DIVISION 23: HEATING, VENTILATING AND AIR CONDITIONING

23000 - BASIC REQUIREMENTS

General
All HVAC designs shall comply with the requirements of the most currently adopted editions of the following codes, regulations, and references:

- International Building Code
- Uniform Mechanical Code
- B31.1 Power Piping Code
- ASHRAE Handbooks
- ASHRAE Standards
- Model Energy Code
- SMACNA Duct Construction Standards
- National Uniform Seismic Installation Guidelines
- ASPE Data Books
- NAC Chapter 618 (Boilers and Pressure Vessels)
- Americans with Disabilities Act
- The American National Standard for Accessible & Usable Buildings & Facilities
- Local codes and ordinances as may be applicable

Energy Conservation
All HVAC systems designs shall comply with the requirements of the Model Energy Code (most current edition). The Model Energy Code requires compliance with (defers to) ASHRAE/IES Standard 90.1 for all commercial building construction.

In accordance with NRS 338.190, prior to the construction or renovation of any public building with a gross floor area greater than 20,000 square feet, a detailed life cycle cost analysis, including the cost of operation and maintenance, must be completed. The study shall identify measures for the conservation of energy (and shall consider the use of alternate non-fossil fuels when applicable). The analysis shall include comparisons of at least three different HVAC system types. The three different system types to be evaluated shall be reviewed and approved by the University Facilities Services Mechanical Engineer prior to beginning the analysis. A separate narrative shall be provided outlining the building envelope insulating values (for walls, glass, roof, etc.) and specific HVAC system components (i.e., plate and frame heat exchangers, variable frequency drives, compensating type kitchen exhaust hoods, etc.) as they relate to energy conservation.

HVAC Systems and Equipment
All new buildings shall utilize heat provided by the Central Heat Plant unless directed otherwise by FSD.
Heating and air conditioning load calculations for Reno Nevada shall be completed utilizing the following criteria:

<table>
<thead>
<tr>
<th>Indoor</th>
<th>Outdoor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating</td>
<td>72F</td>
</tr>
<tr>
<td>Cooling</td>
<td>74F</td>
</tr>
</tbody>
</table>

All equipment shall be rated for an elevation of 5,000 feet above mean sea level.

Propylene glycol shall be used in any system that has a hydronic coil and uses 100% outside air such as a makeup air unit. This pertains to new systems as well as existing. Engineering calculations shall be performed on the entire new or existing hydronic system to verify that the equipment will perform satisfactorily with glycol. Glycol shall be added to the system in the amount to provide freeze protection down to 0°F, unless specifically requested otherwise by Facilities Services. The percentage of glycol added to the system shall not exceed 40%.

Heating and air conditioning load calculations shall not incorporate safety factors. Safety factors shall only be applied in selecting the desired equipment.

Equipment Manufacturers

The following manufacturers shall be used for the equipment listed:

- Frequency Drives: Yaskawa, ABB, or Danfoss
- Roof-top units: York, Carrier, or Trane
- Modular, Copper Fin, Gas-Fired Hot Water Boilers: Lochinvar, Hydrotherm
- Chillers: Carrier, Trane, York, McQuay.
- Centrifugal Pumps: Goulds, Bell & Gossett, or Grundfos
- Custom Air Handlers: Temptrol, Scott Springfield, Governair, Marcraft, Energy Cabs
- Plate and Frame Heat Exchangers: Alfa-Laval, ITT Bell & Gossett or Tranter
- Shell and Tube Heat Exchangers: Bell & Gossett
- Make-Up Air Units: Greenheck, Reznor, Modine, Trane, Rapid

BASIC MATERIALS AND METHODS

All equipment, ductwork, and piping shall be braced for the applicable seismic zone. Seismic bracing requirements shall be specifically identified in the Contract Documents (such that bracing requirements and/or methods are not merely left to the discretion of the Contractor).

Maintenance

All equipment and equipment rooms shall be designed to ensure adequate provisions for maintenance. Special consideration shall be given to ensure proper clearances for maintenance of filters and removal of chiller and boiler tubes, fan housings, and fan shafts.
Access to equipment for service and maintenance shall be thoroughly coordinated with FSD and the State Public Works Division. Required clearances shall be specifically identified on the drawings (for equipment such as fan coils, VAV boxes, air handling units, control panels, etc.). Coordinate with other disciplines to ensure that other trades (electrical, fire sprinkler, etc.) are made aware of the required clearances.

230593 – AIR CLEANING DEVICES
Contractor to provide one complete air filter change prior to air balance and provide one additional set of filters to UNR for all new equipment installed. See Section 234100 – Filters for Filter types.

230593 – TESTING, ADJUSTING AND BALANCING
New or remodeled HVAC systems shall have an air and water balance performed by a certified AABC balancing company. Balance reports shall include HVAC equipment data, air/water flows, and test equipment calibration reports.

Remove clean and replace all strainers prior to water balance.

Replace all air filters with new prior to air balance.

230900 – INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 – GENERAL REQUIREMENTS
1.1 BMS GENERAL:
A. BACKGROUND: Many of UNR’s buildings are controlled by Direct Digital Controls (DDC). The majority of the campus Direct Digital Controls are either Johnson Metasys or Automated Logic. Pneumatic controls make up the rest and are slowly being converted over to DDC. Prior to mid-2007, all Metasys DDC controls communicated on a Johnson Controls proprietary N2 bus. Since the release of JCI’s BACnet controllers, UNR has begun to pursue BACnet as the campus HVAC control system platform. All new buildings shall use BACnet standard MS/TP, TCP/IP bus protocol ASHRAE Standard-135 or ALC Arcnet. Additions to existing buildings may be BACnet, ALC Arcnet or N2. This will be considered on a case by case scenario with the UNR Controls Department. Network Control Modules (NCM’s) are used on the existing N2 bus. NCM’s are migrated into the web based architecture via the Network Integration Engines (NIE’s). Network Automation Engines (NAE’s) are available for N2, and/or BACnet bus topologies. When installing a Metasys system, NAE’s shall be the Network Controller installed on all new UNR buildings and building additions. If ALC is being installed, ALC Land Gate Routers shall be used. If Alerton is being installed, Building Control Modules (BCM’s) will be used. BACnet, to include BACnet over Arcnet and BACnet MS/TP, will be the unitary bus of choice for all new buildings. BACnet IP will be used for the Global level communications. All new construction must provide graphics with accompanying text fields for all pertinent data along with user view trees (see UNR Controls Department for any questions). Servers are used as part of the Building Management System (BMS) for extensive archiving of system configuration data, trending, operator transactions, and alarming purposes. These functions shall be performed through the use of virtual servers for the Metasys, ALC and Alerton systems. All will be using SQL databases.

B. GENERAL: The control system shall provide direct digital control with a Windows-based user interface. The manufacturer and/or their authorized representative shall be responsible
1. Furnish and install a microprocessor based BMS that is compatible with Microsoft Windows complete with surge suppressors, operating software, and training. All software should be updated to the latest revision, but check with the UNR Controls Department first before performing any upgrades.

C. BMS SOFTWARE AND PROGRAMMING REQUIREMENTS:

1. The Temperature Control Contractor shall program the eleven State Holidays into the EMCS software for the five years following the date of the installation.
2. Equipment Schedules - A separate occupied/unoccupied schedule shall be provided for each air handling unit, fan coil unit, exhaust fan, and/or other individual air handling system.
3. Outside air temperature sensors which are capable of sensing both temperature and humidity shall be programmed to display dry bulb temperature, wet bulb temperature, and relative humidity. The University has gone to a great expense to provide reliable outside temperature/humidity sensors. The campus has been divided into climatic zones. The Temperature Controls Contractor is required to map the point from the nearest climatic zone instead of installing a new sensor.
4. Each zone shall be capable of being set to either a global set point or a remote set point with adjustable dead bands for each. The global set point can be utilized to set/adjust the temperature in all associated zones with a single set point. Each air handling unit and its associated zones and/or each floor of fan coil units shall have a separate global set point. The strategy for global set point assignment shall be confirmed with the State Public Works Board and UNR’s Controls Department prior to programming. The remote set point is an individually adjustable set point for each zone provided by the Controls Department.
D. GRAPHIC DISPLAYS

Graphics:

1. Campus Graphic:
   a. The campus graphic will show all UNR buildings.
   b. Each building footprint will be a link to that building’s main screen.
   c. If an alarm is present anywhere in that building, the footprint will be red. If it is a critical alarm, it will flash red at 2X/second.

2. Common Main Screen/Sub-screen Items:
   a. Begin all graphics with the default screen layout for “graphic without navigation tree” (980W x 652H).
   b. Text font:
      i. All Acronyms to be CAPITALIZED as well as the First Letter Of Each Word.
      ii. All text to be standardized as Arial 12pt. except for:
         1. Equipment labels: Arial/12pt/bold adjacent to equipment (above if possible)
         2. Links: Arial Unicode MS/12pt/bold/underlined/left justified, located at top left of page. Links should reflect screen names, but may be abbreviated.
         4. Date & Time: Arial Unicode MS/12pt/yellow, locate the date and time on the top center below the screen name. The date (format: month/day/year) followed by day of week. The time follows date (format: hour/minute/am, pm) all on a single line.
   c. If a screen is a thermographic floor plan, it will follow the guidelines under “Main Screen”.
   d. Variable formatting: all temperatures, pressures, flows, energy readings and analog outputs shall exclude decimal places with the following exceptions:
      i. Zone, OSA DB, OSA WB temperatures, and water loop differential pressures to have a single decimal place.
      ii. Duct and filter pressures to have two decimal places.
      iii. Building static pressure to have three decimal places.

3. Main Screen:
   a. Building picture (small) to be located at top right quadrant with OSA-DB, %RH and Sun/cloud symbol. This is the only page where %RH shall be shown except for humidifiers, and zone humidification sensors.
   b. Graphic screen links:
      i. Equipment may be accessed through the actual equipment foot prints as shown on the floor plans. Equipment text names shall be displayed on each floor graphic sub screen.
ii. In addition to equipment footprint links, there will be other links in text, examples are shown below:
   1. UNR Campus
   2. Energy
   3. Heating Hot Water
   4. Chilled Water
   5. AHU: 1-X
   6. Fan Coils
   7. Lighting
   8. Miscellaneous

For small projects, the thermographic floor plans and text links may all be on the main screen. For larger projects, there will be a link to a Text Link Page which will follow the Main Screen. The Text Link Page will provide enough space for all the building equipment allowing the equipment to be reached either through the Text Link Page, or the floor plans.

   c. Sequence of operations link will bring up a detailed sequence of all equipment operations. It will be organized top to bottom in like manner to the tree (Hot Water System, Chilled Water System, etc.).

   d. Organize the tree to match the order of the equipment links.

   e. If a building needs “Summer/Winter” mode, it shall be located on the main screen under time/date.

   f. Thermographic floor plans:
      i. Shall be located below.
      ii. The color code legend shall be below the floor plans with the North indicator to the right of the legend. The color code shall be as follows:
         1. Green = satisfied within dead band, typically 69-77°F
         2. Yellow is up to two degrees hotter than Green’s range (77-79°F)
         3. Orange is up to two degrees hotter than Yellow’s range (79-81°F)
         4. Red is hotter than Orange’s range (>81°F)
         5. Light blue is up to two degrees cooler than Green’s range (69-67°F)
         6. Dark Blue is up to two degrees cooler than Light Blue’s range (67-65°F)
         7. Red is cooler than Dark Blue’s range (<65°F)
      iii. If possible, thermographic screens will be interactive on the main screen. The floor text name will link you to a full screen interactive thermographic floor plan.
iv. If possible, the entire zone will be the link, not just a thermostat, or label within the zone. If there is more than one room in a zone, all rooms shall be linked.

v. Floor plans shall be stripped down from AutoCad floor plans, and shall include the following.
   1. Room Numbers
   2. Thermostat locations
   3. Equipment locations and designations only if actually located in the space.
   4. Roll over to show zone equipment name

4. Sub Screens:
   a. Screen name to follow building name in this format, “Building Name: Screen Name”.
   b. Screen names will reflect depicted equipment such as: Hot Water System, Chilled Water System, AHU-1, AHU-1’s VAV’s (if all are shown), AHU-1’s VAV’s: 1-14 (if multiple screens are required), etc. (UNR note: each piece of equipment to be named per PM’s ACAD identifiers. Notify EH&S anytime you find their drawings not following the PM names).
   c. A Miscellaneous graphic will be used for components not closely associated with other screens such as sump pumps, DW systems, EF’s, etc.
   d. An Energy screen will display all kW and BTU meter data for each project.
   e. If system has a hand/off/auto switch, it will be located below Date/Time text.
   f. Outside air dry bulb temperature to be shown at top/right on each screen for all air moving equipment next to the Sun/cloud symbol. This value does not need any designation text. Outside air dry bulb, and wet bulb to be included on all screens with evaporative cooling (cooling towers, etc.) Wet bulb temperature to be preceded with “WB”. Note: percent relative humidity only to be shown on main screen in this format “XX%RH”.
   g. CHWS and HWS temperatures to be shown at the piping for each associated coil.
   h. At a minimum, each sub screen will have a link to the “Main” screen. In addition to the main screen, sub screens will have other links as follows:
      i. AHU’s will have a link to/from the next/previous AHU, the cooling system and the heating system, and to its VAV summary page if applicable.
      ii. VAV summary screens (described below) will link back to its AHU, or to additional VAV summary pages from this AHU if applicable. Individual VAV graphic pages can be accessed either via thermographic floor plans, or the VAV summary page.
      iii. Individual VAV graphics will have links for the heating system, the cooling system, and the associated AHU.
iv. The Chilled Water System shall have a link to the Condenser Water System, and vice versa.

i. In general, all data fields shall be adjacent to their associated equipment. Any data fields not associated with a graphic item shall be located at the screen bottom in columns/rows.

j. Commanded Equipment: equipment which is commanded must follow the command or an alarm shall follow. It shall be commanded on or off with “S/S” such as: “S/S On”, or “S/S Off”. A “Status” line will be located below the command. If the status does not equal the command, a “Failure” text will show up in red below the status line.

k. Enabled Equipment: equipment which is enabled, such as a boiler, has its own onboard controls that will start/stop it. Therefore, the status may not follow the command and will not be alarmed. These devices have a separate “Alarm” field. The command for enabled equipment shall still be “S/S” such as: “S/S Enabled”, or “S/S Disabled”.

l. Object labels should be on the left side (right justified) and data on the right (left justified).

m. Valve and damper positions to be shown in “%”. Other text indicating “Open” or “Closed” is not needed since it is assumed to be reading the open position. The exception is for 3-way valves. In this case, locate text identifying the main flow path after the “%” such as “Coil”, or “Chiller”.

n. Piping lines should never cross unless there is no other option. If they must cross, one pipe is to show a break. Provide flow direction arrows and water flow animation.

5. Summary Screens:

a. To be efficient, multiple typical equipment, such as Fan Coils, VAV’s, Exhaust Fans, etc., shall be shown in a summary matrix. Each screen shall provide: zone location, temperature, set point (global/remote), discharge air temperature, valve position, fan command, fan status, dead band set point(s), CFM set points, CFM flow rate, etc. as is applicable for the equipment. Summary screen format and required display data shall be approved by UNR’s Controls Department prior to screen development.

