with isolation valves.
4. Flow Control: Electronic or thermal expansion valve satisfying performance requirements and sized for maximum operating pressure.
5. Pressure Relief Device:
    a. Comply with requirements in ASHRAE 15 and in applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
    b. Pressure relief valve(s) shall be provided for each heat exchanger. Condenser shall have dual valves with one being redundant and configured to allow either valve to be replaced without loss of refrigerant.
6. Provide each evaporator with sight glass or other form of positive visual verification of liquid-refrigerant level.
7. Provide each condenser with sight glass or other form of positive visual verification of refrigerant charge and condition.
8. Charging valve.
9. Refrigerant Isolation Valves: Provide factory installed, positive shutoff, manual isolation valves to allow storage of full refrigerant charge inside the chiller condenser to reduce refrigerant loss and time-consuming transfer procedures during routine servicing.
10. Refrigeration Transfer: Provide service valves and other factory-installed accessories required to facilitate transfer of refrigerant from chiller to a remote refrigerant storage and recycling system. Comply with requirements in ASHRAE 15 and ASHRAE 147.

Formatted: Font: (Default) Arial
Formatted ...
Formatted: Not Highlight
Formatted: Not Highlight
Formatted: Left
Field Code Changed
Formatted: Hyperlink, Font: (Default) Arial
Formatted: Left
Formatted: Font: (Default) Arial, No underline, Font color: Auto
Formatted: Normal, Left, Indent: Left: 2", No bullets or numbering
Formatted: Font: (Default) Arial
Formatted: Left
Formatted: Font: (Default) Arial
Formatted: No underline, Font color: Auto, Not Highlight
Formatted ...
Formatted ...
Formatted ...
Formatted ...
Formatted: Font: (Default) Arial, No underline
Formatted: Font: (Default) Arial, No underline
Formatted: Font: (Default) Arial, No underline
Formatted ...
Formatted: Space After: 0 pt
Formatted ...
Formatted ...
Formatted ...
Formatted ...
Formatted: Font: (Default) Arial, No underline
Formatted: Font: (Default) Arial, No underline
Formatted ...
Formatted: Font: (Default) Arial
Formatted: Font: (Default) Arial, No underline
Formatted ...
Formatted: Font: (Default) Arial, No underline
Formatted: Font: (Default) Arial, No underline
Formatted: Font: (Default) Arial, No underline
Formatted: Font: 11 pt, No underline
Formatted: Font: (Default) Arial, No underline
Formatted ...
Formatted ...

11. Discharge and oil line check valves.

F. Evaporators:
1. The evaporator shall be designed, tested, and stamped in accordance with ASME code for refrigerant side working pressure and waterside working pressures suitable for each application.
2. Shall be designed to prevent liquid refrigerant carryover from entering compressor.
3. Provide water drain connection, vent and fittings for factory installed leaving water temperature control and low temperature cutout sensors.
4. Evaporator shall have only one entering and one leaving connection. If manufacturer provides 2 separate evaporators, contractor shall provide manifold and pressure gauges to ensure equal flow is provided to each evaporator. Such requirements shall be accounted for in manufacturer's chiller bid and submittal.

G. Insulation:
1. Apply insulation over all cold surfaces of chiller capable of forming condensation. Components shall include, but not be limited to, evaporator shell and end tube sheets, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant-cooled motor, and auxiliary piping.
    a. Apply adhesive to 100 percent of insulation contact surface.
    b. Before insulating steel surfaces, prepare surfaces for paint, and prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
    c. Seal seams and joints to provide a vapor barrier.
    d. After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.
2. Type: Closed-cell, flexible elastomeric thermal insulation with Conductivity (k) of 0.22-0.28 Btu·in./(h·ft^2·°F) complying with ASTM C 534, Type I for tube and Type II for sheet materials, meeting 25/50 flame spread/smoke developed ratings.
3. Minimum thickness: Shall meet the most stringent of the following.
    a. For condensation control: Shall avoid surface condensation under all operating conditions of application.
    b. For High-Performance Energy Efficiency: Shall meet minimum pipe insulation thickness for cooling systems listed in current High Performance Design Standard referenced in 01 80 00 PERFORMANCE REQUIREMENTS.
    c. Review these requirements and availability of options with manufacturer. It is preferable to have chillers factory insulated to meet requirements above. However, if manufacturer's available options for factory installed insulation are not able to satisfy the above, then coordinate to specify field-installed supplemental insulation as required.

