BSD Technical Standard
Division 23: HVAC

1. PURPOSE

This technical standard is a narrative describing Beaverton School District's (BSD's) Basis of Design for mechanical systems and heating, ventilation, and air conditioning (HVAC) control systems. The information contained herein shall be used by the Project Design Team to develop a sustainable, integrated mechanical, HVAC, and controls system that is economical to maintain and operate and that enhances learning by providing a suitable work environment for staff and students. This document shall be used as part of BSD's General Design Standards (comprised of the BSD Educational Specifications and BSD Technical Standards).

2. GENERAL

2.1. DESIGN DOCUMENTS

2.1.1. Narrative

2.1.1.1. The Project Design Team shall provide to the BSD, as part of all Design Document Submittals, a narrative with detailed descriptions of system features, functionality, limitations, design assumptions, and parameters.

2.1.1.2. The narrative shall be provided as a "deliverable" with the Schematic Design and shall be updated with each subsequent design delivery including Design Development (DD) and Construction Document (CD) Phases.

2.1.1.3. The narrative shall be detailed enough to provide necessary and beneficial information to future Project Design Teams and shall be written in a manner that is informative and useful to building operations personnel. In its final form, this document shall be incorporated into the Construction Documents and placed on the first sheet of the mechanical drawings.

2.1.2. Drawings

2.1.2.1. Drawings shall contain all equipment schedules including HVAC, plumbing, lighting, glazing, and insulation.

2.1.2.2. Design assumptions that define the capabilities of the building shall be documented on the drawings. These include, but are not limited to: maximum occupancy, indoor and outdoor HVAC design conditions, Oregon Energy Code Compliance documentation, lighting thermal load , hours of operation, and provisions for future expansion (if any). This will ensure that the information is retrievable years later when only the drawings are available to facility operations.

2.1.3. Design Considerations

2.1.3.1. Life-cycle costing will be the decision-making tool for evaluating new systems and equipment. Mechanical systems should be evaluated on a 50-year life-cycle.

2.1.3.2. Energy modeling shall be incorporated in new school design and schools with major mechanical remodels. Small projects may incorporate other ASHRAE approved methods for calculating energy use.

2.2. COMMISSIONING

2.2.1. Commissioning is required for all HVAC or Controls Capital Improvement Projects. The Commissioning Agent shall be brought on board prior to the beginning of DD for projects that incorporate mechanical and/or control system changes.

2.2.2. The Commissioning Agent will be expected to participate in the 100% DD review and the 80% CD review presentations by the Project Design Team. Remodel projects without major system changes may bring the Commissioning Agent at the beginning of CD.

2.2.3. The Commissioning Agent is expected to develop specific testing and verification protocols as part of the Project's Commissioning Plan. The testing and verification protocols need to clearly define what is expected of the controls subcontractor so that they will be able to accurately and adequately bid on the Project. A draft of this plan shall be included as part of the Project's Construction Documents at the 50% CD stage and finalized as part of the Bid Documents.

2.3. BUILDING AUTOMATION

2.3.1. All building automation systems should fit into the District's enterprise network model. Systems that will not currently be included in the enterprise network should be designed so that they may be integrated at a later date with minimal equipment changes.

2.3.2. The District currently has two enterprise level platforms: the ADS server and Tridium Niagara AX. Programming tools not already owned by the District must be provided for all levels of the system as part of the Project.

2.3.3. All projects greater than $100,000 shall include a control contractor as part of the Project Design Team to specify Basis of Design through the development of line drawings and sequence of operation. (Subsequently, all requests for substitution must include line drawings.)

2.3.4. At the end of SD, the Project Design Team shall request from the BSD HVAC Department what current versions of controls are appropriate for the project.

2.4. ENERGY USE

2.4.1. All mechanical systems shall meet and/or exceed both current ASHRAE 90.1 standards and current Oregon Energy Code. Design goals should provide building energy use that would allow easy qualification as an Energy Star rated building.

2.4.2. Controls Contractor shall install BSD-supplied schedules as part of the initial programming. Equipment must be running on BSD-supplied schedules and utilizing all other control measures as soon as equipment is operational to minimize energy use during the Project.

2.4.3. New schools and major remodels should use energy modeling to confirm compliance with Energy Star ratings and be at the bottom of the Oregon Department of Energy's Energy Use Index (EUI) Range guidelines.

2.5. NAMING CONVENTIONS

2.5.1. BSD equipment and system naming conventions shall be used on all Project documents at and beyond the Design Development Phase. This will ensure that equipment labels are consistent with programming conventions.

2.5.2. Equipment naming for new construction and retrofits must follow industry standard naming conventions. Remodels and retrofits shall follow the naming used for the existing building and on the prints. Request points list from BSD HVAC Department prior to DD.