6. Alarms:

a. Alarm conditions will be shown in red and will begin on the campus map with the entire building footprint. As you drill down to the main screen, the entire equipment footprint and link will be red, and so on until you arrive at the final sub-screen. Critical alarms shall follow the same alarm strategy with the exception that they will flash red on/off at twice per second.

b. UNR has an alarm matrix that will be used to define alarm groups and routing.

c. Every alarm shall have an associated pop-up.

7. Offline Controller/Points:

a. Either of these issues will follow the same guidelines as “Alarms” with the exception that the color code shall be pink instead of red. In the event that a
piece of equipment has both conditions occurring at the same time, the color code on the equipment link shall be red, but the graphic screen shall differentiate which point(s) are in alarm (red), and which point(s) are experiencing a failure condition (pink). If the entire controller is offline, then all associated point fields shall show pink.

8. Overrides:
   a. When a point has been manually overridden, both the data and associated text field shall change to orange and will only show up on the bottom tier graphic.

9. Custom Graphic Elements:
   a. UNR has some modified graphic elements (.PNG files) so all contractors shall use our data base to keep everything standard. All graphic elements (.BMP, .JPG, .PNG) files that are created and used on any graphic shall be stored on our common G-drive, in a folder. The contractor shall have rights to access this folder and no others.

10. Miscellaneous:
    a. All graphic displays shall be submitted to the State Public Works Board and UNR’s Temperature Controls Dept. for review and approval prior to commencing any programming. Required screen resolution shall be confirmed with the State Public Works Board (in writing) prior to development of graphic displays (note that the typical graphic display screen resolution is 1024 by 768).
    b. All displays specified to be dynamic shall depict motion. As a minimum, dynamic displays shall include rotating fan wheels and rotating pump impellers and water flow through pipes.
    c. All set points which are identified as “adjustable” in the written control sequences shall be adjustable via the associated graphic displays (including dead band between heating and cooling room set point).
    d. All occupied mode and unoccupied mode room temperature set points shall have an adjustable dead band (adjustable from the associated graphic display).
    e. All set points adjustable from the graphic displays shall be programmed with the dead band on one side of the set point, not split evenly across the set point, unless otherwise specified.
    f. All inputs and outputs shall be programmed with the capability to override the values via the associated graphic display (this requirement applies to all equipment, valves, dampers, fans, pumps, temperatures, etc.).
    g. The main graphic page shall have a link to the as-built control drawings, all commissioning documentation, schedules and operation and maintenance manuals as defined in 1.6.
1.2 QUALITY ASSURANCE:
A. Permits and Inspections: Unless covered under the Mechanical Contractor’s Construction Permit, the Controls Contractor shall obtain all permits and shall submit written evidence to the University Project Manager that required permits and inspections have been secured.

B. In the case of conflicts or discrepancies between the drawings and specification, it must be brought to everyone’s attention via the RFI process.

C. Engineering, Supervision, and Documentation: The Controls Contractor shall supply all labor and materials for documentation of provided equipment, job supervision, checkout, start-up, and calibration, and commissioning with designated agent for all specified equipment and systems, and for training of University personnel on the new equipment provided by the Controls Contractor.

D. Controls Contractor Availability: The Controls Contractor’s Project Coordinator shall be present at the job site as required for job supervision, trade coordination, installation assistance, inspection, certification of the equipment installation and testing, start-up assistance, control system demonstration, and training of University personnel.

E. Hardware to be Furnished and Installed: The Controls Contractor shall furnish, calibrate, and install all electronic, electrical and pneumatic instrumentation, plus associated wiring and/or tubing required to operate the systems according to the design intent and letter of the specifications. This includes but is not limited to all-sensing elements, transmitters, transducers, and actuators. All hardware shall conform to the current UNR standards.

F. System Testing: The Controls Contractor shall test the complete control system in accordance with UNR’s standards. The Controls Contractor shall demonstrate to the Controls Department that the controls system performs per the sequence of operation.

G. Controls Contractor shall be responsible for ensuring all other aspects of the complete control system are provided, installed and complete in all respects so as to perform the measurement, monitoring, and control functions specified in the design and construction documents. The BMS Controls Contractor’s work shall consist of the provision of all labor, materials, tools, equipment, software, software licenses, software configurations and database entries, interfaces, wiring, tubing, installation, labeling, engineering, calibration, documentation, samples, submittals, testing, commissioning, control loop fine tuning, reasonable sequence changes, training services, permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance, temporary protection, warranties, services, and items, even though these may not be specifically mentioned in these Division documents which are required for the complete, fully functional and commissioned BMS.

H. Provide a complete, neat and workmanlike installation. Use only manufacture representatives or direct subcontractors to them who are skilled, experienced, trained, and familiar with the specific equipment, software standards and configurations to be provided for the project.

I. Manage and coordinate the BMS work in a timely manner in consideration of the project schedules. Coordinate with the associated work of other trades to not impede or delay the work of associated trades.
The Contractor shall be the primary manufacturer owned branch for JCI or the local associate dealer for ALC or the local associate dealer for Alerton that is regularly engaged in the engineering, programming, installation, and service of total integrated BMS. The contractor shall maintain a staffed local office within 50 miles of the UNR campus.

K. Workplace Safety and Hazardous Materials
1. Provide a safety program in compliance with the Contract Documents.
2. The BMS Contractor shall have a corporately certified comprehensive Safety Certification Manual and a designated Safety Supervisor for the Project.
3. The Contractor and their employees and sub-trades shall comply with federal, state and local safety regulations.
4. The Contractor shall ensure that all subcontractors and employees have written safety programs in place that covers their scope of work, and that their employees receive the training required by OSHA which has jurisdiction for at least each topic listed in the Safety Certification Manual.
5. Hazards created by the Contractor or its subcontractors shall be eliminated before any further work proceeds.
6. Hazards observed but not created by the Contractor or its subcontractors shall be reported to either the General Contractor or the Owner within the same day. The Contractor shall be required to avoid the hazard area until the hazard has been eliminated.
7. The Contractor shall sign and date a safety certification form prior to any work being performed, stating that the Contractors’ company is in full compliance with the Project safety requirements.
8. The Contractor’s safety program shall include written policy and arrangements for the handling, storage and management of all hazardous materials to be used in the work in compliance with the requirements of the authority having jurisdiction (AHJ) at the Project site.
9. The Contractor’s employees and subcontractor’s staff shall have received training as applicable in the use of hazardous materials and shall govern their actions accordingly.

L. Quality Management Program
1. Designate a competent and experienced employee to provide BMS Project Management. The designated Project Manager shall be empowered to make technical, scheduling and related decisions on behalf of the BMS Contractor. At minimum, the Project Manager shall:
   a. Manage the scheduling of the work to ensure that adequate materials, labor and other resources are available as needed.
   b. Manage the financial aspects of the BMS Contract.
   c. Coordinate as necessary with other trades.
   d. Be responsible for the work and actions of the BMS workforce on site.
1.3 COORDINATION OF TRADES:

A. General: The work of this Division shall be scheduled, coordinated, and interfaced with the associated work of other trades. Reference Division 15 and 16 Sections for details. If the BMS Contractor believes there are conflicts or missing information in the project documents, the Contractor shall promptly request clarification and instruction from the design team.

B. Mechanical Contractor Coordination:

1. All temperature control dampers shall be furnished and installed by the Mechanical Contractor. This includes all economizer dampers, back draft dampers, airflow control dampers, fire dampers, fire smoke dampers, and VAV/CAV terminal units. The intent of this requirement is to keep all of the sheet metal work under the Mechanical Contractor.

2. The Controls Contractor shall provide and install necessary control elements and control signals to all temperature control dampers, and test the operation of these dampers following installation by the Mechanical Contractor. The responsibility for repair or replacement of control elements shall be by the Controls Contractor, whereas the dampers shall be borne by the Mechanical Contractor and/or control damper supplier.

3. All measurement and control devices requiring connection into piping, such as pressure transmitters, thermo wells, temperature transmitters, flow transmitters, and control valves, shall be furnished by the Controls Contractor for installation by the Mechanical Contractor.

C. Electrical Contractor Coordination:

1. The Electrical Contractor shall furnish and install all motor starters, motor disconnect switches as required, all line voltage service conduit and wiring to motors, and all line voltage conduit and wiring to VFD’s. The Controls Contractor will provide and install interposing relays as required for start/stop and monitoring functions in the field terminal panel(s), and interconnect wiring between the relays and motor starters. The controls contractor is to provide all VFD’s.

2. The electrical contractor to provide and furnish the power panels and dedicated 120 VAC, 20A circuits for controls. The electrical contractor shall pull power from the breakers to the controls contractor’s field devices, or panel as required for a complete system. If emergency power is provided for the building, control circuits will be on emergency power circuits. Please reference electrical drawings for circuit locations.

1.4 REFERENCES:

A. All work shall conform to the following Codes and Standards, as applicable:

3. Underwriters Laboratories (UL) listing and labels.
4. UL 864 UUKL Smoke Control
5. UL 268 Smoke Detectors.
6. UL 916 Energy Management
10. Factory Mutual (FM).
12. National Electric Manufacturer’s Association (NEMA).
13. American Society of Mechanical Engineers (ASME).
14. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE), ASHRAE standard 62.1 IAQ as applicable, and standard 135 BACnet as applicable.
15. Air Movement and Control Association (AMCA).
16. Institute of Electrical and Electronic Engineers (IEEE).
18. Electronics Industries Association (EIA).
19. Occupational Safety and Health Administration (OSHA).
22. Americans Disability Act (ADA)

B. All work shall meet the authorities having jurisdiction at the project site.

1.5 SUBMITTALS:
A. Shop Drawings, Product Data, and Samples:
1. The BMS contractor shall submit a list of all shop drawings with submittals within 30 days of BMS contractor contract award.
2. Submittals shall be in defined packages. Each package shall be complete and shall only reference itself and previously submitted packages. The package shall be as approved by the Architect, Engineer, and UNR Controls Department.
3. Allow 30 working days for the review of each package in the scheduling of the total BMS work.
4. Equipment and systems requiring approval of local authorities must comply with such regulations and be approved. Filing shall be at the expense of the BMS Contractor where filing is necessary. Provide a copy of all related correspondence and permits to the Owner.
5. Prepare an index of all submittals and shop drawings for the installation. Index shall include a shop drawing identification number, Contract Documents reference and item description.
6. The BMS Contractor shall correct any errors or omissions noted in the first review as required by the engineer, architect, and UNR Controls Department.
7. At a minimum, submit the following:
   a. BMS network architecture diagrams including all nodes and interconnections.
   b. Systems schematics, sequences and flow diagrams.
   c. Points schedule for each point in the BMS, including: Point Type, Object Name, Display Units, Controller type, and Address.
   d. Samples of Graphic Display screen types.
   e. Detailed Bill of Material list for each system or application, identifying quantities, part numbers, descriptions, and optional features.
   f. Control Damper Schedule including a separate line for each damper provided under this section and a column for each of the damper attributes, including: Part Number, Fail Position, Damper Type, Duct Size, Damper Size, Mounting, and Actuator Type, and damper manufacturer torque requirements.
   g. Control Valve Schedule including a separate line for each valve provided under this section and a column for each of the valve attributes: Part Number, Configuration, Fail Position, Pipe Size, Valve Size, Body Configuration, Close off Pressure, Capacity, Valve CV, Design Pressure, and Actuator Type.
h. Room Schedule including a separate line for each VAV box and/or terminal unit indicating location, box size, CFM: min, max, reheat, type (series, parallel), with/without reheat, and address.
   i. Details of all BMS interfaces and connections to the work of other trades.
   j. Product data sheets or marked catalog pages including part number, photo and description for all products including software.

1.6 RECORD DOCUMENTATION:
A. Operation and Maintenance Manuals
   1. A total of four (4) copies of Operation and Maintenance Manuals shall be provided. Three (3) copies shall be provided to the Owner's Representative upon completion of the project. One (1) copy shall be hand delivered directly to the Control Shop Supervisor upon completion of the project. The entire Operation and Maintenance Manual shall be furnished on Compact Disc media, and include the following for the BMS provided:
      a. Table of contents.
      b. As-built system record drawings must have complete updates and report all modifications during construction and the acceptance testing. CAD record drawings shall represent the as-built condition of the system and incorporate all information supplied with the approved submittal.
      c. Manufacturer's product data sheets or catalog pages for all products including software.
      d. System Operator's manuals.
      e. Archive copy of all site-specific databases and sequences to include set points, PID parameters, timers, delays, etc.
      f. BMS network diagrams.
      g. Interfaces to all third-party products.
   2. The Operation and Maintenance Manual CD shall be self-contained, and include all necessary software required to access the product data sheets. A logically organized table of contents shall provide dynamic links to view and print all product data sheets. Viewer software shall provide the ability to display, zoom, and search all documents.

1.7 WARRANTY:
A. General: The Controls Contractor shall warrant that all equipment supplied, and all work performed shall be free from defects in workmanship and materials for a period of one year from acceptance by the University. If any such products or workmanship should prove to be defective within the one year period, the contractor agrees either to correct by repair or by replacement with equivalent product or corrective workmanship, provided that such defects developed under normal and proper use. The equivalency determination rests with the University. Troubleshooting services shall be the responsibility of the contractor; preventative maintenance of the system is the responsibility of the Owner.
2.0 PART 2 - PRODUCTS

2.1 DDC CONTROL MODULES:
A. Acceptable Manufacturers/Controllers: Automated Logic Corporation; Johnson Controls Inc., or Alerton.
   1. Land Gate Router (LGR); Network Automation Engine (NAE); Alerton Integration Engine (AIE)
   2. Multi-Equipment Control Module (M-Series); Field Equipment Controller (FEC); Visio Logic Expanded (VLX)
   3. Room Controllers (RC-Series); Network Thermostats (TEC), Visual Logic Displays (VLD)
   4. Multi-Equipment Control Expanders’ (ME/MX Series); Input / Output Modules (IOM); Expansion Modules (EXP)
   5. Control Modules (ZN-Series); Network Sensors (NS), VAV Controller (VMA); Visual Logic Controllers (VLC)
   6. Single Equipment Control Module (SE-Series); Visual Logic Controller (VLC); Field Equipment Controller (FEC)
B. Spare Controller Capacity: All controllers (except application-specific controllers for fan coils, heat pumps, and VAV boxes) shall be furnished with a minimum of 20% spare points capacity to allow for addition of both analog and digital inputs and outputs. Expansion cards will not be accepted as a means of providing additional inputs and/or outputs to meet this requirement. Controller’s memory and/or CPU shall not be overloaded.

2.2 BMS INTEGRATION:
A. Direct Protocol (Integrator Panel)
   1. The BMS system shall include appropriate hardware equipment and software to allow bi-directional data communications between the BMS system and 3rd party manufacturers’ control panels. The BMS shall receive, react to, and return information from multiple building systems, including but not limited to chillers, boilers, variable frequency drives, power monitoring system, and medical gas.
   2. All data required by the application shall be mapped into the Network controller and shall be transparent to the operator.
   3. Input and output points from the third-party controllers shall have real-time interoperability with BMS software features such as: Control Software, Energy Management, Custom Process Programming, Alarm Management, Historical Data and Trend Analysis, Totalization, and Local Area Network Communications.
B. BACnet Protocol Integration
   1. The neutral protocol used between systems will be BACnet over Ethernet and comply with the ASHRAE BACnet standard 135.
   2. A complete Protocol Implementation Conformance Statement (PICS) shall be provided for all BACnet system devices.
   3. The ability to command, share point object data, change of state (COS) data and schedules between the host and BACnet systems shall be provided.