H. Electrical Power: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to water chiller.
1. Field power interface shall be to NEMA KS 1, heavy-duty, nonfused disconnect switch.
2. House in a unit-mounted enclosure of the type rated for the application with hinged access door with lock and key or padlock and key.

Formatted: Font: (Default) Arial
Formatted: PR2, Indent: Left: 1"
Formatted: Font: 11 pt, No underline, Font color: Auto
Formatted
Formatted: Font: 11 pt, No underline, Font color: Auto
Formatted: Font: 11 pt, No underline, Font color: Auto
Formatted: Font: 11 pt, No underline, Font color: Auto
Formatted: Font: 11 pt
Formatted: Font: (Default) Arial, No underline, Font color: Auto
Formatted: Font: 11 pt, No underline, Font color: Auto
Formatted: Font: 11 pt, No underline, Font color: Auto
Formatted
Formatted: Font: (Default) Arial, No underline, Font color: Auto
Formatted: Font: (Default) Arial, No underline, Font color: Auto
Formatted: Font: (Default) Arial, No underline, Font color: Auto
Formatted: No underline, Font color: Auto
Formatted: Not Highlight
Formatted
Formatted: Don't adjust space between Latin and Asian text
Formatted: Not Highlight
Formatted: No underline, Font color: Auto
Formatted: No underline, Font color: Auto, Not Highlight
Formatted: No underline, Font color: Auto, Not Highlight
Formatted: Not Highlight
Formatted: No underline, Font color: Auto, Not Highlight
Formatted
Formatted: No underline, Font color: Auto, Not Highlight
Formatted: No underline, Font color: Auto, Not Highlight
Formatted: No underline, Font color: Auto, Not Highlight
Formatted: Indent: Left: 1.25", No bullets or numbering

3. High Power Factor: Equipment shall maintain minimum power factor of 0.95 lagging at all operating conditions.
4. Provide terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
5. Factory-installed wiring outside of enclosures shall be in metal raceway except make connections to each motor and heater with not more than a 24-inch length of liquid-tight conduit. **[Designer Note: Review application specific requirements and retain to enclose wiring. Chiller manufacturers do not normally enclose all wiring. Verify availability with manufacturers].**
6. Provide branch power circuit to each motor, dedicated electrical load and controls with NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
7. Motor Controllers: Select type for each application as required to meet electrical system requirements. Refer to 23 05 01.01 for motor inrush current and voltage drop requirements.
8. NEMA- and ICS 2-rated motor controller for auxiliary motors, hand-off-auto switch, and overcurrent protection for each motor.
9. Provide variable frequency controller for each variable-speed motor furnished. Furnish in accordance with University guide specifications, 26 29 23 Variable-Frequency Motor Controllers
10. Control-circuit transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load of unit mounted controls plus spare capacity.
11. Overload Relay: Shall be sized according to UL 1995 or shall be an integral component of chiller control microprocessor.
12. Phase-Failure, Phase-Reversal, and Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hardwired connection.

I. Accessories:

1. Flow Switches: Chiller manufacturer shall furnish a dependable safety flow switch for each evaporator, and condenser, when water cooled, and confirm field-mounting location before installation.

2. Vibration Isolation: Chillers shall include vibration isolation properly selected for each application both for supporting unit and for piping connections.

3. Sound Control: Designer shall determine if sound attenuation option is required and specify the following accordingly.
   a. Sound-reduction package shall consist of removable acoustic enclosures around the compressors and drive assemblies that are designed to reduce sound levels without affecting performance.
   b. Noise Rating: <**Insert dBA**> sound power level when measured according to ARI 575 (indoor chillers) or ARI 370 (outdoor chillers). Provide factory-installed sound treatment if necessary to achieve the performance indicated.