2.5.3. Numbering of equipment shall logically and sequentially follow the numbering used on existing equipment.

2.5.4. Room numbers used on all plans should be the final room number as assigned by the District. The Project Design Team is responsible for obtaining a copy of the District's standardized classroom numbering system from the BSD.

2.6. TRAINING

2.6.1. Provide for training of District and building personnel with additional detailed training for Maintenance staff. Maintenance training shall provide a minimum of the following:

2.6.1.1. Review of complete O&M manuals, including but not limited to, programming and setup of any control systems

2.6.1.2. Training on all required maintenance and troubleshooting

2.6.1.3. Listing of all current factory support contact names and phone numbers

2.6.2. Regarding retrofit projects, BSD HVAC Department shall be notified of start-up date and will attend at their discretion as part of the training requirement.

2.6.3. The District shall be provided with factory service manuals, software tools, and specialized test equipment. This requirement may be modified for equipment already in use by the District.

2.6.4. Additional specialized training shall be required for any new technology being introduced to the District, and for any equipment that is new to the District (i.e., equipment not already installed and being maintained by the District). A determination of specialized training requirements shall be made by the Maintenance staff at 80% CD.

2.6.5. Formal institute training shall be provided locally, either on-site or in the Portland area. All costs associated with the training shall be covered by the project.

3. CONTROLS

3.1. GENERAL

3.1.1. The controls contractor is responsible for delivering a complete and workable system. On retrofit and remodel work, it is assumed that the system is complete and operable before the controls modifications.

3.1.2. It is the responsibility of the Controls Contractor to submit in writing a list of any unworkable equipment to the Owner prior to beginning any demolition work or modifications to the existing equipment.

3.2. QUALIFIED CONTROLS CONTRACTOR

3.2.1. The Controls Contractor shall be regularly engaged in the engineering, programming, installation, and service of Control Systems by the selected manufacturer and shall have a minimum of five years experience with the complete, turn-key installation of Controls by the same manufacturer of similar size and technical complexity.

3.2.2. If portions of the installation will be performed by a subcontractor, the Controls Contractor will submit to BSD, two sample installations performed by subcontractor which are similar to the current project.

3.2.3. The Controls Contractor shall have a local branch facility within a 75-mile radius of the job site. Emergency service shall be available on a 24-hour, 7-day-a-week basis.

3.2.4. Acceptable Controls Contractors: Johnson Controls, Inc., Northwest Control Contractors, or selected Johnson Controls Inc. Authorized Building Controls Specialist (ABCS), and their designated agents. Selection of Controls Contractors is subject to approval by BSD.

3.2.5. Controls Contractors not currently approved by the District shall provide a list of five comparable projects that have Controls with the features as specified for this project. These projects must be on-line and functional.

3.3. GENERAL CONTROL SYSTEMS

3.3.1. Enterprise Servers are programs installed on a server class PC that use the District's IT network to collect and send information to the supervisory level controllers. This is the level that houses graphics and long-term trends (limited graphics also reside in the Supervisory Controller).

3.3.2. The District currently has two enterprise level platforms: the ADX server, Tridium Niagara AX. Appendix A contains a diagram of the District Controls Network Structure.

3.3.3. All Niagara products will be open licensed, and all programming tools used in the project will be licensed to BSD and provided as part of the project.

3.3.4. All Johnson programming tools used in the project will be provided to BSD as part of the project.

3.3.5. For control systems in new construction, Johnson Metasys will be the Basis of Design.

3.3.6. For control system renovations, the mechanical engineer and BSD HVAC Department will choose the Basis of Design for the controls portion of the project.

3.3.7. Supervisory Controllers shall have a web-based user interface available through current web browsers using standard communications protocols. The Supervisory Controller shall be housed at the local building level. Supervisory Controllers shall have communications buses for, and be capable of communicating on, one of the two approved protocols. Approved communications protocols include LON and BACnet. Preferred bus shall be specified by the District for individual projects.

3.3.8. Basic graphics shall reside in the Supervisory Controller. As a cost savings measure on smaller projects, supervisory controllers that only communicate on the needed bus may be approved by BSD for that particular project only. Software application used to access server and supervisory controllers on building network shall be Windows and Macintosh based and approved by BSD.

3.3.9. Local (building level) controls that use IP standards shall communicate on a subnetwork behind a Router/Switch. When BACnet IP communications are used, the Project Design Team shall

coordinate capacity and security needs with IT design. Otherwise, the Supervisory Controller will serve as the switch or gateway between the District network and the communications buses. All IP communication lines and equipment shall be tested to meet or exceed current industry standards.

3.3.10. Systems using more than one internet connection must have prior approval from BSD Representative. It may be desirable to use existing BSD IT infrastructure when considerable overall cost savings can be realized stand-alone reliability can be maintained.

3.3.11. Programming shall use BSD naming conventions to ensure continuity between systems. The existing file path on an Enterprise Server defines the naming convention and file structure for that server. This convention provides a unique name for every point on the District's network and ensures that summaries and reports are consistent.