2.3 INPUT DEVICES:
General: All equipment shall be sized, selected, installed, setup, and calibrated as appropriate for the application and per the manufacturer’s specifications.
A. Temperature Sensor General Requirements:
1. Sensors and transmitters shall be provided, as outlined in the input/output summary and sequence of operations.
2. The temperature sensor shall be of the resistance type, and shall be two wire 1000 ohm nickel RTD, two-wire 1000 ohm platinum RTD, or thermistor 10k-2 (10k ohms @ 25°C, -55 to 150°C)
3. Room sensors shall be mounted per ADA requirements if not otherwise specified in the project plans/specs.
4. Room sensors on exterior walls must be mounted with adequately insulated bases, and insulation must be stuffed inside the wall to block off internal wall air flows. Wall boxes shall be caulked around perimeter and conduit penetrations sealed.
5. All fluid temperature monitoring must be accomplished by using insertions sensors inside thermo wells. Wells must be filled with thermo conducting compound.
6. All HVAC air moving equipment shall have a duct discharge air temperature sensor installed. This includes but is not limited to: Air Handling Units, Roof Top Units, Make Up Air units, Fan Coils, Terminal Units, etc.
7. The following point types (and the accuracy of each) are required, and their associated accuracy values include errors associated with the sensor, lead wire, and A to D conversion:
   a. Chilled Water +/- 0.5°F.
   b. Room Temp +/- 0.5°F.
   c. Duct Temperature +/- 0.5°F.
   d. All Others +/- 0.75°F.

B. Room Temperature Sensors
1. Room sensors shall be constructed for either surface or wall box mounting.
2. Room sensors shall have the following options when specified:
   a. Set point adjustment providing a minimum +/- 3 degree (adjustable) range.
   b. A momentary override request push button for activation of after hour’s operation with LED status.
3. Temperature and mode display.
4. Acceptable Manufacturers: Johnson Controls, BAPI, ACI or equal upon approval.

C. Thermowells
1. When thermo-wells are required, the sensor and well shall be supplied as a complete assembly.
2. Thermo wells shall be pressure rated and constructed in accordance with the system working pressure.
3. Thermo wells and sensors shall be mounted in a thread-o-let or 1/2” NFT saddle and allow easy access to the sensor for repair or replacement.
4. Thermo-wells and sensors must be matched in size. It must be sized such that the end of the well is located in the center of the pipe.
5. Thermo-wells shall be constructed of 316 stainless steel, if installed in the High Temperature Hot Water System (HTHWS), all other installations may be brass.
6. Acceptable Manufacturers: Johnson Controls, Mamac, BAPI, ACI or equal upon approval.

D. Outside Air Sensors
1. UNR has divided its campus into zones which group buildings into similar OSA climates. Each zone has a NIST certified Vaisala OSA temperature sensor and %RH
transmitter. The values from these devices are mapped across the BMS network to all buildings in their respective zones.

2. New buildings or new control installations in buildings that do not have a standalone OSA sensor will have a new OSA and %RH sensor installed. After the new control system is brought online on the campus network, the mapped sensors will be programmed as the primary sensor and the standalone sensors will be programmed as the backup in the event that the primary goes unreliable. In addition, the program will be written in such a way as to allow for manually selecting which sensor is used as the primary.

E. Duct Mount Sensors
1. Duct mount sensors shall mount in an electrical box through a hole in the duct, and be positioned so as to be easily accessible for repair or replacement.
2. If the duct has exterior insulation, the sensor shall be provided with standoff spacers with insulating material firmly fitted around spacers.
3. Duct sensors shall be insertion type and constructed as a complete assembly, including lock nut and mounting plate.
4. For outdoor duct applications, a weatherproof mounting box with weatherproof cover and gasket shall be used.
5. Acceptable Manufacturers: Johnson Controls, Mamac, BAPI, ACI or equal upon approval.

F. Averaging Sensors
1. For ductwork greater in any dimension than 48 inches, mixed air applications, or where air temperature stratification could exist, an averaging sensor shall be used.
2. The sensor shall have continuous averaging over the entire element; discrete points will not be accepted.
3. The sensor element shall be installed in a serpentine fashion with no less than 18” between each pass. The element must span horizontally to within 8” from each coil edge.
4. Capillary supports at the sides of the duct shall be provided to support the sensing string.
5. Acceptable Manufacturers: Johnson Controls, Mamac, BAPI, Veris Industries, Grey Stone, and Minco ACI.

G. Humidity Sensors
1. The sensor shall be a solid-state type, relative humidity sensor. The sensor element shall resist surface contamination.
2. The humidity transmitter shall be equipped with non-interactive span and zero adjustment; a 2-wire isolated loop powered 4-20 mA, or 0-10VDC, and 0-100% linear proportional output.
3. The humidity transmitter shall meet the following overall accuracy, including lead loss and Analog to Digital conversion. 3% between 20% and 80% RH @ 77 Deg F unless specified elsewhere.
4. Transmitters shall be shipped factory pre-calibrated.
5. Acceptable Manufacturers: Veris, Mamac, ACI or equal upon approval.

H. Pressure Transmitters
General Air and Water Pressure Transmitter Requirements:
1. Pressure transmitters shall be constructed to withstand 100% over-range pressure without damage, and to hold calibrated accuracy when subject to a momentary 40% over-range input.

2. Pressure transmitters shall transmit a 0 to 5 VDC, 0 to 10 VDC, or 4 to 20 mA output signal. Maintain accuracy up to 20 to 1 turndown ratio. Reference Accuracy: +0.2% of full span. Acceptable manufacturer: Veris or equal upon approval.

3. Differential pressure transmitters used for flow measurement shall be sized to the flow sensing device, and shall be supplied with Tee fittings. Shut-off valves in the high and low sensing pick-up lines shall only be provided for water to allow the balancing Contractor and Owner a permanent, easy-to-use connection. Acceptable manufacturer: Veris or approved equal.

4. A minimum NEMA 1 housing shall be provided for the transmitter. Transmitters shall be located in accessible local control panels wherever possible.

5. The exterior sensing tip for a building differential air pressure transmitter shall be installed with a shielded static air probe to reduce pressure fluctuations caused by wind. The outside air static probe must be a Static Outside Air Probe (S.O.A.P.) provided by Air Monitor Corporation. Location of pressure sensors shall be shown on control as-built drawings.

6. Sensors shall be Veris, Setra or equal upon approval. Veris PX series shall be used for Air and PW series for wet application.

Room pressure monitoring and/or control:

a. Any pressure monitoring and/or control below 0.10” shall not be done by mechanical diaphragm, strain gauge, or similar means. It shall be by thermal anemometer technology which senses air flow and correlates this to a pressure difference.

b. It shall be a through the wall pressure sensor UL listed for 2-hour fire walls, bi-directional +/- 0.00001” accuracy. Display shall have audio & visual alarms along with keypad and LCD display for field adjustment of parameters. Monitor shall have dual alarm time delays for door closed and door open conditions. Furnish and install GE 1076 flush mount door switches on all associated doors. Monitor shall be a native node on BACnet control network. Sensors shall be TSI, Setra or equal upon approval.

I. Carbon Dioxide: CO₂ sensors shall be silicon based NDIR single beam dual wavelength technology. Acceptable manufacturers are Vaisala, Johnson Controls, INTEC or equal upon approval.

J. Air Flow Monitoring: Acceptable manufacturer: Ebtron or equal upon approval.

K. Static Pressure Traverse Probe

1. Duct static traverse probes shall be provided where required to monitor duct static pressure. The probe shall contain multiple static pressure sensors located along exterior surface of the cylindrical probe.

2. Acceptable manufacturers: Cleveland Controls or equal upon approval.

L. BTU Monitoring Devices

1. Building BTU’s shall be monitored by the building’s gas supply source, if the building is not on the HTHW loop, using a Sierra Instruments model series 640S gas mass flow meter, or equivalent upon approval. The meter shall provide an output which can be read
by the BMS. Mass flow shall be sent to the Bulb server where it will be converted to BTU's and the data held in long term storage.

2. Heating hot water system: if the building heat is supplied by the campus HTHWS, the secondary side of the building heat exchanger shall be monitored. Flow shall be read by strap on ultrasonic flow sensors and a matched pair of strap on temperature sensors. All inputs shall go into a centralized BTU meter which performs all data calculations.

Acceptable manufacturers are: the Fluxus ADM 7407 by Flexim with either Modbus or BACnet communication options, or the SITRANS FUE1010 by Siemens which comes in Modbus or N2 communication protocols.

M. Electrical Power Monitoring Devices

Power meters shall be supplied and installed under Division 16 (see 16010). Meters shall be Nexus series 1262.

N. Refrigerant Leak Detectors

1. The refrigerant leak detector shall be a standalone device and shall provide a SPDT output to directly energize the refrigeration room exhaust ventilation fans. The detector shall include a sensor or sensors connected to a control panel. Two relay contacts at the control panel shall provide trouble and alarm indication to the BMS. The alarm relay contact shall also directly energize the exhaust fans.

2. The sensor(s) shall be mounted at 18” above finished floor. The detector shall have an adjustable sensitivity range to allow for alarming at any refrigerant concentration from 100PPM to 1,000PPM. The sensor(s) shall be factory calibrated with the first stage alarm (non-audible alarm) calibrated at 600PPM, the second stage alarm (non-audible alarm) calibrated at 800PPM, and the third stage alarm (audible and visible alarms) calibrated at 1,000PPM. The third stage alarm shall also enable the emergency ventilation system. Refrigerant leak monitor shall be furnished with optional remote audible/visible alarms (horn/strobe combination). Locate two horn/strobes at each chiller room exit (one inside and one outside of each exit door). Install each horn/strobe at approximately 7’-6” above finished floor. Remote audible/visible alarms shall be suitable for either indoor or outdoor installation Acceptable manufacturers: Amseco Model CSHB-BG (with blue light lens) or approved equal by Kele & Associates.

3. The refrigerant leak detector shall sense the type of refrigerant used in the specified chillers. Multiple sensors shall be required to detect different refrigerants and/or provide proper sensing coverage for the area of the refrigeration room. Acceptable manufacturers: MSA Instruments, or equal upon approval.

O. Smoke Detectors: Smoke detectors shall be furnished as specified elsewhere in Division 16, and for installation under Division 15. All wiring for air duct detectors shall be provided under Division 16, Fire Alarm System.

P. Current Sensing Switches

1. The current sensing switch shall be self-powered with solid-state circuitry and a dry contact output. It shall consist of a current transformer, a solid state current sensing circuit, adjustable trip point, solid state switch, SPDT relay, and an LED indicating the on or off status. A conductor of the load shall be passed through the window of the device. It shall accept over-current up to twice its trip point range.
2. Current sensing switches shall be used for run status for fans, pumps, and other miscellaneous motor loads. Note: If VFDs are used, motor status shall come from VFD status output.

3. Current sensing switches shall be calibrated to show a positive run status only when the motor is operating under load. A motor running with a broken belt or coupling shall indicate a negative run status.

4. Devices shall be split core to have the ability to be installed and removed on a conductor without disconnecting the conductor.

5. Acceptable manufacturers: Veris Industries, Functional Devices, or equal upon approval.

Q. Air Filter Status
   1. Differential pressure transducers shall be used to monitor air filter status.
   2. A complete installation kit shall be provided, including: static pressure taps, tubing, fittings.
   3. Acceptable manufacturers: Veris Industries or equal upon approval.

R. Air Pressure Safety Switches
   1. Air pressure safety switches shall be of the manual reset type with DPDT contacts rated for 2 amps at 120VAC.
   2. Pressure range shall be adjustable with appropriate scale range and differential adjustment for intended service. Installed device locations shall be indicated on control as-built drawings.
   3. Acceptable manufacturers: Penn, Dwyer or equal upon approval.

T. Water Flow Switches: Water flow switches shall be Penn P74 or equal upon approval.

U. Low Temperature Limit Switches
   1. The low temperature limit switch shall be of the manual reset type with Double Pole/Single Throw snap acting contacts rated for 16 amps at 120VAC.
   2. Mount on the discharge side of the first water or steam coil in the air stream.
   3. The sensing element shall be a minimum of 15 feet in length and shall react to the coldest 18-inch section. Element shall be mounted horizontally across duct in STRICT accordance with manufacturers recommended installation procedures.
   4. The sensor element shall be installed in a serpentine fashion with no less than 18” between each pass. The element must span horizontally to within 4” from each coil edge.
   5. Capillary supports at the sides of the duct shall be provided to support the sensing string.
   6. For large duct areas where the sensing element does not provide full coverage of the air stream, additional switches shall be provided as required, and wired in series, to provide full protection of the air stream. Provide additional switches at a ratio of one linear foot of element per one square foot of duct opening or coil surface area.
   7. The low temperature limit switch shall be Penn A70 or equal upon approval.

2.4 OUTPUT DEVICES:
General: All equipment shall be sized, selected, installed, setup, and calibrated as appropriate for the application and per the manufacturer’s specifications.
A. Actuators

1. General Requirements
   a. Damper and valve actuators shall be electronic
   b. Electronic control actuators for all valves and dampers shall be modulating 4-20 mA or 0-10 VDC control signal, unless the application calls for a two position function. Two position functions with fail safe positions shall be achieved with actuators that are powered to drive and unpowered to spring return to the fail safe position. Three wire “floating control” actuators are powered to drive one direction, and reverse powered to drive in the other direction. They shall only be allowed for 2-position, non-fail safe applications. They shall never be used for modulating applications, except for the onboard integrated actuator on the VAV controller. Modulating actuators with fail safe positions shall do so via spring return.
   c. All actuators shall have external adjustable stops (to limit the travel in either direction), and a gear release to allow manual positioning.
   d. Two-position or open/closed actuators shall accept 24 or 120 VAC power and be UL listed.
   e. Modulating actuators shall accept 24 or 120 VAC or 24 VDC power, consume no more than 15 VA, and be UL listed. The control signal shall be 2-10 VDC or 4-20 mA.
   f. Each actuator shall have current limiting circuitry incorporated in its design to prevent damage to the actuator.
   g. Acceptable manufacturers: Belimo, or equal upon approval.

2. Damper Actuators
   a. Electronic damper actuators shall be mounted directly to the shaft.
   b. Actuator sizing shall be based on actuator manufacturer’s recommendations in regards to face velocity, differential pressure and damper type. The actuator mounting arrangement and spring return feature shall permit normally open or normally closed positions of the dampers, as required.

3. Valve Actuators
   a. Actuators shall provide the minimum torque required for proper valve close-off against the system pressure for the required application. The valve actuator shall be sized based on valve manufacturer’s recommendations for flow and pressure differential. All actuators shall fail in the last position unless specified with mechanical spring return in the sequence of operations. The spring return feature shall permit normally open or normally closed positions of the valves, as required. All direct shaft mount rotational actuators shall have external adjustable stops to limit the travel in either direction.
   b. Butterfly isolation and other valves, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop the associated pump or chiller.