J. Controls: Shall be standalone and microprocessor based with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.

Formatted: PR1, Space Before: 0 pt, Outline numbered + Level: 1 + Numbering Style: A, B, C, ... + Start at: 1 + Alignment: Left + Aligned at: 0.25" + Tab after: 0.5" + Indent at: 0.5"

Formatted: PR1, Space Before: 0 pt, Outline numbered + Level: 2 + Numbering Style: 1, 2, 3, ... + Start at: 1 + Alignment: Left + Aligned at: 0.75" + Tab after: 1" + Indent at: 1"

Formatted: Font: (Default) Arial, No underline, Font color: Auto

Formatted: Font: (Default) Arial, No underline, Font color: Auto

Formatted: Font: (Default) Arial, No underline, Font color: Auto

Formatted: Font: (Default) Arial, Not Bold, No underline, Font color: Auto

Formatted: Font: Not Bold, No underline, Font color: Auto

Formatted: Font: (Default) Arial, No underline, Font color: Auto

Formatted: Font: (Default) Arial, No underline, Font color: Auto

Formatted: Font: (Default) Arial, No underline, Font color: Auto

Formatted: Font: (Default) Arial, No underline, Font color: Auto

Formatted: Font: (Default) Arial, No underline, Font color: Auto

Formatted: Indent: Left: 0.75", No bullets or numbering

Formatted

Formatted: Font: Not Bold, No underline, Font color: Auto

Formatted: Font: Not Bold, No underline, Font color: Auto

Formatted: No underline, Font color: Auto

Formatted

Formatted: Tab stops: -3", Left + Not at

Formatted: Font: (Default) Arial, No underline, Font color: Auto

Formatted: PR1, Space Before: 0 pt, Outline numbered + Level: 1 + Numbering Style: A, B, C, ... + Start at: 1 + Alignment: Left + Aligned at: 0.25" + Tab after: 0.5" + Indent at: 0.5"

Formatted: Font: (Default) Arial, No underline, Font color: Auto

Formatted: Font: (Default) Arial

1. General: Coordinate with OPP Engineering Services and Building Automation System (BAS) Application Engineering Groups and Chilled Water Services Supervisor.
2. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. In either imperial or metric units, display the following information:

    a. Date and time.
    b. Operating or alarm status.
    c. Pump status.
    d. Fault history with not less than last 10 faults displayed.
    e. Set points of controllable parameters.
    f. Trend data.
    g. Operating hours.
    h. Number of starts for each compressor.
    i. Antirecycling timer status.
    j. Outdoor-air temperature or space temperature if required for chilled-water reset.
    k. Temperature and pressure of operating set points.
    l. Entering- and leaving-fluid temperatures of evaporator and condenser.
    m. Difference in fluid temperatures of evaporator and condenser.
    n. Fluid flow of evaporator and condenser.
    o. Fluid pressure drop of evaporator and condenser.
    p. Refrigerant pressures in evaporator and condenser.
    q. Refrigerant saturation temperature in evaporator and condenser.
    r. Oil temperature.
    s. Oil discharge pressure.
    t. Percent of maximum motor amperage.
    u. Demand power (kilowatts).
    v. Energy use (kilowatt-hours).
    w. Current-limit set point.
    x. Phase current.
    y. Phase voltage.
    z. Power factor.
    aa. Compressor bearing temperature.
    bb. Motor bearing temperature.
    cc. Motor winding temperature.

3. Control Functions:

    a. Manual or automatic startup and shutdown time schedule.
    b. Entering and leaving chilled-water temperatures, control set points, and motor load limits. Evaporator fluid temperature shall be reset based on system cooling demand. **Coordinate with Division 25 – BAS Guidespec and Sequence of Operations.**
    c. Current limit and demand limit.
    d. Condenser-fluid temperature.
    e. External chiller emergency stop.
    f. Antirecycling timer.
    g. Variable evaporator flow.

Formatted ...

h. Thermal storage.
i. Heat reclaim.
j. <**Insert other control functions as required by specific application**>.
i. Designer Note: Consider if the application would benefit from remote fault reset as an option – perhaps a transient over/under voltage spike from electrical storm on a chiller serving a critical research process.

4. Manually Reset Safety Controls: The following conditions shall shut down chiller and require manual reset:

a. Low evaporator pressure or temperature; high condenser pressure.
b. Low evaporator fluid temperature.
c. Low oil differential pressure.
d. High or low oil pressure.
e. High oil temperature.
f. High compressor-discharge temperature.
g. Loss of condenser-fluid flow.
h. Loss of evaporator-fluid flow.
i. Motor overcurrent.
j. Motor overvoltage.
k. Motor undervoltage.
l. Motor phase reversal.
m. Motor phase failure.
n. Sensor- or detection-circuit fault.
o. Processor communication loss.
p. Motor controller fault.
q. Extended compressor surge.