3.3.12. Programming and point naming shall follow conventions used on the applicable Enterprise Server and must be obtained from the BSD HVAC Department no later than the beginning of Design Development. These conventions must be used during controls design, programming, and in the specifications.

3.4. APPLICATION-SPECIFIC CONTROLLERS AND LOCAL CONTROL UNITS

3.4.1. Application-Specific Controllers are specialized Local Control Units and can include, but are not limited to, PLCs (programmable logic controllers), unitary controllers, manufacturers' on-board controls, vendor devices, and other controls.

3.4.2. The BSD prefers Application-Specific Controllers with standard ("canned") sequences. Controllers requiring custom programming and complex sequences shall be avoided. The goal at each level of Application-Specific Controls is to provide the simplest most straightforward sequence, program, and system that will meet the District's operational and maintenance needs, consistent with the District's established energy standard. Where cost effective, design, and build each system with capacity for expansion to meet future operational needs.

3.4.3. Local Control Units for HVAC equipment shall be factory installed.

3.4.4. Local Control Units shall be by approved manufacturer. Controls by HVAC equipment manufacturer must be approved by BSD (see Appendix B) on a project-specific basis.

3.4.5. Local Control Units shall use approved communication protocol. Preferred protocol is JCI Metasys BACnet. Other protocols shall be approved on a project-specific basis include: BACnet IP: BTL listed, BACnet MS/TP: Metasys Compliant, LON: Lonwork® Certified.

3.4.6. Local Control Units shall operate as stand-alone controllers capable of performing specified control responsibilities independent of other controllers in the network.

3.4.7. The District maintains the control system with in-house staff so programming should favor Application-Specific Controllers with standard sequences.

3.4.8. All Application-Specific Controllers must be capable of remote programming over the District Enterprise network and all programs required will be installed, licensed to BSD, and BSD personnel will be trained on their use.

4. HVAC SYSTEMS

4.1. GENERAL

4.1.1. Refrigerants

4.1.1.1. The following refrigerants are acceptable for use in chillers and DX equipment as appropriate on District projects: R-410a, R-134a, R-404a, and R-407c.

4.1.1.2. The District goal is to use the same refrigerant throughout each individual facility. Refrigerant selection for equipment over 20 tons will be finalized at 100% DD review with District Maintenance input.

4.1.2. Air Filters

4.1.2.1. Air filters are required on all air handlers. MERV 8 (Farr 30/30), 2" pleated high efficiency filters or better required.

4.1.3. Life Cycle

4.1.3.1. All HVAC systems should be designed around a 50-year life cycle. The Project Design Team must provide unbiased life-cycle costing as part of the evaluation process for any system requiring BSD approval. Replacement cost and equipment life must be based on industry accepted and recognized sources.

4.1.3.2. HVAC systems cannot be accurately analyzed without defined setpoints and sequence of operation. HVAC systems must have setpoints and sequence of operation defined at beginning of Design Development, prior to doing life-cycle cost comparison.

4.1.4. Air-Handling Equipment

4.1.4.1. The BSD prefers air-handling equipment installed in penthouse spaces as opposed to being roof mounted. This will allow the opportunity to explore the use of alternate roof systems. Hot water or chilled water coils on rooftop air handlers may only be used with BSD approval. The entire system must be freeze protected to 10°F.

4.1.5. Load Calculations

4.1.5.1. The Project Design Team shall provide HVAC load calculations and demonstrate that equipment is not oversized or undersized. Equipment shall be designed to accommodate load swings.

4.1.5.2. Air handling (fan capacity) shall provide 110% of calculated design requirements. Equipment heating and cooling capacity for any single system should not exceed calculated design load by more than 10%.

4.1.5.3. HVAC calculations will include both the maximum and minimum heat/cool loads. Energy efficiency shall be maintained down to 25% of maximum building load.

4.1.6. Redundancy

4.1.6.1. Redundancy is desired in heating systems. Full redundancy in each system is not required; however, no single equipment failure should take the building out of its established operating parameters (such as a single boiler or pump).

4.1.7.Miscellaneous

4.1.7.1. Airside economizers are required for all air handling equipment, regardless of size. Provide necessary outside air, but no more than required. On systems of greater than 2,000 cfm (5 tons) design controls to dynamically vary outside air with occupancy.

4.1.7.2. Evaluate use of heat recovery ventilation on all systems larger than 2,000 cfm.

4.1.7.3. Any gas fired unit with a burner rating over 199,000 Btu shall have a fully modulating burner with at least a 4:1 turndown ratio.

4.1.7.4. Air handling units over 5,000 cfm shall have a method for reducing ventilation fan power during light loads (i.e., VFD).