B. Control Relays

1. Control pilot relays shall be of a modular plug-in design with retaining springs or clips.
2. Mounting Bases shall be snap-mount.
3. DPDT, 3PDT, or 4PDT relays shall be provided, as appropriate for application. SPDT are not allowed. DPDT is the minimum number of contacts.
4. Contacts shall be rated for 10 amps at 120VAC.
5. Relays shall have an integral indicator light.
6. Acceptable manufacturers: Idec or equal upon approval.
C. Control Valves
   1. All automatic control valves shall be fully proportional and provide near linear heat transfer control. The valves shall be quiet in operation and fail-safe open, closed, or in their last position. All control valves shall be sized by the control manufacturer, and shall be guaranteed to meet the heating and cooling loads, as specified. All control valves shall be suitable for the system flow conditions and close against the differential pressures involved. Body pressure rating and connection type (sweat, screwed, or flanged) shall conform to the pipe schedule.
   2. Chilled water control valves shall be modulating ball, and/or butterfly, as required by the specific application. Modulating water valves shall be sized per manufacturer’s recommendations for the given application.
   3. Ball valves shall be used for hot and chilled water applications, water terminal reheat coils, radiant panels, unit heaters, package air conditioning units, and fan coil units except those described hereinafter.
   4. Butterfly valves shall be acceptable for modulating only on condenser water supply to a chiller for head pressure control application, and for all two-position, open/close applications. In-line and/or three-way butterfly valves shall be heavy-duty pattern with a body rating comparable to the pipe rating, and a replaceable lining suitable for temperature of system. Valves for isolation service shall be the same as the pipe. Valves in the closed position shall be bubble-tight.
   5. Acceptable manufacturers: Belimo or equal upon approval.

2.5 MISCELLANEOUS DEVICES:
   A. General: All equipment shall be sized, selected, installed, setup, and calibrated as appropriate for the application and per the manufacturer’s specifications.
   
   B. Variable Frequency Drives shall be provided by the controls contractor. The following points must be hard wired: start/stop, status, and speed, whereas kW and fault shall be networked. Acceptable manufacturers: ABB, Dan Foss, or Yaskawa.

   C. Local Control Panels:
      1. All control panels shall be professionally constructed, incorporating the BMS manufacturer’s standard designs and layouts. Control panels shall be fully enclosed, with perforated sub-panel, hinged door, and slotted flush latch.
      2. Low and line voltage wiring shall be separated. All wiring that comes into the panel, must first go to the terminal strip, and then to the controller. All provided terminal strips and wiring shall be UL listed 300-volt service and provide adequate clearance for field wiring.
      3. All wiring shall be neatly installed in plastic trays or tie-wrapped.
      4. Panels shall not be located directly underneath valves or other areas where they may be subject to water, heat, or steam damage. Panels shall be mounted with the top no higher than 7 feet above the floor with a minimum of 3 feet frontal clearance.
      5. Panels shall be mounted on, or adjacent to the equipment they serve – with the exception of Network Controllers. If a panel must be located away from the equipment it serves, contact the Controls Shop for location coordination. Network Controllers are to be located in data rooms. Contact the Controls Shop for any deviation from this directive.
      6. A convenience 120 VAC duplex receptacle shall be provided in each enclosure, fused on/off power switch, and required transformers (transformers to have secondary protection via onboard circuit breaker).
7. Surge suppression is required for all control panels and network controllers.
8. All panels must have terminal strips with enough extra slots to allow for the 20% extra point count of the controllers.

D. Power Supplies:
1. DC power supplies shall be sized for the connected device load. Total rated load shall not exceed 75% of the rated capacity of the power supply.
2. Input: 120 VAC +10%, 60Hz.
3. Output: 24 VDC.
4. Line Regulation: +0.05% for 10% line change.
5. Load Regulation: +0.05% for 50% load change.
6. Ripple and Noise: 1 mV RMS, 5 mV peak to peak.
7. An appropriately sized fuse and fuse block shall be provided and located next to the power supply.
8. A power disconnect switch shall be provided next to the power supply.

E. Thermostats:
4. Electric room thermostats of the heavy-duty type shall be provided for unit heaters, cabinet unit heaters, and ventilation fans, where required. All of these items shall be provided with concealed adjustment. Finish of covers for all room-type instruments shall match and, unless otherwise indicated or specified, covers shall be manufacturer’s standard finish.

3.0 PART 3 - PERFORMANCE/EXECUTION:

3.1 SPECIFIC REQUIREMENTS:
A. Graphic Displays: Contact the UNR Controls Department for current graphic specifications.
B. Object Naming: See UNR Controls Department for current list.
C. Custom Reports: Provide custom reports, alarm points and messages as required for this project.
D. 30-minute point history samples will be provided on all analog points and all inputs and outputs involved in control loops for 72 hours of first in first out data trends. Binary inputs and outputs to trend change of state.

3.2 INSTALLATION PRACTICES:
A. BMS Wiring:
1. All conduit, wiring, accessories and wiring connections required for the installation of the Building Management System, as herein specified, shall be provided by the BMS Contractor unless specifically shown on the Electrical Drawings under Division 16. All wiring shall comply with the requirements of applicable portions of Division 16 and all local and national electric codes, unless specified otherwise in this section.
2. Bus communication cabling shall be selected to only have the minimum quantity of conductors required. Doubling of the conductors for the purpose of bringing the bus communication back from the device shall not be allowed in the same cable. All Johnson Controls Metasys bus cable (N2 and BACnet) shall be blue jacketed. ALC Arcnet and MSTP bus cables shall be green. Alerton MSTP bus cables shall be orange. All bus
communication cable shall meet controls manufacturer requirements/standards. Paint all conduit covers blue for Metasys or green for ALC. Alerton to be orange.
3. Each device that requires an IP address (such as a global controller, chiller, boiler, VFD, etc.) shall have a dedicated network drop from the IT department’s managed switch. Single network drops that split to multiple devices via a hub or mini-switch shall not be allowed. Hubs or Mini-switches shall only be installed with written authorization from the Controls Department on a case by case basis but are generally not allowed.
4. Cables shall be continuous and without splices (except at field terminal panels). Cable jacketing must extend into the cabinet.
5. All low voltage wiring (whether plenum rated or not) shall be installed in raceways with the following conditions, clarifications, and exceptions:
   a. Fire alarm and security system wiring shall follow National Electrical Code guidelines.
   b. Low voltage wiring for data, communications, intercom, temperature controls, and energy management systems may be routed utilizing open cable trays above accessible ceilings.
   d. Where open cable trays are utilized above accessible ceilings the following conditions apply.
      i. Low voltage wiring routed in open cable trays shall be plenum-rated (whether or not the ceiling space is utilized as a return air plenum).
      ii. Low voltage wiring concealed in walls, floors, and above inaccessible ceilings shall be routed in raceways or conduit.
      iii. Low voltage wiring routed between conduit stubs and cable trays shall be secured with appropriately spaced J-supports.

B. Identification – Equipment / Wiring:
1. Wire Labels: All instrument and output device wiring shall be labeled at every termination including both sides of interim splices within field terminal panels (splices out in the field are not acceptable). Labels are required for wire pairs, and not for individual wires. Labels shall be installed within two (2) inches of termination, or in the case of I/O devices around the wire jacket anywhere in the device wiring cavity within six (6) inches of termination. Labels shall be machine printed with indelible ink on heat shrinkable plastic tubing. In no case are self-adhesive labels accepted, unless machine printed and protected with clear heat shrinkable tubing. Label names shall reflect the BMS object name as displayed on the network (i.e. SF-S). The Controls Contractor to contact the UNR Controls Department for current nomenclature.
2. Equipment Labeling: Equipment, devices and sensors which is located above the ceiling must be indicated by a label on the ceiling beneath the unit. For T-bar ceiling, locate label on metal cross supports. The equipment label must follow the nomenclature called out on the mechanical prints (example: TU-113, AHU-1, etc.).
3. Panel Labeling:
   a. Each panel face shall have an engraved plastic tag bearing the panel number designated in the riser drawing along with the equipment name it controls.
   b. Each component shall be tagged on the panel back plate with a machine printed tag bearing the BMS object name, i.e. SF-C for the relay that commands on the supply fan. Controls contractor must Contact UNR Controls Department for current object name list.
4. Sensor Labeling: a. Room sensors shall be labeled with the corresponding terminal unit or fan coil unit number and controller address. Labels shall be self-adhesive clear back
C. Accessibility: All instruments shall be installed such that they are accessible for removal, repair, or recalibration in place. All instrument cabinet doors shall allow full one hundred twenty (120) degree opening without interference. Any installation deemed by the University to be inaccessible shall be corrected by the Contractor at no extra cost to the University.

D. Penetrations:
1. Provide fire stopping for all penetrations used by dedicated BMS conduits and raceways.
2. All openings in fire proofed or fire stopped components shall be closed by using approved fire resistive sealant.
3. All wiring passing through penetrations, including walls shall be in conduit or enclosed raceway.
4. Penetrations of floor slabs shall be by core drilling. All penetrations shall be plumb, true, and square.

3.3 TRAINING:
A. Contractor to provide a training submittal that outlines both the subjects to be covered and the time for each. The Contractor shall furnish the services of competent instructors who will give instruction in the adjustment, operation, programming and maintenance (including pertinent safety requirements) of the equipment and system specified. The training shall be oriented toward the specific project system installed rather than being a general training course. Each instructor shall be thoroughly familiar with all aspects of the subject matter they are to teach. All equipment and material required for classroom training shall be provided by the Contractor. The training shall include but not be limited to:
1. General Equipment Layout and panel locations
2. Troubleshooting Procedures
3. Preventive Maintenance Procedures
4. Sensor Maintenance and Calibration
5. Controller and network level programming
6. Graphics creation/modification
7. Upload/download of controllers
8. Other topics as requested by Owner
3.4 COMMISSIONING:

A. CALIBRATION AND COMMISSIONING

1. The calibration and commissioning procedure shall consist of validating field I/O calibration, loop checks, actuator stroking, fine tuning and integrated system operation validation. Document all commissioning information on commissioning data sheets, which shall be submitted to the University for approval prior to testing. Notify the Controls Department and HVAC Shops of the testing schedule so that operating personnel may observe calibration and commissioning. Controls Contractor shall provide all tools necessary (i.e., laptops, calibration equipment, radios, etc.).

2. Perform a single point measurement validation of all analog devices for both inputs and outputs. Outputs must be visually verified at: 0%, 50% and 100%. VAV reheat valves and dampers are the only exception to this.

3. Verify instrument ranges.

4. Verify and document binary switch setting

5. Verify and document fail-safe position on loss of control power. Submit calibration data sheets. Data sheets shall include the device designation, the date of calibration, required offset, and name of the person who performed calibration.

6. Loop checks: Perform test of every control device. Contact University Personnel 48 hours before start of test (775-784-1165).

7. System Program Commissioning: After control devices have been calibrated and loop controls verified, each program shall be put on-line and commissioned. The Controls Contractor shall confirm that the program logic follows the approved sequence of operation. Each control loop shall be adjusted to provide stable control within the specified accuracies.

B. ACCEPTANCE TESTING:

1. Submit a detailed acceptance test procedure designed to demonstrate compliance with contract requirements at least 4 weeks prior to testing. This procedure shall be approved by the Controls Department before testing begins. Acceptance test documentation must include equipment sequence of operations, provisions for customer and contractor sign off with date, and remarks for each piece of equipment.

2. During acceptance testing, provide services of a fully qualified building automation technician who is knowledgeable of the project.

3. The Owner and/or his representative shall test all major equipment AHU’s, chillers, heating systems, etc. All functions shall be demonstrated by the Controls Contractor to be in accordance with the sequence of operations. Minor equipment such as VAV boxes shall be selected at random (roughly 15 to 20%) and there functions shall be demonstrated by the Controls Contractor to be in accordance with the sequence of operation. 100% of the functions demonstrated must perform as specified and documented on commissioning data sheets for all major equipment or the system must be re-tested and the owner can then require 100% testing of all equipment including VAV boxes.

4. Furnish instruments required for testing. Submit catalogue data on all instruments for approval prior to performance of tests.

5. Instrument Accuracy

   a. Temperature: 0.5°F or 1/2% of full scale, whichever is less

   b. Pressure: 1.0 PSI or 1/2% of full scale, whichever is less

   c. Humidity: 2% RH

   d. Electrical: 1.0% of full scale
C. ENDURANCE TESTING:

1. After the Control Hardware and Program Performance has been validated, a 60-day endurance test period shall begin. The Controls Contractor is to run trends to fine tune the control loops, and make any adjustments necessary for optimal system functioning. If the system functions as specified throughout the endurance test period requiring only routine maintenance and adjustment, the system shall be accepted. If it fails to perform as specified, the owner may require the endurance to be started over after the problems have been corrected. Any program modifications required during the warranty period shall be the responsibility of the Controls contractor.

2. The Controls Contractor is to provide the UNR Controls Department with a transmittal sheet that can be signed off to begin warranty period.

SEQUENCE OF OPERATION

1.1 Chilled Water Systems - General

A. System enable: The chilled water and condenser water pumps shall be enabled whenever the outside air temperature is above set point (50°F, adjustable, with a 10°F dead band, disabled at 40°F) and any one of the chilled water control valves is 100% open and the chilled water system schedule is enabled (utilize chilled water control valve position for system enable only – do not disable system based on a valve position less than 100% open). Disable the system when the chilled water system schedule goes unoccupied or all the chilled water valves are closed, or if the outside air temperature is below its set point.

B. Unoccupied mode: When the chilled water system is in the unoccupied mode (as determined by the chilled water plant schedule) and any chilled water valve is 100% open, the chilled water system shall be enabled to operate according to the normal occupied mode sequence. In this mode the current outside air wet bulb and/or the dry bulb temperature set point, utilized to switch from heat exchanger mode to chiller mode, is increased by 5°F (adjustable). Pseudo points similar to the object that switches the cooling system from free to mechanical cooling need to be available on the graphic so it can be overridden. This will provide UNR a single point override from which the cooling system can be forced into either condition.

C. Heat exchanger mode: when the outside air temperature is 3°F below the outside air wet bulb temperature set point (50°F minus dead band of 3°F = 47°F) the system is in the heat exchanger mode. The cooling tower fan VFD shall be modulated from 15% to 100% of maximum speed (from 9 to 60 Hz) as required to maintain the condenser water supply temperature set point (46°F, adjustable – with a 12°F range; fan on at 52°F, fan off at 40°F).

D. There shall also be the capability to switch the changeover function from wet bulb to dry bulb temperature control – for example, whenever the outdoor dry bulb temperature exceeds set point (70 °F, adjustable).

E. Chiller mode: The chiller shall be enabled and the flow control valves shall be positioned for flow through the chiller whenever the wet bulb temperature is greater than the HX wet bulb set point, or dry bulb set point (whichever is selected), the heat exchanger can no longer maintain the chilled water below 55 deg f (adj) and the cooling tower has been running a full capacity for 10 minutes. When entering either the heat exchanger mode or chiller mode provide a minimum on timer to keep the system from short cycling. The initial time for the chiller mode is 60-minutes (adj.); for the heat exchanger mode it is 30-minutes (adj.) There is a delay between the initial call for mechanical cooling and the time the chiller is actually enabled – first to allow the condenser water supply to rise to 60°F (adjustable) and then an additional 3 minutes to allow the flow control valves to re-position for flow through the chiller.