5. Trending: Capability to trend analog data of up to five parameters simultaneously over an adjustable period and frequency of polling.
6. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: view only; view and operate; and view, operate, and service.
7. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.
8. Communication Port: RS-232 port or equivalent connection capable of connecting a portable computer and and/or a printer.
9. BAS Interface: Chiller manufacturer shall include factory-installed hardware and software to enable the BAS primarily to monitor and display chiller status, alarms and energy usage, and secondarily to allow but not be fully dependent on BAS control commands. Each individual chiller shall have the protocol in the base controller.

a. Hardwired Points: Essential functions shall be hardwired.

i. Monitoring: On-off status, common fault alarm, pump enable.
ii. Control: On-off enable, pump status/proof of flow, **[optional - chilled-water, discharge temperature set-point adjustment]**.

Formatted ...

b. ASHRAE 135 (BACnet) communication interface with the BAS shall enable the BAS operator to remotely control and monitor the chiller from an operator workstation. Control features and monitoring points displayed locally at chiller control panel shall be available through the BAS.

i. Designer Note: Typically include the above in accordance with BAS subsystem integration requirements in Division 25 - Integrated Automation. Requests for exceptions in certain applications (such as no existing BAS with little or no probability for having any BAS for the expected life of the drive) shall be submitted to OPP, Environmental Systems Manager for review and approval.Requests for exceptions to use MODBUS protocol in certain applications shall be submitted to OPP, Environmental Systems Manager for review and approval.

G. Chilled Water Buffer Tank:

1. The buffer tank shall be baffled to ensure optimal temperature difference and time lag between entering and leaving conditions.
2. The tank must be constructed as an ASME unfired pressure vessel in accordance with most recent addition of Section VIII of the ASME Boiler and Pressure Vessel Code.

H. Equipment Schedules:

1. Shall be shown on drawings,
2. Shall include at a minimum: tag designation, description/type, service, location, capacity (peak and minimum), operating conditions (flows (max design and minimum allowable), temperatures, pressure drops), minimum efficiency (at full and integrated part-load), number of compressors, electrical characteristics, KW, voltage, (including starter/speed drive type), and whether on normal/emergency standby power (where applicable), method of control, maximum dimensions and weights, and any application-specific options and remarks.
   a. Determine and clearly indicate in contract documents the maximum allowable equipment sound pressure levels per ARI Standard 575 for indoor chillers and ARI Standard 370 for outdoor chillers. Be sure to evaluate sound performance when listing or comparing acceptable manufacturers.
   b. Similarly clearly indicate all required sound attenuation performance requirements.

.03 Execution

A. Chiller Installation:

1. General: Comply with manufacturer's installation instructions. Maintain manufacturer's recommended clearances. Coordinate requirements on Drawings.
2. Equipment Mounting: Install chillers on supporting base.
   a. Indoor Mechanical Room: concrete base
   b. Outdoor on grade: concrete pad with turndown edges below frost line to prevent heaving.

Formatted: Font: (Default) Arial, Not Bold, No underline, Font color: Auto

Formatted: Font: (Default) Arial, No underline, Font color: Auto

Formatted: Outline numbered + Level: 3 + Numbering Style: a, b, c, … + Start at: 1 + Alignment: Left + Aligned at: 1.25" + Tab after: 1.5" + Indent at: 1.5", Tab stops: Not at 1.4"

Formatted: No underline, Font color: Auto

Formatted: Space Before: 0 pt, Don't adjust space between Latin and Asian text

Formatted: No underline, Font color: Auto

Formatted: Font color: Auto

Formatted: Font: (Default) Arial, No underline, Font color: Auto

Formatted: PR3, Left, Outline numbered + Level: 4 + Numbering Style: i, ii, iii, … + Start at: 1 + Alignment: Left + Aligned at: 1.75" + Tab after: 2" + Indent at: 2"

Formatted: Indent: Left: 0.25", No bullets or numbering

Formatted: Outline numbered + Level: 1 + Numbering Style: A, B, C, … + Start at: 1 + Alignment: Left + Aligned at: 0.25" + Tab after: 0.5" + Indent at: 0.5"

Formatted: Outline numbered + Level: 2 + Numbering Style: 1, 2, 3, … + Start at: 1 + Alignment: Left + Aligned at: 0.75" + Tab after: 1" + Indent at: 1"

Formatted: Font:

Formatted: Indent: Left: 0.25", No bullets or numbering

Formatted: Outline numbered + Level: 1 + Numbering Style: A, B, C, … + Start at: 1 + Alignment: Left + Aligned at: 0.25" + Tab after: 0.5" + Indent at: 0.5"