4.1.7.5. Mixed air low limit required for all air handlers (even with gas heat).

4.1.7.6. Areas that regularly have occupancy scheduled outside of the schools operating hours (e.g., summer office hours and auditoriums) shall be identified. Options that minimize energy use shall be evaluated using life-cycle costing.

4.1.7.7. All spaces with year-round cooling demand, such as computer rooms and data centers, shall have their own dedicated system with airside economizer. Heat recovery opportunities will be evaluated for areas with more than 5 kW of equipment load.

4.1.7.8. Design Zone HVAC to minimize simultaneous heating and cooling. Where possible, design with separate systems for interior and exterior zones. This will improve comfort and also reduce the inherent need for simultaneous heating and cooling. Variable refrigerant flow systems should be designed and zoned per manufacturer's recommendations.

4.1.7.9. Design for ASHRAE Standard 55 comfort envelope, which indicates 90% comfort in our climate at a space temp of 70°F heating and 75°F cooling. Installed control set points should meet this standard.

4.1.7.10. Design shall allow easy maintenance, with unobstructed access to items requiring regular maintenance. Installation must allow all access doors to fully open. All filters, valves, controls, sensors, motors, and bearings must be accessible. Minimize fan-powered Variable Air Volume (VAV) boxes. BSD approval required at beginning of DD.

4.1.7.11. Phase monitors and protection required for all 3-phase equipment larger than 5 hp.

4.1.7.12. Install HVAC shut-off button to shut down building HVAC system. Locate button in the main office. Provide an openable, clear plastic cover to prevent accidental activation, as well as a visual indicator to alert office staff if activation occurs.

4.2. DUCTWORK

4.2.1.General

4.2.1.1. Ductwork shall be installed to current industry recommended standards.

4.2.2.Flex Duct

4.2.2.1. Flex duct shall be limited to a maximum length of 6'-0".

4.2.3. Duct Board

4.2.3.1. Duct board shall not be used on new installations. During remodels if the ductwork being modified is duct board, then removal and replacement of the duct board is required in effected area.

4.3. PIPING AND VALVE SCHEDULE

4.3.1. Hydronic Piping

4.3.1.1. No black iron piping below 3"Ø.

4.3.1.2. Threaded pipe and fittings shall only be used at terminations.

4.3.1.3. No threaded fittings or drains shall be located above hard lids.

4.3.1.4. See Division 22 Plumbing for domestic water, sanitary and natural gas connections.

PIPING SCHEDULE			
Service	**Size**	**Location**	**Material**
Hydronic and Chilled Water Systems	Through 2"Ø	All	Copper-Type "L" or Better, Soldered Fittings. ProPress fittings allowed where accessible for maintenance
	2-1/2"Ø	All	Copper-Type "L" or Better, Brazed Fittings
	3"Ø And Larger	All	Black Steel w/ Welded or Flanged Fittings
	All Ø's, Two foot maximum length	All	Flex Connectors, Stainless Steel, or Copper, Two foot maximum length

VALVE SCHEDULE				
System	**Service**	**Valve Type**	**Size**	**Material**
Hydronic and Chilled Water Systems	Shut-Off, Throttling, Drain	Ball, Full-Port	All	Bronze
	Shut-Off, Throttling	Butterfly	3"Ø Or Larger	Cast Iron or Bronze
	Throttling	Globe	All	Bronze

4.4. MOTORS AND VARIABLE FREQUENCY DRIVES (VFD)

4.4.1. All HVAC fan and pump motors that are 1/6th horsepower and greater shall provide status signal to the building management system through use of a current sensing device to verify that the motor is running.

4.4.2. All field installed VFDs shall be manufactured by ABB or District approved equal. All VFDs other than ABB will require additional training.

4.4.3. All variable frequency drives (VFD) shall be rated for HVAC service. Mount VFDs on the equipment being controlled (within sight of) and served by the same disconnect as the equipment it serves.

4.4.4. Bypasses shall not be used on VAV HVAC air handling equipment. Bypasses are acceptable for use on pumps.

4.4.5. Factory installed VFDs are acceptable when provided on package equipment if thoroughly covered in manufacturer's service manual and fully covered by the package equipment manufacturer's warranty.

4.5. VARIABLE AIR VOLUME (VAV)

4.5.1. VAV is the most commonly used system in the District. VAV is not the only system allowed, but it is the only one that has been used enough in the BSD to be a valid point of comparison. All other proposed systems should be compared to VAV with the parameters found in Appendix C.

4.5.2. All energy modeling and cost comparison should use VAV as the baseline.

4.6. VARIABLE VOLUME BY TEMPERATURE (VVT)

4.6.1. VVT shall only be used with BSD approval. **BSD approval required at beginning of DD**. Review and evaluation based on comparison to VAV system.

4.6.2. VVT should not be used with more than three zones.

4.6.3. Must be minimal disparity between zones if VVT is to be considered. Both the heating load and the cooling load must be similar in all VVT zones.