During the time delay period, the condenser water flow control valves remain positioned for...
flow through the heat exchanger and the condenser water supply set point is at the chiller mode set point (80°F, adjustable) such that the cooling tower fan is off. The cooling tower fan VFD is modulated from 15% to 100% of maximum speed (from 9 to 60 Hz) as required to maintain the condenser water supply temperature set point (80°F, adjustable, with a 12°F range; fan on at 86°F off at 74°F). When the outside air wet bulb temperature falls back 3°F below set point (50°F minus 3°F = 47°F) the chiller shall be disabled and the system shall be returned to the heat exchanger mode. The flow control valves continue to allow flow through the chiller condenser and evaporator for a time delay period of 3 minutes (to prevent developing a high head pressure condition in the chiller condenser or a freeze condition in the chiller evaporator). When the time delay period has elapsed, the flow control valves shall be positioned for flow through the heat exchanger. The 3-way valve in the condenser water supply piping at the chiller (valve furnished by the chiller manufacturer and controlled by the chiller integral controls) is modulated to maintain the desired chiller head pressure. The 3-way valve shall have a maximum stroke time of 60 seconds. The chiller integral controls shall be set to maintain a 45°F (adjustable) CHWS temperature set point to be adjustable thru the network.

F. Freeze protection: The cooling tower first stage sump heater(s) shall be enabled whenever the sump temperature falls below set point (37°F, adjustable, with a 3°F dead band, disabled at 40°F). The cooling tower second stage sump heater(s) shall be enabled whenever the sump temperature falls below set point (34°F, adjustable, with a 4°F dead band, disabled at 38°F). The sump heaters shall be disabled whenever the sump is empty (as sensed by the low water level float switch – furnished with cooling tower). The electric heat tracing on the condenser water supply piping, return piping, make-up water piping, and drain valve at the cooling tower is self-regulating to 40°F (electric heat trace by mechanical).

G. Emergency ventilation: Whenever the refrigerant vapor level in the chiller room exceeds 800 ppm and/or whenever any one of the emergency ventilation switches is switched the emergency exhaust fan is enabled, the louver damper is opened, and an alarm condition is indicated. When refrigerant vapor levels fall back down below 800 ppm, and/or the emergency ventilation switches are returned to their normal position, the fan is disabled and the louver damper is closed. Provide an emergency ventilation switch at each chiller room exit, one just outside of each door (as required by Uniform Mechanical Code) to enable the emergency exhaust fan and louver damper. Switches shall be breakable glass type. Provide plastic nameplate to read “Chiller Emergency Ventilation.” Provide complete system as required by Uniform Mechanical Code.

H. Emergency shut-down: Provide an emergency shut-down switch at each chiller room exit, one just outside of each door (as required by the Uniform Mechanical Code) to disconnect the power to the chiller(s) and to the associated pumps. Switches shall be break-glass type. Provide plastic nameplate to read “Chiller Emergency Shut-Off.”

I. The chilled water and condenser water pumps are started whenever the chilled water system is enabled. Chilled water pumps will delay five minutes and then turn off when the chilled water system is disabled.
1.2 Heating Water System – General
A. The lead heating water pump and the lead boiler (if the building has its own boiler), or HTHW heat exchanger along with the corresponding circulating pump (if the building is heated by the central heat plant), shall be enabled whenever the outside air temperature falls below set point (initially 60°F, with a 10°F dead band, off at 70°F) and when any heating valve is calling for 100% heat. Whenever the outside air temperature is below 40°F (with a 10°F dead band, off at 50°F) regardless of call for heating, start the HX, hot water pumps or boilers and modulate to maintain temperature. When the outside air rises above the set point and there is no call for heat from any hot water valve, the boiler(s) (or HTHW heat exchanger) is disabled, the lead heating water pump and the lead boiler’s (or HTHW heat exchanger) circulating pump shall remain enabled for 5 minutes (to prevent residual heat from exceeding the boiler high limit temperature or cause the PRV to operate on HTHW heat exchanger). Should the lead heating water pump fail, the lag pump shall be enabled and an alarm shall be generated. When the lead pump restarts, the lag pump shall be disabled. The hot water return temperature shall be reset by modulating the 3 way valve in accordance with the following schedule (initially a 1:1 ratio): 160°F hot water return at 30°F outside air temperature and 130°F hot water return temperature at 90°F outside air temperature. There shall be the ability to select either automatic hot water supply reset or to select a manual hot water supply set point. The lag boiler (along with its corresponding circulating pump) shall be enabled whenever the hot water return temperature falls more than 20°F (adjustable) below the current hot water return set point. The lag boiler shall be disabled when the hot water return temperature (after the bypass loop) reaches the current hot water return set point. When the lag boiler is disabled, the lag boiler’s circulating pump shall remain enabled for 5 minutes (to prevent residual heat from exceeding the boiler high limit temperature). The boiler integral controls (on each boiler) shall be set to cycle the burner to maintain set point (180°F with a differential set at 7°F, i.e. on at 153°F, off at 160°F). Note: the operating control on the specified boiler is sensing/controlling hot water return temperature. The manual reset high limit control on each boiler shall be set at approximately 210°F. An alarm condition shall be indicated upon failure of each boiler burner and/or whenever the hot water supply temperature is 15°F above or below the set point for more than 15-minutes with an additional 15-minute delay on startup.
B. Emergency Shut-Down: Provide an emergency shut-down switch at each boiler room exit, one just outside the exterior door and one just outside of the interior door (as required by ASME Code) to disconnect the power to all boiler burners. Switches shall be break-glass type. Provide plastic nameplate to read “Boiler Emergency Shut-Off.”

1.3 Air Handling Systems – Mixed Air Single Path VAV with CO2 Control
A. Occupied Mode: the air handling unit supply and return fan (if applicable) shall be enabled at the occupied time (unless started earlier utilizing the optimum start program). The return fan shall start first. The supply fan VFD shall be modulated from 15% to 100% of maximum speed (from 9 to 60 Hz) as required to maintain the duct static pressure set point (approximately 1.0” w.c. adjustable, or as determined by the test and balance contractor). If a return fan is used, its VFD will track the supply fan VFD minus an offset. The outside air damper shall open to minimum position. Additionally the outside air damper shall be modulated open - as needed to maintain the return air CO2 levels below 800ppm. Provide mixed air low limit strategy to throttle back outside air damper anytime mixed air temp drops below setpoint (45° F adjustable). The heating water control valve, the economizer dampers, and the chilled water control valve shall be modulated in sequence to maintain the supply air temperature set point (55°F, adjustable).
B. Economizer mode: Shall be enabled whenever the outside air is below the return air temperature plus an adjustable differential. If the OSA temperature is less than 50°F, lock out cooling.

C. Unoccupied mode: the air handling unit fans are disabled, the control valves are closed, the outside air and exhaust air dampers are closed and the return air damper is open.

D. Unoccupied heating mode: the operation of the outside air damper shall be closed and the return air damper shall be open. The air handling unit supply air temperature shall be reset to 70°F (adjustable). Please refer to “VAV unoccupied heating mode”.

E. Unoccupied cooling mode: the operation of the outside air damper shall be closed and the return air damper shall be open (unless the outside air economizer mode is enabled). See “VAV unoccupied cooling mode”.

F. VAV unoccupied override mode: Whenever one of the room sensor override buttons is pressed during the unoccupied time period, the air handling unit shall be enabled and shall control in the normal occupied mode for a period of two hours (adjustable). All VAV terminals whose override buttons were pushed associated with that air handling unit shall control to their occupied mode room temperature set points, all VAV terminal whose override buttons were NOT pressed shall control to their unoccupied mode room temperature set points.

G. Morning warm-up and morning cool-down modes: the air handling unit shall operate in accordance with the appropriate unoccupied mode sequence (Unoccupied heating mode or unoccupied cooling mode). The optimum start period shall be limited to a maximum of 4 hours (adjustable).

H. Safeties:
1. Freeze Protection – Stage 1: First stage of freeze protection will be utilizing the mixed air averaging sensor in a reverse acting algorithm to modulate the OSA dampers closed to maintain the mixed air low limit set point.
2. Freeze Protection – Stage 2: The second stage of freeze protection shall be via a manual reset freeze thermostat (located downstream of the heating coil). If it falls below set point (approximately 37°F) the outside air damper shall close, the return air damper shall open, the supply and return fans are stopped, heating valve open 100%, and an alarm condition shall be indicated.
3. Smoke Detection: The duct-mounted smoke detector shall disable the fans and dampers whenever smoke is detected.
4. Duct Static: The supply duct static pressure high limit control shall be via a manual reset pressure switch and it will disable the fans whenever the duct static pressure exceeds set point (as per specification – approximately 3.5” w.c.)
5. Filter Alarms: Filters shall be set to alarm at 1.0” w.g. pressure drop (both pre-filters and final filters).

I. Time Schedule: Start and stop supply and return fans. If the fan fails to start as commanded, an alarm shall be sent to the EMCS.

J. Unoccupied Override Mode: If any zone sensor pushbutton override is enabled, the air handler shall go occupied. The enabled zone shall go to occupied, all other zones on that air handler shall go from the unoccupied off mode to the unoccupied controlling mode set points for a predetermined time period of 4-hours (adj.).

K. Optimum Start Mode (Morning Warm-Up & Morning Cool-Down Modes): During morning warm-up and/or morning cool-down modes the air handling unit shall operate in accordance with the appropriate unoccupied mode sequence (Unoccupied Heating Mode and Unoccupied Mode) and shall be enabled at such a time that all zones are at the occupied mode set point at the occupied time. The optimum start period shall be limited to a maximum of four hours (adjustable).
1.4 Variable Air Volume (VAV) Boxes with Reheat

A. Occupied mode: The air volume damper shall be modulated between the minimum and maximum CFM set points as required to maintain the current room temperature set point (initial cooling set point at 74°F, with a 2°F dead band, heating on at 72°F). Upon demand for heating, the damper shall be set to deliver the specified reheat CFM. The reheat global room temperature set point dead band shall be adjustable. The VAV box reheat CFM shall not be allowed unless the hot water supply temperature is above 120°F.

B. Unoccupied heating mode: Whenever any zone temperature falls below the unoccupied mode heating set point (55°F, with a 5°F differential, off at 60°F). The air handling unit fan(s) shall be enabled (with the outside air damper fully closed and the return air damper fully open). The air handling unit supply air temperature shall be reset to 70°F. At the time of the call for heating, the VAV boxes shall be separated into two groups. The first group (VAV boxes serving zones that are below the unoccupied heating set point differential – below 60°F) shall control to the occupied mode heating set point (such that those VAV boxes operate at their reheat CFM with the reheat valve fully opened). Once any zone temperature rises above the heating set point differential (above 60°F), that VAV box shall operate at the minimum CFM, and its hot water valve shall close. The second group (VAV boxes serving zones that are above the unoccupied heating set point differential – above 60°F) shall operate at their minimum CFM. The unoccupied heating mode shall be terminated when all zones have reached the top end of the unoccupied heating set point differential (60°F).

C. Unoccupied cooling mode: Whenever any zone temperature rises above the unoccupied mode cooling set point (85°F set point with a 5°F differential, off at 80°F), the air handling unit fan(s) shall be enabled, with the outside air damper fully closed and the return air damper fully open – unless the outside air economizer mode is enabled. The chilled water system shall be enabled to operate according to the normal occupied mode sequence. At the time of the call for cooling, the VAV boxes shall be separated into two groups. The first group (VAV boxes serving zones that are above the unoccupied cooling set point differential – above 80°F) shall control to the minimum CFM (such that those VAV boxes operate at their maximum cooling CFM). Once any zone temperature falls below the cooling set point differential (below 80°F) that VAV box shall operate at the minimum CFM. The unoccupied cooling mode shall be terminated when all zones have reached the bottom end of the unoccupied cooling set point differential (80°F).

D. Morning warm-up and morning cool-down modes: The air handling unit shall operate in accordance with the appropriate unoccupied mode sequence (Unoccupied heating mode or unoccupied cooling mode). The optimum start period shall be limited to a maximum of 4 hours (adjustable) prior to the occupied time.

E. Unoccupied override mode: Whenever one of the room sensor override buttons is pressed during the unoccupied time period, the air handling unit shall be enabled and controlled in the normal occupied mode for a period of four hours (adjustable). All VAV boxes shall control to the occupied mode room temperature set point.

1.5 Air Handling Systems – Constant Volume

A. Occupied Mode

1. The heating water control valve, the economizer dampers, and the chilled water control valve shall be modulated in sequence to maintain the room temperature set point (initially 74°F cooling set point, with a 2°F dead band to heating set point of 72°F). The minimum supply air temperature shall be set at 55°F (adj.)
2. The economizer mode shall be enabled whenever the outside air temperature is below the return air temperature by 2°F.

B. Unoccupied Mode: the air handling unit fan is disabled, the chilled water and heating water control valves are closed, the outside air damper is closed, and the return air damper is open.

C. Unoccupied Heating Mode: the fan is enabled (with the outside air damper closed and the return air damper open) and the heating water control valve modulated to fully open whenever the zone temperature falls below set point (55°F, adjustable, with a 5°F differential, off at 60°F).

D. Unoccupied Cooling Mode: the fan is enabled (with the outside air damper closed and the return air damper open – unless the outside air economizer mode is enabled) and the chilled water control valve is modulated to fully open whenever the zone temperature rises above set point (85°F adjustable, with a 5°F differential, off at 80°F).

E. Morning Warm-up and Morning Cool-Down Modes: during morning warm-up or morning cool-down modes, the air handling unit shall operate in accordance with the appropriate unoccupied mode sequence (Unoccupied Heating Mode or Unoccupied Cooling Mode). The optimum start period shall be limited to a maximum of 4-hours prior to the occupied time.

F. Unoccupied Override Mode: whenever one of the room sensor override buttons is pressed during the unoccupied time period, the air handling unit shall be enabled and controlled in the normal occupied mode for a period of 4-hours (adj.).

G. Safeties:
   1. Freeze Protection – Stage 1: First stage of freeze protection will be utilizing the mixed air averaging sensor in a reverse acting algorithm to modulate the OSA dampers closed to maintain the mixed air low limit set point.
   2. Freeze Protection – Stage 2: The second stage of freeze protection shall be via a manual reset freeze thermostat (located downstream of the first heating coil). If it falls below set point (approximately 37°F) the outside air damper shall close, the return air damper shall open, the supply and return fans are stopped, heating valve open 100%, and an alarm condition shall be indicated.
   3. The duct-mounted smoke detector shall disable the fans and dampers whenever smoke is detected.
   4. Filter alarms shall be set to alarm at 1.0" w.g. pressure drop (both pre-filters and final filters).

1.6 Fan Coil Units

A. Occupied mode – the fan is enabled and the chilled water and heating water control valves are modulated in sequence to maintain the space temperature set point. The initial cooling set point shall be set at 78°F, and the heating set point at 68°F with a 10° dead band. Both set point and dead band shall be adjustable. Note: Mechanical spaces shall be enabled in unoccupied mode only, unless the occupied override button on the thermostat is enabled. This will place the fan coil in the occupied mode for 4 hours (adj.). In the occupied mode, the fan coil will follow the same sequence. All values are adjustable.

B. Unoccupied mode – the fan is disabled, the chilled water and heating water control valves are closed.

C. Unoccupied heating mode – the fan is enabled and the heating water control valve is modulated to fully open whenever the zone temperature falls below set point (55°F, adjustable, with a 5°F differential, off at 60°F).
D. Unoccupied cooling mode – the fan is enabled and the chilled water control valve is modulated to fully open whenever the zone temperature rises above set point (85°F, adjustable, with a 5°F differential, off at 80°F).
E. Freeze protection: A manual reset freeze stat shall be provided as an additional safety device only when the fan coil has outside air available. The device shall be hard wired to disable the unit. Set the t-stat to 37°F and alarm at the EMCS. The heating and cooling valves will be forced to 100% open in a freeze condition.