Formatted: Outline numbered + Level: 2 + Numbering Style: 1, 2, 3, … + Start at: 1 + Alignment: Left + Aligned at: 0.75" + Tab after: 1" + Indent at: 1"

Formatted: Outline numbered + Level: 3 + Numbering Style: a, b, c, … + Start at: 1 + Alignment: Left + Aligned at: 1.25" + Tab after: 1.5" + Indent at: 1.5"

Formatted

c. Roof: Continuous equipment curb or raised structural steel frame with corrosion resistant finish. Base details shall allow independent replacement of roofing and mechanical equipment.

d. Concrete bases:

i. Comply with requirements for concrete bases specified in Section 03 00 00 CONCRETE.

ii. Coordinate with Structural Engineer to detail the connection of concrete base to structural floor with dowel rods.

iii. Place and secure anchorage devices. Install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor or as otherwise directed by Structural Engineer. Install anchor bolts to elevations required for proper attachment to supported equipment. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

3. Vibration isolation: Comply with requirements for vibration isolation devices specified in Section 23 05 01 Mechanical General Requirements, .04 Sound and Vibration Control.

a. Review application with a vibration consultant to verify suitability.

b. Include isolator heights in clearance requirements.

c. Coordinate piping connections to allow for deflection changes between full and drained chiller.

4. Charge chiller with refrigerant and fill with oil if not factory installed.

5. Install separate devices furnished by manufacturer and not factory installed.

B. Connections:

1. General: Coordinate piping installations and specialty arrangements with schematics on Drawings and with requirements specified in piping systems. Drawings shall indicate general arrangement of piping, fittings, and specialties.

a. Comply with requirements for piping specified in the following Sections.

i. 23 21 13 Hydronic Piping

ii. 23 23 00 REFRIGERANT PIPING

b. Install piping adjacent to chiller to allow service and maintenance. Arrange piping for easy dismantling to permit tube cleaning.

c. Thoroughly flush all water piping to the unit before making final connections. Construct a temporary bypass around the unit to prevent damage to internal components.

2. Fluid Connections:

a. Make easily detachable final piping connections to chiller with a flange or mechanical coupling and flexible pipe connectors.

b. To prevent evaporator or condenser damage, pipe strainers must be installed in the water supplies to protect components from water born debris.

c. To prevent damage, install pressure relief valves in both the evaporator and condenser water systems.

Formatted

Formatted

Formatted: Space After: 0 pt, Line spacing: single

Formatted: Font: (Default) Arial

Formatted: Normal, Indent: Left: 0.25"

Formatted: No underline, Font color: Auto

Formatted: List Paragraph, Outline numbered + Level: 1 + Numbering Style: A, B, C, ... + Start at: 1 + Alignment: Left + Aligned at: 0.25" + Tab after: 0.5" + Indent at: 0.5"

Formatted: List Paragraph, Outline numbered + Level: 2 + Numbering Style: 1, 2, 3, ... + Start at: 1 + Alignment: Left + Aligned at: 0.75" + Tab after: 1" + Indent at: 1"

Formatted: List Paragraph, Outline numbered + Level: 3 + Numbering Style: a, b, c, ... + Start at: 1 + Alignment: Left + Aligned at: 1.25" + Tab after: 1.5" + Indent at: 1.5"

Formatted: List Paragraph, Outline numbered + Level: 4 + Numbering Style: i, ii, iii, ... + Start at: 1 + Alignment: Left + Aligned at: 1.75" + Tab after: 2" + Indent at: 2"

Formatted: List Paragraph, Outline numbered + Level: 3 + Numbering Style: a, b, c, ... + Start at: 1 + Alignment: Left + Aligned at: 1.25" + Tab after: 1.5" + Indent at: 1.5"

Formatted: Font: (Default) Arial, 11 pt, Not Bold, No underline, Font color: Auto

Formatted: Font: Not Bold

Formatted: List Paragraph, Outline numbered + Level: 2 + Numbering Style: 1, 2, 3, ... + Start at: 1 + Alignment: Left + Aligned at: 0.75" + Tab after: 1" + Indent at: 1"

d. Provide vents at high points in the piping to bleed air from the chilled water system.
e. Provide drain valve at low points.
f. Comply with requirements of 23 05 19 Measuring Instruments for HVAC for all measuring instruments on chiller inlets and outlets.
g. Connect to evaporator inlet with vibration isolator flexible connector, strainer, temperature and pressure measuring instruments and shutoff valve.
h. Connect to evaporator outlet with vibration isolator flexible connector, flow switch (if shipped loose, not factory installed), temperature and pressure measuring instruments, balancing valve (if used), and shutoff valve.
i. Connect to condenser inlet with vibration isolator flexible connector, strainer, temperature and pressure measuring instruments, and shutoff valve.
j. Connect to condenser outlet with vibration isolator flexible connector, flow switch, (if shipped loose, not factory installed), plugged tee with shutoff valve, temperature and pressure measuring instruments, balancing valve (if used), shutoff valve.