4.7. DISPLACEMENT VENTILATION

4.7.1. Displacement ventilation shall only be used with BSD approval. **BSD approval required at beginning of DD**. Review and approval shall be based on comparison to VAV system.

4.8. SPLIT SYSTEMS

4.8.1. Condensing units on grade are discouraged.

4.8.2. **For approved systems:** All condensing units must be isolated from sight. Noise generated by the condensing unit must be controlled so that sound levels are not increased in instructional areas when the condensing unit is running. Condensing units shall be protected from vandalism.

4.8.3. Limit split systems to the following areas, with BSD approval. BSD approval required at beginning of DD. Review and evaluation based on comparison to single-zone rooftop air handler with economizer.

4.8.3.1. Elevator mechanical rooms

4.8.3.2. Server rooms

4.8.3.3. Electrical rooms

4.8.3.4. Retrofit computer labs

4.8.3.5. Office portables or modular buildings with multiple zones

4.8.4. Areas with occupancy should be provided with independent ventilation such as a heat recovery ventilator. Mechanical rooms should have an exhaust fan with thermostatic control.

4.8.5. All split systems must have control strategy specified at design and be integrated into the total system.

4.8.6. Gravity feed condensate drains are required on all indoor units. Condensate evaporators and pumps are not acceptable.

4.9. DATA FRAME ROOMS

4.9.1. Provide engineered HVAC system for MDF (main data frame) and IDF (intermediate data frame) server rooms.

4.9.2. Design shall provide outside air intake, adequate air changes per hour, and cooling to meet anticipated equipment load and maintain temperatures below 80°F on a Design Day.

4.9.3. Data frame room HVAC systems shall be thermostatically controlled with cooling and ventilation available 24 hours, seven days a week.

4.9.4. Data frame rooms that are designed with exhaust only systems must provide outside air intake and a chase adequate to allow future addition of mechanical cooling.

4.10. UNIT VENTILATORS

4.10.1. Avoid unit ventilators and Package Terminal Air Conditioning (PTAC) units in new construction. **BSD approval required at beginning of DD**. Review and evaluation should be based on comparison to single-zone rooftop air handler with economizer and/or fin tube as appropriate.

4.10.2. Univents **shall not** be approved for use in new classroom construction.

4.10.3. Univents may be approved for use as replacement for existing univents in remodels and retrofits. Univents may be approved for use in new construction for corridors and lobbies (compare to fin tube).

4.10.4. Valve control only. No face and bypass heating control.

4.11. MULTI-ZONE AIR HANDLERS

4.11.1. Multi-zone air handlers **are not approved** for use in the Beaverton School District.

4.12. RESIDENTIAL FURNACE HEATING AND COOLING

4.12.1. Residential furnace heating and cooling **is not approved** for use in the Beaverton School District.

4.13. SINGLE-ZONE ROOFTOP SYSTEM

4.13.1. Must have an airside economizer

4.13.2. Any unit larger than 2,000 cfm shall have a fully modulating outside air damper.

4.13.3. All single-zone units over five tons shall have demand ventilation.

4.13.4. Any gas fired unit with a burner rating over 199,000 Btu shall have a modulating burner with at least a 4:1 turndown ratio.

4.13.5. Large units, such as high school gyms, should have a method for reducing ventilation fan power during light loads (e.g., Variable Frequency Drive (VFD)).

4.14. HEAT PUMPS

4.14.1. Must have an airside economizer.

4.14.2. Systems must have control strategy specified at design and be integrated into the total system. Special care should be taken to minimize use of electrical resistance heating and associated demand charges.

4.14.3. Heat pump systems over five tons should have gas heat as supplemental heat source.

4.14.4. Due to limited air conditioning season, heat pump efficiency shall be evaluated on Heating Seasonal Performance Factor (HSPF).

4.15. EXHAUST FANS

4.15.1. Kiln Rooms

4.15.1.1. Kilns shall not be located in conditioned space. Provide adequate ventilation to maintain space temperature at or below 80°F while the kiln is being fired with the kiln room door closed.

4.15.1.2. Kiln room ventilation shall be designed with high exhaust and low make-up air intake. Exhaust fan shall be brought on at 80°F regardless of building HVAC schedules.

4.15.2. Restrooms

4.15.2.1. Exhaust fans for single stall restrooms shall be controlled by the lighting occupancy sensors. Multiple stall restrooms shall have exhaust fans controlled through the building management system (BMS).

4.15.2.2. The exhaust fan operation shall be scheduled to start and stop with the HVAC for that portion of the building. The exhaust fan shall be capable of being scheduled or overridden to operate independent of the HVAC systems operation.