1.7 Unit Heaters – Natural Gas
   A. Single temperature electric thermostat set at 68°F maintains constant space temperature. Provide a T500 Thermostat for on/off control if applicable or an Automated Logic ZN module, or a TEC Controller with BACnet communication to allow for monitoring by the EMCS.

1.8 Unit Heaters – Hydronic
   A. Single temperature electric thermostat set at 68°F maintains constant space temperature. Provide a T500 Thermostat for on/off control if applicable or an Automated Logic ZN module, or a TEC Controller with BACnet communication to allow for monitoring by the EMCS. The thermostat will open the heating control valve. Fan is enabled by an aqua stat that senses hot water temperature in the coil.

1.9 Cabinet Heaters
   A. Single temperature electric thermostat mounted as noted on plan set at 68°F maintains constant space temperature. Fan is controlled by an aqua stat based on water temperature and the thermostat. Provide a T500 Thermostat for on/off control if applicable or an Automated Logic ZN module, or a TEC Controller with BACnet communication to allow for monitoring by the EMCS.

1.10 Exhaust Fans – Mechanical Rooms
    A. On room temperatures above 80°F, open intake dampers and start exhaust fans.

1.11 Parking Garage Ventilation Systems
    A. Carbon Monoxide (CO) detector maintains maximum CO level of 50 ppm by cycling exhaust fan. When CO level exceeds 100 ppm, signal alarm.
    B. When exhaust fan starts, start make-up unit.

1.12 Schedules
    A. Each air handling unit, fan coil, exhaust fan, etc., and the central chilled water and heating water plant shall have its own separate occupied and unoccupied time schedule.

Energy Monitoring and Management
Provide University Facilities Services Department a standard electrical monitoring system for each new building. The monitoring system shall use a Veris Industries 8100 series KW power meters with current transformers matched to the actual load. The meters shall have N2 bus capability to interface with Johnson Controls BAS. Mount the meter in the main supply and return piping on the building loop.

Data output shall be:

<table>
<thead>
<tr>
<th>kWh, Consumption</th>
<th>Powerfactor ØB</th>
</tr>
</thead>
<tbody>
<tr>
<td>kW, Real Power</td>
<td>Powerfactor ØC</td>
</tr>
<tr>
<td>kVAR, Reactive Power</td>
<td>Voltage, ØA to ØB</td>
</tr>
<tr>
<td>kVA, Apparent Power</td>
<td>Voltage, ØB to ØC</td>
</tr>
</tbody>
</table>
230910 – LABORATORY SYSTEMS - INSTRUMENTATION AND CONTROL FOR HVAC

A life cycle cost analysis shall be performed to compare constant volume type fume hoods and variable volume systems, and other appropriate technologies, to determine the life cycle costs for each type of system. The analysis will consider energy costs, other operating costs, maintenance costs and initial capital costs. The results shall be reviewed by UNR.

If the analysis indicates a payback of ten (10) years or less for the variable volume system, that system should be specified.

If a variable volume system is chosen, it shall have an occupant sensor for each fume hood which will reduce the air flow to a minimum level when the hood is not in use.

For all variable volume systems, the fume hood shall have a local override control that will permit the operator to run the hood air volume to its maximum rate.

Variable air volume systems controllers must be integrated with the campus controls system – Automated Logic, Johnson Metasys, or Alerton. The system shall provide BACnet interface capabilities.

Variable air volume systems shall have pressure independent airflow control valves suitable for up to 3” w.g. pressure drop.

Variable volume control system must react within 3 seconds to changes in air flow.

Fume hood average face velocities shall be a minimum of 80 fpm at the design sash position of 16” with no individual face velocity measurement less than 65 fpm. All hoods must be tested both in the factory and on-site in accordance with ASHRAE 110. Fume hood designs that demonstrate as installed containment with an average face velocity of less than 80 fpm, such as low flow constant volume hoods, can be considered with approval from Facilities Services and EH&S; however, average face velocities at the design sash position shall be at least 60 fpm. In addition to meeting the requirements of ASHRAE 110 as installed, hood field certification by EH&S is required before being turned over for service to the user.

All fume hoods shall have a flow indicator installed which has both an audible and visual alarm for low flows.

All fume hood exhaust ducting shall be made from 16 or 18 gauge 316 stainless steel with screwed slip joint connections sealed with an appropriate sealant such as polysulfide. Facilities Services will determine if welded ‘TIG’ joints are required based on the laboratory materials and use planned for the fume hoods. (Type 316L must be used if welded joints are specified.)
Additionally, Facilities Services will review alternate duct materials such as galvanized steel if proposed.

Fume hood exhaust shall not pass through unducted areas. Exhaust ducts shall always be at a negative pressure with regard to ambient.

All exhaust fans shall be located outside of the building on the roof or in a dedicated penthouse mechanical room with its own independent ventilation. All motors shall be outside of the duct and be of spark-proof design.

Laboratories with fume hoods shall maintain a slightly negative air pressure with regards to non-laboratory areas. Biosafety level 3 & 4 laboratories require a minimum of -0.03 to -0.05 w.g. differential between the laboratory and adjacent areas.

The fume hood and ducting shall have materials with a flame spread rating of 25 or less, per NFPA method 255.

Fume hood exhausts shall extend above the building roof at least seven (7) feet to prevent personnel exposure and re-entrainment unless modeling demonstrates a higher point of discharge. Air dispersion modeling shall be done for new installations with two or more fume hoods.

Fume hood exhausts should be located at least fifty (50) feet away from any supply air intakes. Exhaust discharge velocities shall be 3,000 fpm to prevent personnel exposure and re-entrainment unless modeling determines a different value is required. This requirement does not negate the need to perform air dispersion modeling. Mixed-flow exhaust fans shall be considered in addition to centrifugal type fans.

Fume hood discharge air shall not be recirculated.

Biological safety cabinets and clean benches are not a substitute for laboratory fume hoods. EH&S is responsible for annual testing of all fume hoods.

The minimum air changes for laboratories are six (6) air changes per hour (ACH) for occupied conditions and four (4) ACH for unoccupied conditions. Supply air is 100% outside air. Variable volume (and constant volume) systems should be designed to have some capability for additional ventilation rates beyond the design level. Facilities Services and EH&S will work with the design team on what additional capacity is feasible for each zone. For a single lab which is served by a single, dedicated make-up air unit and the cooling load cfm exceeds the required exhaust cfm, a make-up air system with outside air and return air is acceptable provided however that the 6 ACH minimum cfm rate required must be outside air.

Fume hoods shall not have automatic sprinkler systems or fire detection devices installed in them, unless specifically required by the authority having jurisdiction.

Heat recovery systems for room and/or laboratory fume hood exhaust shall be considered and a life cycle cost analysis should be performed to determine if the heat recovery system has a payback of ten (10) years or less. Heat recovery for fume hood exhausts shall be 100% cross contamination free between two air stream.
Fume hoods shall be located away from opening windows, doors and high traffic areas. The fume hood shall be designed to contain minor spills. A ¼ inch lip or recess shall be provided within the hood.

Time clocks shall not be used to control fume hood exhaust or sash height.

All hood lighting shall be of UL-listed fixtures and meet NFPA 70, be of fluorescent type and be replaceable from outside the hood.

Sashes shall be made of laminated or tempered safety glass.

Dampers, when used in exhaust systems, shall fail open.

Room ambient air velocities directly adjacent to fume hoods shall avoid strong air currents. Ambient air velocities shall be less than 35 fpm as measured directly in front of the fume hood. Perchloric acid hoods shall meet the requirements of NFPA Chapter 8 and be reviewed by EH&S and Facilities Services during the design phase.

Fume hoods shall meet a noise criteria (NC) curve of NC 55 (DBA) for research labs and NC 40 for teaching labs; measured four (4) feet from the sash face.

Natural-gas, direct-fired make-up air units are not permitted for laboratory make-up (supply) air. Used fume hood are not acceptable unless approved by UNR EH&S.

230933 - ELECTRICAL REQUIREMENTS FOR MECHANICAL EQUIPMENT
All motors over 1/2 horsepower shall be premium efficiency type. Motors shall be open drip-proof (ODP), or totally enclosed fan cooled (TEFC) in high heat or high humidity locations. Minimum motor efficiencies at full load shall be as follows:

<table>
<thead>
<tr>
<th>HP</th>
<th>Efficiency</th>
</tr>
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<tbody>
<tr>
<td>1.0</td>
<td>86%</td>
</tr>
<tr>
<td>5.0</td>
<td>89.5%</td>
</tr>
<tr>
<td>10.0</td>
<td>91%</td>
</tr>
<tr>
<td>50.0</td>
<td>94.1%</td>
</tr>
<tr>
<td>100.0</td>
<td>95.1%</td>
</tr>
</tbody>
</table>

Those motors that will be controlled by a frequency drive shall be inverter rated. Any motor that could possibly have a frequency drive installed at a future date shall be inverter rated.

Ceiling mounted fan coils shall have a power disconnect switch mounted ON the cabinet on the same side as the filter access door. In addition the motor and V-Belt shall be accessible from the same side of the unit.
232100 – HIGH TEMPERATURE HOT WATER (HTHW) PIPING SYSTEMS WITHIN BUILDINGS

Design Parameters
All HTHW systems shall be engineered and tested in accordance with ANSI/ASME B31.1, Power Piping Code. A professional engineer registered in the state of Nevada shall take full responsibility for HTHW system design by affixing his stamp to the drawings and specifications.

All piping, components and heat exchangers shall be rated for hot water service with continuous duty at 400 deg. F at 400 psig. See HTHW Heat Exchanger Piping Diagram Drawing #232116-3.

Materials
Piping located inside buildings shall be ASTM A53B Schedule 40 seamless type S or electric resistance welded type E, schedule 40 or wall thickness as determined by calculations per B31.1 Power Piping Code, whichever thickness is greater. Any piping that is threaded shall be ASTM A53B Schedule 80 seamless type S or type E.

In no case shall piping be smaller than ¾” diameter (NPS)

Fittings shall be 300lb. ASTM A105 forged, socket weld for 2” and below. Above 2”, use butt-weld or 300# flanged carbon steel fittings meeting ASTM A234 WCB and ANSI B16.5. Gaskets shall be 316 stainless steel and graphite spiral wound by Flexitallic Type CG or approved equal.

Only piping fittings, valves and materials manufactured in the USA or Canada are acceptable.

Insulation
Piping located inside a building shall be insulated with either fiberglass or calcium silicate. Calcium silicate shall be used at the direction of UNR anywhere there is the possibility of incidental contact due to maintenance activities or foot traffic. Jacketing shall be kraft-faced, fittings shall be preformed plastic, and the piping shall be labeled.

Thermal Expansion
Expansion loop shall be used whenever feasible. Where not feasible, expansion joints shall be used.

Valves
Isolation valves shall be rising stem gate with bolted bonnet, cast carbon steel body ASTM A216 WCB, 13% Cr stem and disc with satellite seat, ANSI Class 300 with raised face flanges, and high temperature graphite packing.

Control valves shall be globe type with cast carbon steel body ASTM A216 WCB, with stainless steel trim, ANSI Class 300 with raised face flanges, and high temperature graphite packing. Valves 2” and smaller shall be socket weld or flanged. Control valves shall seat tightly to class IV seat leakage sent leakage at a pressure equal to 110% of the design pressure of 400 psig and 400°. Actuators shall have a minimum 25% margin over valve seating torque. Provide a 1/3 and 2/3 modulating control valves on the high temperature hot water return side and a two-way shutoff valve on the supply side. Valves to close on temperature in excess of 210 degrees F on the low temperature supply side and be manually reset.
Instrumentation
Thermometers shall be installed in threaded 316 stainless steel thermowells installed in ¾” 300 lb. carbon steel threadolets. Thermometers shall be 4-1/2” dial, bi-metal type.

Pressure gages shall be no smaller than 4-1/2 dial. Isolation valves shall be installed between the line and the gage, and gages shall be selected such that the operating pressure falls between 40 and 50 percent of the full scale. Gage stems shall be no smaller than ½”. Water filled gages are not acceptable.

Branch Piping
Taps shall be made using 300 lb. Forged carbon steel ASTM A105 Grade B, ANSI B16.11 sockolets. No direct welding or use of half or full couplings is allowed.

All branches shall utilize forged fittings, unless code calculations are provided.

Piping Supports
All piping shall be seismically restrained as required by IBC, latest edition.

Testing and Flushing
Piping shall be flushed prior to hydrotest. Contractor shall provide all temporary measures to facilitate flushing and testing, and shall provide a flushing and testing plan to the engineer for approval prior to flush or testing.

232120 - THERMAL ENERGY METERS
BTU Meter for thermal energy flow measurement.
Provide a fully integrated thermal energy metering system to calculate BTU's.
* Ultrasonic clamp-on transit-time flow measurement: temperature measurement with clamp-on or insert temperature sensors.
* System has an onboard memory to store energy trends
* Quantities of measurement: Instantaneous thermal energy output, totalized thermal energy, volume and mass flow, temperature Ts,Tr,Td, flow velocity, liquid's sound speed, signal strength.

Product: Fluxus Btu Ultrasonic Meter
Approved Manufacturer :
Flexim
Flexim Americas Corp.
250-v Executive Drive
Edgewood, NY 11717
1-888-852-7473
www.flexim.com

233113 - UNDERGROUND HIGH TEMPERATURE HOT WATER (HTHW) PIPING

System Description
High temperature hot water (HTHW) is the primary heat source for a variety of heating functions throughout the University. HTHW is generated at the Central Heat Plant and distributed via a loop piping system which operates at 325-375°F. Design conditions for piping are 400 psig and 400F.
Code Compliance and Standards
Use current edition in effect at time of design and construction.
A. American Society of Mechanical Engineers (ASME) – Boiler and Pressure Vessel Code (B&PV).

Quality Assurance
A. All materials shall be certified new from factory. Pipe, and fittings shall be built in the USA or Canada to ANSI/ASME standards. Piping components made in other countries shall not be used unless specifically approved in advance by the Project Coordinator. Valves shall be made in the USA or Canada unless otherwise approved by the Construction Coordinator.
B. Welder Qualifications: Welder(s) shall be qualified in accordance with ASME Boiler & Pressure Vessel Code, Section IX, Welding and Brazing Qualifications. Welders shall be thoroughly familiar with ANSI B31.1 requirements.
C. The Contractor shall furnish to the Project Coordinator all applicable welding procedures, individual welder certifications and procedure qualification records. All documentation shall be signed and dated by the appropriate Contractor personnel.

Submittals
A. Manufacturer’s Data: Manufacturer’s standard drawings, catalog cuts, specifications, and data sheets for all materials and equipment (piping, valves, expansion joints, insulation, etc.) shall be submitted to the Project Coordinators.
B. Shop Drawings: Manufacturer’s shop drawings for underground piping or conduit systems, including anchors, guides, supports, vault penetrations and trenches shall be submitted to the Project Coordinator for approval.
C. Welder’s Performance Qualifications: Welder’s performance qualification records shall be submitted to the Project Coordinator for approval prior to beginning work.