3. Refrigerant Pressure Relief Device Connections: For chillers installed indoors, extend separate vent piping for each chiller to the outdoors without valves or restrictions. Comply with ASHRAE 15. Connect vent to chiller pressure relief device with flexible connector and dirt leg with drain valve.
4. For chillers equipped with a purge system, extend separate purge vent piping for each chiller to the outdoors. Comply with ASHRAE 15 and ASHRAE 147.
5. Connect each chiller drain connection with a union and drain pipe, and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection.
6. Designer Note: Refer to Detail [23 64 00, .xx] for typical piping connections. ***Reserved for future. Details are not yet available in WEB-based manual.***

C. Chilled Water Buffer Tank Installation:

1. Tank shall be fully insulated to prevent condensation and to meet insulation requirements in high performance building standard.
   a. Closed-cell, flexible elastomeric thermal insulation with Conductivity (k) of 0.22-0.28 Btu·in./(h·ft^2·°F) complying with ASTM C 534, Type I for tube and Type II for sheet materials.
   b. Minimum thickness: Conform to current edition of ASHRAE 189.1
      i. 1.5 inch for fluids operating temperature range of 40-60°F.
      ii. 2 inch for fluids operating temperature range less than 40°F.
   c. Seal seams and joints to provide a continuous vapor barrier.
   d. Provide protective embossed aluminum jacket covering where located in areas subject to harsh conditions, abuse or exposed to weather.
2. Provide manual shut off valves at inlet and outlet to allow tank repair/replacement and a main bypass valve with automatic actuator interlocked with BAS to open for scheduled chemical treatment flush of normally closed leg.

D. Control Wiring Installation and Coordination

Formatted: List Paragraph, Outline numbered + Level: 3 + Numbering Style: a, b, c, … + Start at: 1 + Alignment: Left + Aligned at: 1.25" + Tab after: 1.5" + Indent at: 1.5"
Formatted: Font: No underline, Font color: Auto, Not Highlight
Formatted: No underline, Font color: Auto
Formatted: No underline, Font color: Auto
Formatted: Font: Not Bold, No underline, Font color: Auto
Formatted: Font: No underline, Font color: Auto, Not Highlight
Formatted: No underline, Font color: Auto
Formatted: No underline, Font color: Auto
Formatted: No underline, Font color: Auto
Formatted: No underline, Font color: Auto
Formatted: List Paragraph, Outline numbered + Level: 2 + Numbering Style: 1, 2, 3, … + Start at: 1 + Alignment: Left + Aligned at: 0.75" + Tab after: 1" + Indent at: 1"
Formatted: Font: Not Bold, No underline, Font color: Auto
Formatted: Font: No underline, Font color: Auto
Formatted: Font: No underline, Font color: Auto
Formatted: Font: No underline, Font color: Auto
Formatted: Font: Bold, Italic, No underline, Font color: Auto
Formatted: Font: Bold, No underline, Font color: Auto
Formatted: Font: Italic, No underline, Font color: Auto
Formatted: Font: Not Bold, Italic, No underline, Font color: Auto
Formatted: Font: Italic
Formatted
Formatted: Outline numbered + Level: 2 + Numbering Style: 1, 2, 3, … + Start at: 1 + Alignment: Left + Aligned at: 0.75" + Tab after: 1" + Indent at: 1"
Formatted
Formatted
Formatted …
Formatted …
Formatted …
Formatted: No underline, Font color: Auto
Formatted
Formatted: No underline, Font color: Auto

1. The Control Systems Contractor shall install control wiring between chillers and remote devices and facility's central BAS per requirements in BAS specifications.
    a. Connect all hard-wired control inputs from BAS devices to chillers.
    b. Connect all hard-wired control outputs (normal/fault indication) from chillers to BAS.
    c. Connect network communication and coordinate with chiller start-up representative that correct parameter values are reading to BAS.