5. CENTRAL PLANTS

5.1. BOILERS

5.1.1. General Requirements (Applies to New Construction and Remodels)

5.2. NATURAL GAS FIRED ONLY.

5.3. BOILER SYSTEMS MUST BE CAPABLE OF STAND-ALONE OPERATION.

5.4. NO DOMESTIC HOT WATER (DHW) ON HEATING BOILER SYSTEMS.

5.5. FULLY REDUNDANT PUMPING SYSTEMS.

5.6. HYDRONIC HEATING SYSTEMS ARE PREFERRED.

5.7. CHEMICAL WATER TREATMENT REQUIRED FOR ALL HEATING BOILERS.

5.7.1. New construction

5.7.1.1. Hydronic heating systems are preferred

5.7.1.2. No distributed pumping. Central pump with VFD and full redundancy is required.

5.7.2. Heating Boilers

5.7.2.1. Fully modulating burner control with a minimum 4:1 turndown ratio.

5.7.2.2. For systems without rooftop gas packs, boiler plants should be designed N+1 to provide redundancy.

5.7.2.3. Systems using condensing boilers should be designed around the manufacturer's recommendations to provide the best life-cycle cost. Constant flow loops may need to be of the primary secondary type to operate the boiler in its efficiency range.

5.7.2.4. Steam boilers will not be installed in new heating distribution systems.

5.7.2.5. Condensate treatment required for all condensing boilers.

5.7.2.6. Above 4 MMBtu total capacity, cast iron sectional boiler(s) with a condensing boiler as "pony" boiler to increase seasonal efficiency is preferred.

5.7.2.7. Control panels on Condensing boilers must be integrated into the BAS system.

5.7.2.8. Sequencing controllers shall only be used for installation with multiple boilers. Multiple boilers shall have a manufacturer's approved sequencing panel with dedicated outside air sensor for stand-alone operation.

5.7.2.9. Single boilers will have onboard modulating control.

5.7.2.10. Boiler controls and sequence of operation require Owner approval no later than 100% Design Development (DD).

5.7.3. Domestic Hot Water

5.7.3.1. Central system in boiler room vs. distributed system shall be determined by site-specific comparison. Comparison should be based on life-cycle costing.

5.7.3.2. Specific retrofit and remodeling application may require life-cycle comparison of electric vs. natural gas vs. tankless demand.

5.8. <u>DISTRICT PREFERRED SYSTEMS</u>: COMMERCIAL 199,000 BTU HIGH-EFFICIENCY NATURAL GAS WATER HEATERS WITH A 90+ RATING, OR CONDENSING HOT WATER BOILER WITH STORAGE TANK. FOR LARGE SYSTEMS PROVIDE LIFE-CYCLE COST COMPARISON OF MULTIPLE 199,000 BTU WATER HEATERS VS. SINGLE CONDENSING BOILER WITH STORAGE TANK.

5.9. CHILLERS

5.10. ALL PROJECTS

5.10.1.1. Chilled water coils on rooftop air handlers shall be used only with BSD approval and entire system must be freeze protected to 10°F. BSD approval required at beginning of DD.

5.10.1.2. Life-cycle costing should be used for system comparisons if chilled water systems are being considered as an option during design. Only use chillers if it "pays" through life-cycle costing. Comparison should include Direct Expansion (DX) (as baseline) vs. Air Cooled Chiller vs. Water Cooled Chiller vs. Chiller with Water-Side Economizer.

5.10.1.3. No chilled water systems under 100 tons.

5.10.1.4. Always consider chilled water system in multi-story buildings with high ratio of interior to exterior zones.

5.10.1.5. Because of limited summer run-time, emphasize turn down ratio and Integrated Part Load Value (IPLV) over Energy Efficiency Rating (EER).