Delivery, Storage, and Handling
A. Delivery and Storage:
   1. Contractor shall be responsible for inspecting materials delivered to site for damage.
   2. Materials shall be stored on-site in enclosures or under protective coverings. Materials shall not be stored directly on ground.
   3. Insulation, expansion joints, joint materials, fittings, valves, and gaskets shall be stored under cover out of direct sunlight.
B. Handling:
   1. Pipe, conduit sections, fittings, valves and other accessories shall be handled in such a manner as to ensure delivery to the trench in sound, undamaged condition.
   2. Special care shall be taken to avoid injury to coatings and linings on pipe and fittings. Damaged coatings and linings shall be repaired by the Contractor to the satisfaction of the Project Coordinator.
Pipe and Fittings

A. Pipe:
   1. ASTM A-106 or A-53 type S (seamless) or Type E (electric resistance weld), Grade B, black carbon steel. Type F (furnace butt weld) is not acceptable.
   2. Pipe Wall Thickness:
      a. 2 inch and smaller: Schedule 80
      b. 2.5 inch through 10 inch: Schedule 80

B. Fittings:
   2. Butt Weld (2.5 inch and larger): ANSI B16.9, ASTM A234 WPB, extra strong.
   3. Flanged (2.5 inch and larger): ANSI B16.5, ASTM A105 forged steel, 300 pound class, weld-neck flanges raised face.
   5. All buried pipe fittings shall be butt welded for all sizes.

Valves

A. General: Valves shall be socket welded for 1 1/2 inch and smaller piping, forged steel flanged or socket welded for 2” and larger. Flanged or butt welded for 2 ½ inch and larger. Acceptable valve manufacturers are provided below; no substitutions unless approved by the Project Coordinator.

B. Gate Valves:
   2. Flanged (2 inch and larger): ANSI B16.34, 300 pound class, A216 WCB cast steel body, bolted bonnet, OS&Y, stainless steel trim; Walworth, Crane or Stockham.
   3. Butt weld (2.5 inch or larger): ANSI B16.34, 300 pound class, A216 WCB cast steel body, bolted bonnet, OS&Y, stainless steel trim, Walworth, Crane or Stockham.

C. Globe Valves (where permitted):
   1. Socket Weld (2 inch and smaller): ANSI B16.34 800 pound class, forged steel body, stainless steel seat ring and plug, bolted bonnet, rising steam; Walworth, Vogt, or Edwards.
   2. Flanged (2.5 inch and larger): ANSI B16.34 300 pound class, A216 WCB cast steel body, OS&Y, stainless steel trim, Walworth, Crane or Stockham.

D. Rotary Valves (where permitted):
   1. 300 pound class, carbon steel, flanged, Adams or Keystone Vanessa. stainless steel seats.

Piping Specialties

A. Gaskets: Non-asbestos containing ring gaskets, flexitallic type “cg” grafoil/304ss or equal, suitable for the fluids and temperatures encountered.

B. Bolting: ASTM A193, Grade B7, for bolts and studs, and ASTM A194, Grade 2H for nuts.
C. Sleeves: Sleeves for foundation wall penetrations shall be fabricated of one-eighth inch (1/8") thick steel, with two inch (2") wide collar welded in place, and the assembly hot-dip galvanized.

D. Wall Penetration Seals: High temperature elastomeric link type mechanical seals compressed with corrosion protected bolts and compression plates; Thunderline High Temperature Link Seal, no substitution; or fiberglass rope stuffed packing box if pipe or casing surface temperature exceeds 375 degrees F.

E. Expansion Joints (where permitted, expansion loops are preferred and shall be used wherever possible):
   1. Expansion joints shall be slip tube type as designed for the specific location. They shall be 300 # rating, flanged, and shall conform to the Standards of the Expansion Joint Manufacturer's Association.
   2. Slip-tube type shall have external and internal high performance guides rated for 500°F and designed for packing under pressure; Yarway or Hyspan.
   3. Slip-tube shall be single or double type with center take off taps as required for the given service.

F. Air Vents (for high points): ¾ inch, 300# steel gate valve is required at all high points and be located in accessible manholes. Discharge of air vents in vaults shall be routed to the floor with ¾ inch diameter steel pipe; use socket weld fittings. Install pipe nipple with threaded cap in outlet of valve.

G. Strainers: Y-type with cast or forged steel body. Cast steel 300# rated flanged ends or forged steel 300# socket weld ends; 1/8 inch mesh monel strainer elements, socket weld ends for 2 inch and smaller piping.

H. Pipe Hangers and Supports: Pipe hangers and supports shall be designed and located per the requirements of B31.1 and the recommendations of the powder insulation or prefabricated conduit system vendor.

I. Pressure gauges: 4.5 inch dial, bourdon tube, 0 to 500 psig, Ashcroft or equal. Include 300# forged steel needle isolation valve.

J. Insulation:
   1. In manholes, pipe 2.5 inch diameter and greater shall be insulated with ASTM C533, type I, calcium silicate; 2.5 to 6 inch diameter - 3 inches thick insulation, 8 to 12 inch diameter - 4 inches thick. Less than 2.5 inch diameter -1 inch thick.
   2. In manholes, tunnels, and exterior installations: pipe and fitting insulation shall be covered with 0.016 inch smooth aluminum jackets with integral moisture barrier. Stainless steel band on 12 inch center shall hold the insulation to the pipe.
   3. Valves and equipment shall be insulated with removable shop fabricated fiberglass padding rated for 500°F, with thin wire mesh lining, and covered with 18 ounce high temperature fiberglass cloth with Velcro straps.

Manholes
A. All structures shall be of reinforced concrete. Main line junctions and service connections shall be in vaults, which require two openings.
B. Prefabricated or field constructed manholes, where allowed, shall be provided with walls, floors, and roofs not less than 8 inches thick and reinforced with steel bars. Floors shall drain to sump hole.
C. Concrete shall be 4,000 psi minimum compressive strength after twenty eight (28) days, synthetic fiber, for both prefabricated and field constructed manholes. Air entrained
admixture, 5 to 7% entrainment for all concrete exposed to effects of weather or freezing conditions.

D. Waterproofing shall be provided. Membrane waterproofing is preferred.

E. Steel ladders shall be provided.

F. Covers and openings shall be vehicular traffic rated (H-20).

Steel Pipe and Powder Insulation System

A. The powder insulation system shall provide for minimizing heat loss, corrosion protection, and unrestricted thermal movement between anchors.

B. Powder insulation shall be Gilsulate 500 XR. Thickness of the insulation shall be defined by the Engineer and shown on the Contract Drawings.

C. Expansion Loops and L-Bends: In addition to the powder insulation thickness, bends shall be preinsulated with ASTM C547, Class 1, mineral fiber to allow for thermal expansion of the piping. The mineral fiber thickness at bends should be approximately 200% of the calculated thermal growth.

D. Pipe Supports: Anchors shall be located outside vaults, typically at five feet from the vault wall. Anchors shall not transmit thrust loads to the manhole wall unless the manhole wall has been specifically designed for these thrust loads. Expansion loops shall use guides and vertical supports as required.

Buried Conduit Systems

A. Coated Steel Conduit Casing: Conduit casing shall be manufacturer’s standard drainable, ventable, and pressure testable system with an annular air space. Steel outer casing systems shall be epoxy coated. Perma Pipe Multi-Therm 500 or equal.

B. Conduit End Seals: Conduit end seals shall be fixed type where there is no thermal pipe expansion through the end seal and shall be slip type where there is thermal pipe expansion through the end seal. One-half inch (1/2”) threaded pipe ports at top and bottom of each end seal shall be provided for draining, venting, and pressure testing of conduit casings.

C. Insulation: ASTM C533, Type I, Calcium silicate, mineral fiber, or C552 cellular glass shall be used on the steel pipe within the casing.

D. Expansion Loops and L-Bends:
   1. ANSI B31.1 factory fabricated, with weld testing per design. Casing, couplings, insulation, and piping shall be identical to those used for straight runs and designed to ensure complete drainage. Fabricated materials shall be shipped to the job site in maximum feasible size sections to minimize number of field joints.
   2. Loop casings shall be sized to contain pipe movement without crushing the insulation or causing other damage. Eccentric reducers and increasers or welding collars designed to serve the same purpose shall be used to allow free drainage through the loop.
   3. Pipe supports shall be slotted to permit unrestricted lateral movement of piping and shall be otherwise identical to pipe supports specified for straight runs.

E. Pipe Supports: Anchors shall be located outside vaults away from manhole wall. Inside vaults, vent and drain holes shall be provided at the top and bottom of casing closure plates.

Trenching, Backfilling, and Compacting

A. Trenching: The University may limit the amount of trench to be opened at any time.
B. Bedding:
   1. Pre-insulated conduit systems: Ditch bedding shall be accurately graded with a minimum of six inches (6") of sand. Sand shall pass a ¼ inch screen with not more than fifteen percent (15%) passing a No.200 sieve. Sand shall be backfilled to a minimum of six inches (6") above the pipe casing. Bedding shall be laid to firmly support the piping along its entire length.
   2. Steel pipe and powder insulation system: The steel pipes shall be top hung or bottom supported to allow a bedding of powder insulation underneath (in accordance with manufacturer’s specifications). The powder insulation shall be placed to the minimum thickness shown on the contract drawings. The insulation shall be installed and compacted (per manufacturer specifications) to firmly support the piping along its entire length.

C. Backfilling: Backfilling of trenches shall progress as rapidly as construction, testing, and acceptance of work permits.

E. Damage Repair: Utilities, wall, piping, and other improvements damaged during the course of work shall be repaired to their original condition or replaced by the contractor.

D. Excess Material: Excess material and debris shall be removed and disposed of, at an approved disposal site, within one week after final approval of installation.

Piping Installation
A. General:
   1. Piping and pipe systems shall be fabricated, assembled, welded, installed, and tested in accordance with ANSI B31.1
   2. Piping shall be cut accurately to field measurements and worked into place without springing or forcing, except where cold springing is specified. Piping shall not be buried, concealed, or insulated until it has been inspected, tested, and approved in accordance with FIELD QUALITY CONTROL (below).
   3. Materials and equipment shall be protected from the weather during construction.
   4. Pipe runs underground between vaults shall be welded. Flanged and threaded joints shall not be buried.
   5. Gaskets, packing, and thread compounds shall be suitable for the service. Joint compound shall be applied to male threads only.
   6. Arrangement of all piping shall be shown on the drawings. During installation, care shall be taken to avoid interference with other piping, conduit, and equipment. Lines shall be trapped only where shown on the drawings.
   7. Reducing fittings shall be used for changes in pipe sizes. Bushings shall not be used.
   8. In horizontal lines two inches (2") and larger, reducing fittings of the eccentric type shall be used to maintain the tops of the lines in the same plane.
   9. Pipe shall be adequately supported and anchored so that strain from weight and thermal movement of piping is not imposed on piping, equipment, or structures.

B. Cleaning:
   1. Each section of pipe, fittings, and valves shall be thoroughly cleaned free of all foreign matter before erection. Interior of piping shall be cleaned thoroughly as described in Article 3.7 (below) before final connections are made.
   2. Open ends of mains shall be plugged or capped during shutdown periods. Lines shall not be left open at any place where foreign matter might accidentally enter pipe.
C. Pipe Expansion: Expansion of pipes shall be accommodated by expansion loops, L-bends, Z-bends in buried locations, or by slip type expansion joints in manholes, tunnels and buildings. Expansion joints shall be set to ensure proper function and movement during system operation.

D. Connections: Locations of capped or plugged outlets for future connections shall be shown on the drawings. Weldolets or welding fittings shall be used for tapping existing system.

E. Line Drainage: HTHW lines shall be pitched to allow for drainage to the low point. Buried lines shall be pitched to accommodate the worst case of elevations and must be recorded on the as-built drawings.

F. Welding:
   1. Responsibilities of contractor for electric fusion welding:
      a. Contractor shall be responsible for the quality of all welding.
      b. Contractor shall be capable of performing all welding operations required for construction of the high temperature hot water distribution system.
      c. Contractor shall determine the suitability of welding procedures used to ensure that welds meet the requirements specified herein.
   2. Beveling: Field bevels and shop bevels shall be done by mechanical means or by flame cutting. Where beveling is done after flame cutting, surfaces shall be ground and thoroughly cleaned of scale and oxidation just prior to welding. Beveling shall conform to ANSI standards.
   3. Butt welds: All butt welds shall be open root, multi-pass welds, 6010 or 6011 root with 7018 filler caps (SMAW welding process).
   4. Electrodes shall be stored in a dry, warm area and kept free of moisture during fabrication operations. Electrodes that have lost part of their coatings shall be discarded.
   5. Welds shall be inspected in accordance with ANSI B31.1 requirements. The University will radiograph 5 to 10% of the welds.
   6. If any welds are found to be defective, the contractor is responsible for full 100% radiograph testing of all the welds. Repair of defective welds by adding weld material over the defect, or by peening shall not be permitted. Welders responsible for defective welds shall be re-qualified before performing more welding on the job.
   7. All finished weld joints shall be painted with high temperature black paint.

G. Anchor Blocks:
   1. Anchor Blocks: Concrete anchor blocks shall be provided for pipe anchorage not less than five feet (5') from building or manhole walls (except where metal anchor at the vault wall is shown on the contract drawings). Anchor blocks shall be cast against undisturbed earth using concrete that conforms to ASTM C-94 and has a minimum compressive strength of 4,000 psi at twenty eight (28) days.
   2. Fabricated Structural Anchors: Fabricated structural anchors shall be provided if necessary in vaults, tunnels, and mechanical rooms as described in the contract drawings.

H. Wall Penetrations: Galvanized steel sleeves shall be provided for penetrations in concrete walls six inches (6") or less in thickness and masonry walls. Existing concrete walls thicker than six inches (6") shall be core drilled or equipped with galvanized steel sleeves. High temperature elastomeric link type seals shall be acceptable for use in all locations where the pipe temperature is 375 degrees F or less.
I. Insulation and Jackets:
   1. Insulation shall be continuous through pipe hangers with calcium silicate inserts to prevent crushing of insulation.
   2. Valves and equipment in manholes and buildings shall be insulated and covered with removable jackets. Insulation shall stop short of bolts/studs at flanges to allow their removal without damage of permanent insulation.
   3. No exposed insulation will be permitted. Metal end caps that match the insulation jackets shall be used to cover the ends of insulation runs.

Valve Installation
   A. Valves shall be installed in accordance with ANSI B31.1 and ASME Section VIII.
   B. Valves shall be installed as shown on the drawings and as required for proper functioning of the system.
   C. Valve handwheels shall be installed in locations accessible from floor level, preferably with vertical stems, for operation and repair.
   D. All flange bolts shall be lubricated with a high temperature bolt lubricant approved by the project coordinator. Flanged bolt torquing shall be in an incremental staggered pattern to assure even compression of the gasket.

Piping Special Ties Installation
   A. Hangers and Supports:
      1. Hangers shall be sized to allow for continuous pipe insulation through the hangers. Hangers shall not be permitted to touch pipe.
      2. Expansion bolts shall be acceptable for use in wall or ceiling construction.

Powder Insulation System Installation
   A. Installation of system to be done in strict accordance with the manufacturer’s specifications and design/installation manual. The contractor shall utilize the services of the manufacturer or manufacturer’s agent to oversee and approve the installation of the system at no additional cost to the University.