E. Startup Service
    1. Engage a factory-authorized service representative to perform startup service that includes the following:

        a. Complete installation and startup checks according to manufacturer's written instructions.
        b. Verify that refrigerant charge is sufficient and chiller has been leak tested.
        c. Verify that pumps are installed and functional.
        d. Verify that thermometers and gages are installed.
        e. Operate chiller for run-in period.
        f. Check bearing lubrication and oil levels.
        g. For chillers installed indoors, verify that refrigerant pressure relief device is vented outdoors.
        h. Verify proper motor rotation.
        i. Verify static deflection of vibration isolators, including deflection during chiller startup and shutdown.
        j. Verify and record performance of fluid flow and low-temperature interlocks for evaporator and condenser.
        k. Verify and record performance of chiller protection devices.
        l. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

    2. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assembly, installation, and connection.
    3. Prepare and submit test and inspection startup reports

F. Testing, Adjusting and Balancing:
    1. For requirements, refer to 23 05 93 Testing, Adjusting, and Balancing for HVAC.

G. Vibration Testing:
    1. Perform vibration testing per Section 23 05 01 Mechanical General Requirements, .04 Sound and Vibration Control.
        a. The Contractor shall coordinate and contract the services of the University's HVAC Vibration Analyst (At University Park, arranged through the Supervisor of Refrigeration and Mechanical Services) whenever available. Otherwise (and at Commonwealth Campus locations) the Contractor shall hire an independent, third party Vibration Analyst meeting the approval of the University.
        b. Measured results of vibration testing and final alignment shall be recorded and coordinated to be entered into University's Preventative Maintenance Software at time of start-up AND included in final report to be submitted as part of TAB/O&M submittals.

Formatted
Formatted
Formatted: Font: (Default) Arial
Formatted: Normal, Indent: Left: 0.25"
Formatted: List Paragraph, Outline numbered + Level: 1 + Numbering Style: A, B, C, ... + Start at: 1 + Alignment: Left + Aligned at: 0.25" + Tab after: 0.5" + Indent at: 0.5"
Formatted: List Paragraph, Outline numbered + Level: 2 + Numbering Style: 1, 2, 3, ... + Start at: 1 + Alignment: Left + Aligned at: 0.75" + Tab after: 1" + Indent at: 1"
Formatted: Tab stops: Not at 1"
Formatted: Indent: Left: 0.75", No bullets or numbering, Tab stops: Not at 1"
Formatted
Formatted: Indent: Left: 0.25", No bullets or numbering, Tab stops: Not at 1"
Formatted: Tab stops: Not at 1"
Formatted: Don't adjust space between Latin and Asian text
Formatted: Indent: Left: 0.25", No bullets or numbering, Tab stops: Not at 1"
Formatted: Tab stops: Not at 1"
Formatted: Don't adjust space between Latin and Asian text
Formatted: Tab stops: Not at 1"
Formatted: Font color: Auto
Formatted: Font color: Auto

c. **IMPORTANT: Excessive vibration contributes to noise problems, wastes energy and accelerates equipment failure and therefore must be corrected when found. This work must be completed to the satisfaction of the University as part of the criteria determining Substantial Completion.**

END of revision

Update Commentary:

Section was updated primarily for the following reasons:

1) To expand this section into a 3 part format to more fully define requirements.
    a. Part 01: To list General Owner Requirements of design intent, selection criteria, quality assurance, submittals, and warranties. Crucial issues include:
        i. Ensuring adequate turndown and piping system thermal mass for stable chiller operation in all operating conditions.
        ii. Selecting equipment, designing piping arrangements and controls for optimizing energy efficiency.
        iii. Use of free cooling options whenever practical
        iv. Ensuring acceptable Sound and Vibration levels
        v. Refrigerant safety provisions
        vi. Equipment service access and replacement provisions
        vii. Ensuring systems have flow switches for chiller protection
    b. Part 02: To list the Product Requirements for manufactured equipment.
        i. Refrigerant selection criteria
        ii. Thermal Insulation performance meeting High Performance Building Standard for cooling systems.
        iii. Electrical Power
        iv. Controls with BAS interface
        v. Accessories
    c. Part 03: To list the Execution (Installation, Connections, and Start-up/Commissioning) requirements.
        i. Factory start up
        ii. Vibration Testing by OPP approved Vibration Analyst at startup.