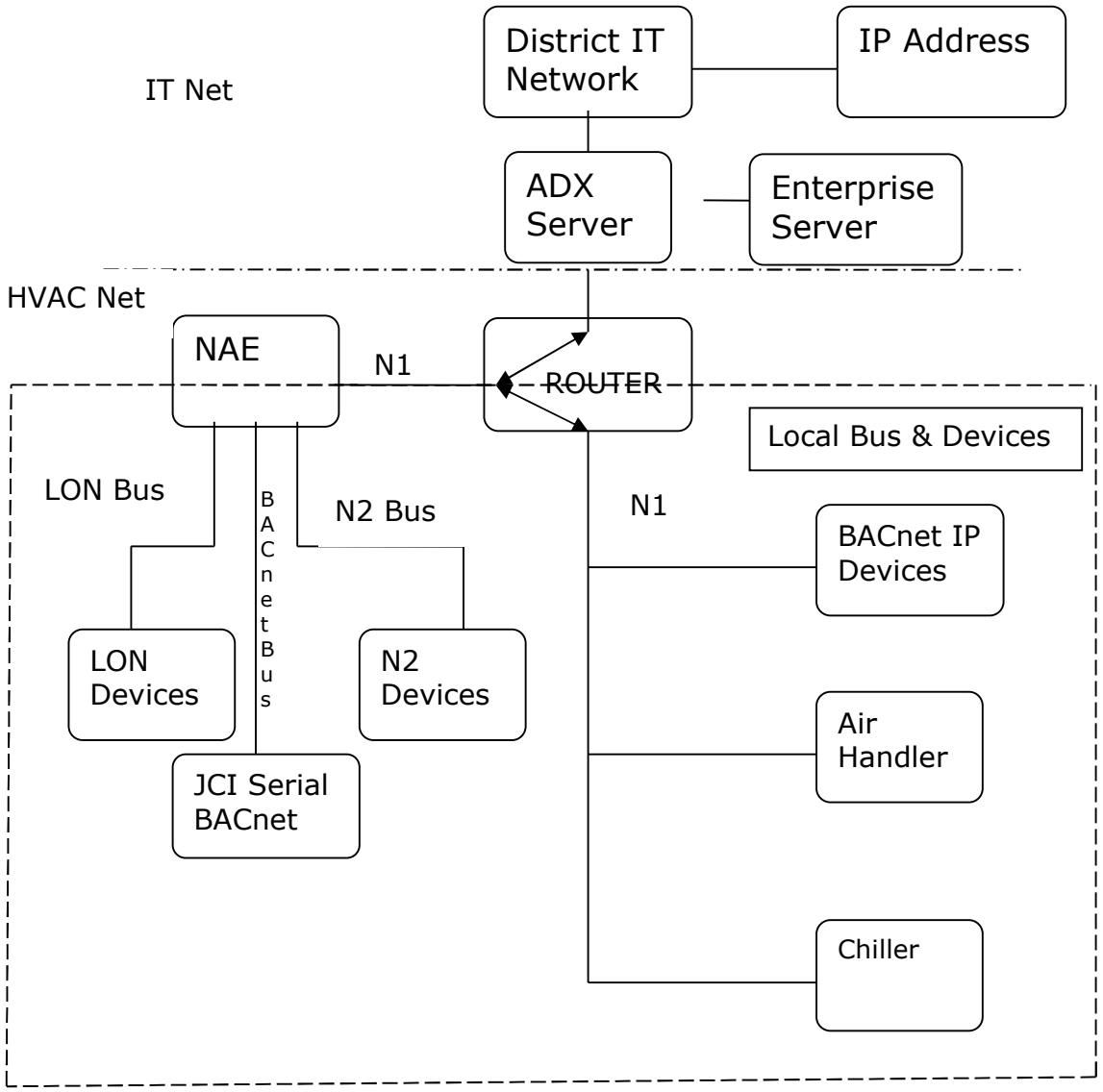
5.10.1.6. Refrigerants: All systems over five tons must use a refrigerant approved by BSD HVAC Department.

5.10.1.7. Refrigerant R-410a is acceptable for small DX equipment (20 tons or less).

5.10.1.8. Ground fault protection for equipment is required on systems over 50 tons.

6. APPENDICES

APPENDIX A: CONTROLS NETWORK STRUCTURE



APPENDIX B: VAV DESIGN PARAMETERS

a) Size to:

   a. Heating: 70 +/- 1°F

   b. Cooling: 75 +/- 1°F

   c. Economizer Return Air (RA)> Outside Air (OSA) > 50°F

   d. Heating Design Day 17°F

   e. For hydronic system (hot water reset = 40°F/140°F)

   f. **Preferred system**: Gas pack Air Handling Unit (AHU) (17°F HDD) and Hydronic VAV (40°F/140°F)

   g. Gas pack used for warm up and Night Low Limit (NLL) only.

   h. Rooftop units over 200,000 Btu = modulating burner 4:1 turndown minimum

b) Match zone loads to avoid simultaneous cooling and heating. **Design with separate interior and perimeter zones.**

c) Airside economizers required for all air handling equipment.

d) Use demand control ventilation when required by Oregon code and for spaces with large population diversity. The method chosen should limit outside air to a reasonable default set point in the event of a sensor going out of calibration.

e) Heat recovery ventilation recommended for areas with greater than 50% minimum outside air. **BSD approval required for any system requiring greater than 50% minimum outside air.**

f) Fume hoods and exhaust fans need tempering of make up air. Air balance must be addressed during design. Design minimum air setting for VAV boxes to balance at less than 50% of cooling cubic feet per minute (cfm).

g) Floating-point valve actuators shall not be used with VAV systems. Self-balancing ball valves are preferred.

h) All rooftop VAV systems with gas packs shall be designed and programmed so that the gas heat is used only for night low limit, morning warm-up, and provide backup during a boiler failure.

i) There are three modes of control for each rooftop unit. A separate Proportional Integral Derivative (PID) control loop shall be required for each mode. The modes are heating mode, ventilate, and mechanical cooling mode.

j) Building static control should be accomplished by controlling return fans to track supply fans. Units with exhaust fan instead of a return fan should have the fan controlled as recommended by the unit manufacturer.

APPENDIX C: VAV SEQUENCE OF OPERATIONS

Gas-Fired, DX Cooled, Variable Air Volume RTU with VAV Exhaust Fan

*Note: All values in parentheses are initial settings and shall be user-adjustable from the graphical and text user interfaces.

a) UNOCCUPIED

a. Fans off, heat off, DX cooling off, and dampers indexed to full recirculation.

b. Unoccupied Low Limit

i. The unoccupied low limit shall be accomplished by both the RTU gas furnace and the terminal unit hot water re-heat (boiler operation). The system shall continuously monitor the lowest VAV terminal unit zone temperature associated with the VAV RTU. When the lowest zone temperature drops below the RTU night low limit set point (55°F), the RTU fan will start and heating staged to full heating. All VAVs shall be indexed to control to current air flow set point to ensure proper flow across RTU heat exchanger. RTU dampers shall remain in full recirculation. Units shall heat until lowest zone is five degrees above RTU night low limit set point.

ii. Subject to the boiler outside air lockout temperature (65°F), when the RTU fan is operational in unoccupied low limit and there is a call for heating at any VAV terminal unit served by that unit, the boiler system will be enabled.

c. Warm-up

i. Fan runs continuously. Based on the average zone temperature, the optimum start/stop function starts the RTU in warm-up mode so that the average zone temperature will reach set point at the scheduled occupancy time. The RTU set point shall be the calculated average of all individual zone temperature set points for the VAV terminal units served by the RTU.

ii. During warm-up, the dampers shall remain in full circulation and shall cycle to minimum outside/CO_2/economizer control at occupancy time regardless of average zone temperature. The boiler system and terminal units shall be enabled for warm-up mode at the same time as the first RTU starts for warm-up.

b) OCCUPIED

a. The occupied sequence of operations for the gas-fired heat, DX cooled, Roof Top Units shall consist of three separate control modes: heating, ventilation and mechanical cooling modes. All modes are active continuously during occupied mode subject to individual mode limits. This will allow heating and ventilation mode to be in effect at the same time and ventilation and mechanical cooling to be in effect at the same time. Based on mode limits, heating and mechanical cooling modes should not be in effect at the same time.

b. Fan runs continuously. Modulate gas furnace, economizer dampers, and mechanical cooling to control zone temperatures per the following operating modes.

c) HEATING MODE

a. The gas furnace shall be locked out above an outside air temperature of (65) °F. Gas furnace is disabled unless average zone temperature falls below RTU heating/warm-up set point.

d) VENTILATION MODE

b. The mixed air control shall modulate to control the following, in the priority order listed:

   i. Mixed air low limit set point (45°F) to prevent comfort problems.

   ii. Mixed air high limit set point (85°F) to prevent excess cooling load.

   iii. CO_2 high limit set point (800–1200 ppm reset).

   iv. Discharge air temperature set point (reset on outside air) subject to outside air temperature lockout. If the outside air is above return air temperature (2 degree dead band), modulate dampers to minimum air flow.

   v. Minimum ventilation air flow rate: (350 cfm)

c. The discharge air set point shall be reset from (55)°F at (70)°F outside air to (65)°F at (50)°F based on an outside air temperature reset. If the outside air temperature is above the return air temperature the mixed air should be at minimum position as allowed by the minimum outside air setting and CO_2 level.

e) MECHANICAL COOLING MODE

d. DX cooling shall be locked out below an outside air temperature of (60) °F. The system shall continuously monitor the highest VAV terminal unit zone temperature associated with the VAV RTU. The RTU will modulate the mechanical cooling to maintain the highest VAV terminal unit temperature at the RTU cooling temperature set point.

e. The computer room unit thermostat should not be allowed to participate in any “voting” for average or maximum zone temperature.

f) FAN CONTROL

f. The RTU supply fan shall control to a duct static pressure set point. The system shall continuously monitor the maximum VAV terminal unit damper position and reset the duct static pressure from 0.5” to 1.5” so the maximum damper position is continuously at 95%.

g. The exhaust fan shall not be energized unless the dampers are positioned at greater than 50%. When operating, the RTU exhaust fan shall control to the building static pressure set point (0.03”).

Revision History

Rev 1: 12/31/18

Section	Section Title	Revision
IV.A.7.	HVAC SYSTEMS; GENERAL; Miscellaneous	▪ Install HVAC shut-off button to shut down building HVAC system. Locate button in the main office. Provide an openable, clear plastic cover to prevent accidental activation, as well as a visual indicator to alert office staff if activation occurs.

Rev 2: 2/2025

Section	Section Title	Revision
All	All	Renumbered all sections of the Technical Standard; included other minor formatting and edits for clarity.