Buried Conduit Installation
   A. Conduit Field Joints:
      1. Conduit sections shall be joined after leak testing of carrier pipe. Conduit joining materials provided or specified by the system manufacturer shall be used.
      2. Pipe shall be insulated and casing joined to provide field joint equal to factory fabricated section on conduit system. Connections to existing conduit systems of a different manufacturer or type shall be made only in manholes or buildings and never in buried locations.
      3. Conduit End Seals: Conduit end seals in manholes or tunnels shall be provided with goose neck vents on the top and drain valves on the bottom. In buildings, conduit end seals shall be provided with threaded brass plugs.

Field Quality Control
   A. General: The project coordinator or his representative will conduct field inspections and shall witness all field tests specified in this section. The contractor shall perform field tests and provide labor, equipment, and incidentals required for testing. The contractor shall produce evidence, when required by the project coordinator, that any item of work has been constructed properly in accordance with the contract drawings and specifications.
B. Field Tests:
1. General: All anchor blocks and restraints shall be complete prior to testing. Concrete supports shall be fully cured.
2. Piping Hydrostatic Pressure Tests:
   a. Test pressure gauges for a specific test shall have dials indicating not less than one and one half (1-1/2) times nor more than two (2) times the test pressure.
   b. Piping shall be flushed prior to hydrotest. Hydrotest at 600 psi for a 1 hr period, witnessed by University personnel. Contractor to provide all temporary measures to facilitate flushing and testing, and shall provide a flushing and testing plan to the engineer for approval prior to flushing or testing. After pressure testing, University personnel and the engineer must approve the completed piping system prior to insulating. At the discretion of the University, all welds that are not able to be hydrotested shall by x-rayed.
3. Cleaning: After pressure and hydrostatic testing, the pipe system shall be flushed with a water/chemical solution such as San Joaquin Chemicals, Inc. Sansolv 6103 or equal. The procedure, cleaning solutions, and disposal shall be approved by the project coordinator.
4. Operational Tests: After completion of the work, the system shall be operated for not less than six (6) hours at operational temperatures and pressure to demonstrate satisfactory function. The movement of each expansion joint shall be checked, and each valve shall be operated in both cold and hot conditions.

233300 - DUCTS
All new round ducting to be spiral. All fittings shall be long radius unless otherwise approved.

Fiberglass duct is prohibited.

234100 – FILTERS
A. Filters
1. General Air Handler Applications
   a. Pre- Filters: Standard efficiency pleated, media filters with average dust spun efficiency of 30 percent to 35 percent (MERV 8) when tested in accordance with ASHRAE 52.2-1999. Flanders 30/30 U/L class 2, 0.10” initial resistance at 300 FPM velocity.
   b. Final Filters: High efficiency pleated media filters with average dust spun efficiency of 80 percent to 85 percent (MERV 13) when tested in accordance with ASHRAE 52.2 – 1999, Flanders U/L class 2, 0.30” initial resistance at 300 fpm velocity.

2. Standard Filter Sizes:
The following filter sizes are acceptable to use at the University Nevada Reno Campus. Sizes other than those noted below will not be accepted without prior approval from the Facilities Services Department.
Thickness | Size
---|---
1” | 12” x 24”
1” | 16” x 20”
1” | 16” x 25”
1” | 20” x 20”
1” | 20” x 25”
1” | 24” x 24”
2” | 12” x 24”
2” | 16” x 20”
2” | 16” x 25”
2” | 20” x 20”
2” | 24” x 24”
4” | 12” x 24”
4” | 12” x 24”
4” | 24” x 24”

A. Filter Gauges
Furnished and installed as part of the DDC system. Assembly shall include an adjustable pressure transmitter with a 4-20 MA output signal for DDC interface. Manufacturer: Dwyer (No Substitutions)

**235200- HEATING HOT WATER BOILERS**

Hot water boilers shall be designed to provide 180 degrees F boiler water. Boilers shall be designed and constructed in accordance with ASME Boiler & Pressure Vessel Code Section IV and designed for 250 degrees F and 160 psig.

Boilers for critical use and/or emergency response facilities shall be dual fuel (natural gas and fuel oil) unless a variance is obtained or an alternate approach is approved by FSD. The secondary fuel (fuel oil) storage shall be for 24 hours maximum load and shall utilize in a double wall day tank located in the boiler room of 660 gallons or less per NFPA 30, of an exterior fiberglass or steel double wall storage tank either above-ground or buried type. All exterior tanks to have full instrumentation including interstitial monitoring and alarms and level reporting and alarm. Dual fuel boilers shall be equipped with electronic spark ignition for firing on fuel oil. Boiler flues for dual fuel boilers shall include a barometric damper at each boiler outlet.

Boiler types include steel vertical tubeless, scotch marine, fire box, fire tube and cast iron sectional. Selection shall be based on boiler horsepower requirements, available floor space and efficiencies. Boilers under 30 boiler horsepower can be cast iron sectional. Flex tube boilers are not permitted. A minimum of 5 square feet of heating surface per horsepower is required.

Burners shall be designed for a minimum 6:1 turndown.

The waterside pressure loss through the boilers at rated load shall not exceed 4psi.
The boiler shall have a factory installed insulation with metal jacket. Minimum of 2” thick fiberglass or mineral wool insulation. Jacket to be 18 gauge, painted steel with heat resistant primer and finish coats.

Provide ASME safety valve(s).

Each boiler shall be equipped with a combination feeder and low water cut-off. Low water cut-off shall be float type with manual reset.

Each boiler shall be equipped with a manual reset type high temperature limit control.

Modular, gas-fired boilers for non-critical facilities up to 1,000,000 BTU/h are non-condensing type, copper fin tube, 85% minimum thermal efficiency. Units shall be forced draft with modulating burners.

The specifications for projects including a boiler shall require that the contractor apply for and obtain all required boiler inspections and operating permits (as required by the Nevada Industrial Relations Division, Occupational Safety and Health Enforcement Section, the contractor shall obtain an installation application prior to beginning any work and shall apply for a final inspection as required to obtain the boiler operating permit). Reference NRS 455C.

All new gas burners on boilers will have an IRI (Industrial Risk Insurers) approved gas train.

235700 –HEAT EXCHANGERS

Plate and Frame Heat Exchangers

For free cooling systems, a plate and frame heat exchanger shall be specified. Heat exchanger shall be sized for a 2 degree F approach, 304 stainless steel plates and nitrile, EPDM or BUNA N gaskets. Flanged connections to be150# ANSI raised faced flanges. Frames shall be epoxy painted carbon steel. Frame bolting to be stainless steel with carbon steel nuts. Provide in line conical stainless steel strainer.

High Temperature Heat Exchangers

High temperature heat exchangers shall be shell and tube type: U-tube design, 2-pass with removable bundle, similar to Bell and Gossett HTWU. Refer to High Temperature Heat Exchanger Standard Detail in the Appendix for piping arrangement.

The high temperature side shall be the tube side with a 400 psig/400 deg. F rating, and the shell side shall have a 150 psig rating.

Provide a ¾ inch HX bypass with orifice plate where required by Facilities Services to provide a minimum bypass flow. Provide a flanged Y-strainer on HTHW supply side with ¾ inch drain valve.

All connections to be steel flanges using spiral wound, 300# gaskets, 316 ss/graphite. All flanges and valves to be 300# rating; cast steel valves 2 inches diameter and above and Class 800 forged steel less than 2 inch. All joints to be welded, no threaded joints except for instrumentation connections.

Exchangers shall be selected with a 0.0005 fouling factor.
Materials shall be steel shell, tube sheet, baffles, and tie rods, with 90/10 cupronickel tubes, 0.035 inches minimum tube thickness.

Provide ASME Code vessel complete with U-1 form.

Provide pressure relief on the shell side.

Specify a ‘Selco Seal’ steel trap heat exchanger head.

236400 –WATER CHILLERS
Chillers shall comply and be tested in accordance with ARI 550/590. Pressure vessels to be in accordance with ASME B&PV Code Section VIII. Units shall be factory assembled including evaporator, condenser, compressor, lubrication system, refrigerant charge and controls/wiring. Chillers shall be UL listed.

The Engineer of Record shall analyze and recommend screw type water chillers or centrifugal chillers based on an energy analysis and IPLV (Integrated Part Load Value). Chillers over 300 tons rating to be centrifugal. Screw type chillers to be dual compressors with independent refrigeration circuits.

Condenser and evaporator tubs to be 0.035 inch wall thickness, copper. Condensers shall be cleanable, thru-tube types. 150 psig working pressure. Water boxes shall be removable. Tube side fluid velocity shall be 5 to 7 feet per second at full load.

Hermetic and semi-hermetic chiller drives shall have a five (5) year drive warranty that also includes refrigerant replacement in the event of drive failure and/or leakage. Open drives shall have squirrel cages, open drip-proof motors, induction type. All chillers to be factory tested to ARI standards..

The chiller shall have a graphic control panel with a stand alone microprocessor to control the chiller. The display shall include the following:

- Chiller liquid leaving temperature
- Chiller liquid entering temperature
- Condenser liquid entering temperature
- Condenser liquid leaving temperature
- Percent full load amps
- Operating Hours
- Input kW
- Evaporator pressure
- Condenser pressure
- Oil Sump Temperature
- Oil pressure

Chiller shall be able to run from 100% to 10% of full load. The controls shall have BacNet capability to interface with the campus controls system: Automated Logic or Johnson Metasys.
Controls shall include an external unit stop pushbutton with indicating lights, oil safety switch, high and low pressure switches, water temperature controller, freeze protection thermostats, lock-out timer, compressor lead/lag switch, manual pump down switch and unloaders. The chiller shall also have local chilled water supply and return temperature gauges.

Screw chillers shall have independent refrigeration circuits and isolation valves.

Compressor drives shall be VFD drives.

Chillers shall be located in refrigeration machinery rooms per the Uniform Mechanical Code and a refrigeration monitoring system and evacuation system shall be provided.

236500 –COOLING TOWERS
Comply with ASCE 7 for seismic supports of equipment (Seismic design requirements for factory assembled cooling towers).

Cooling towers to be designed and constructed in accordance with the Cooling Tower Institute and CTI 201.

Cooling towers to be either cross flow or counter flow design, 2-cell, induced flow type designed for outdoor use, 304 stainless steel construction with PVC fill and mist eliminators. Low noise axial fan with V-belt drive. Towers systems to include conductivity controller and blow down valve. Where exposed to freezing conditions, cold water basin to have electric basin heaters.

Cooling tower basin shall be equipment with a basin cleaning system consisting of PVC piping and nozzles. A filtration system rated for 10% of condenser water system flow shall be provided with a pump that discharges to the basin cleaning system. Flame spread of all materials used shall be 25 or less.

The cooling tower, where required, shall have an OSHA-compliant handrail around the top and/or side where access is necessary and a cage ladder to all platforms.

Cooling Tower Water Treatment:
Provide a chemical treatment system with tanks, pumps, piping and controls. EPA approved dual biocides for microbiological control. The following criteria must be met: 1) Biological control of both bulk water and under deposit bacteria. The program components must be EPA registered as a biocide and be known to be effective against Legionella. Our maximum counts for open systems are 10,000 cells/ml or less for total aerobic; 50 cells/ml or less for anaerobic in the bulk water; and no Legionella. 2) Scale Control - This is normally accomplished with a combination of polymers & phosphonates. The LSI's should be calculated at various cycles and the program limitations identified. The highest skin temperatures are used in this calculation. 3) Corrosion Control - This is normally accomplished with a combination of the water’s naturally scaling tendencies (hardness + alkalinity) and then modified as necessary using phosphates, zinc, molybdenum, etc for mild steel. Azoles are used for copper corrosion control. Our acceptable corrosion rates are 1.0 mils/yr or less for mild steel and 0.2 mils/yr or less for copper. Provide for storage tanks, positive displacement metering pumps and piping for two alternating biocides and two corrosion inhibitors on cooling tower condenser water circuit.
Testing: Biweekly testing and written reports by the vendor for a period of one year from building occupancy, at no cost to the University, of condenser water with the following testing and data: conductivity, M alkalinity, pH, iron, copper, chlorides and microbiological counts (anaerobic and aerobic species and identification of species). Also, install steel, copper and galvanized steel (or 304ss) coupons in a 4-position coupon rack. Examine, weigh and replace coupons every ninety days. Also, the vendor must have a plan and demonstrate passivation of the cooling tower surfaces over a 90 day break-in period, if galvanized. At the end of one year of continuous services the vendor shall perform a borescope inspection of the chiller condenser bundle with photographs showing tube surfaces.

Corrosion Coupon Racks – All cooling towers shall have a four-position corrosion coupon rack, Betz-Dearborn # 2013971 PVC pipe and furnished with a flow meter, Dwyer Visi-Float VFC-142, 1-10 GPM range.
See Drawing Other Applications:
Drawing # 232100-1 Corrosion Test Coupon Rack
Drawing # 232100-2 Injection Quill Detail

237339 – MAKE UP AIR UNITS
Make-up air units shall be indirect gas-fired units with stainless steel heat exchanger. Modulating or staged burners required. UL and Factory Mutual listed. Air filters to meet MERV 8 or better.

237400- AIR HANDLERS
Roof top air handlers shall be built in accordance with AMCA and ARI standards and shall be factory assembled and tested. The exterior casing shall be 22 gauge steel or better with 2” thick acoustic panels. Unit shall have a C-channel steel base and 14 gauge floor plate. Unit shall have fully gasketed access doors same thickness as walls. Minimum door dimensions are 24” x 72”. Finish shall be epoxy prime coat and acrylic finish. Centrifugal fans shall be steel or aluminum. Minimum bearing life to be AFBMA L-10 200,000 Hours.

Hot water and chiller water coils to be rated for 250 psig, 0.20” minimum wall and 5/8 inch tube diameter. Minimum 10 fins per inch copper coils with aluminum fins. Cooling coil racks to be 304 stainless steel. Chilled water coils to have minimum 12 degrees delta T. face velocity not to exceed 500 fpm. Provide compartment in unit for coil valving, accessible from outside the units via access doors.

Unit to have disposable pre-filters, 4 inch thick, meeting MERV 6. Final filters to be MERV 13 or better. Strion electro-static filters shall be evaluated for large units. Provide sound attenuators in unit

237433 – ROOFTOP AND GROUND MOUNTED PACKAGED HEATING/COOLING UNITS
Unless specifically approved by the University, all rooftop and ground mounted packaged heating and cooling units shall be supplied with an outside air economizer section to provide free cooling complete with exhaust air to prevent over pressurizing the space. Dampers to be full modulation with minimum position set to provide 100% or required ventilation air. Heating sections shall be indirect natural gas fired with an electronic ignition system.
Cooling sections shall utilize either R-22 or R-410A refrigerant and use hermetic scroll compressors. Low ambient controls including but not limited to crankcase heaters, head pressure controls, low pressure cut-outs and manual reset high pressure cut-outs shall be included. Each refrigerant circuit shall include a thermostatic expansion valve (TXV) with removable power element.

238100 – HVAC EQUIPMENT: SPOT COOLING APPLICATIONS
For high density cooling applications, such as computer/server rooms or other sensitive electronic equipment, that requires constant 24/7 cooling: the product allowed is Liebert precision air conditioning systems. For controls, a field supplied 3 or 4 wire connection, (24 VDC) is required between the evaporator and condenser. Control wiring must not allow a voltage drop in the line of more than 1 volt (16 gauge minimum for 75 feet). On a small system, the wall box is connected to the system’s microprocessor board using a four wire system. Wiring to be Belden shielded cable, 20-22 AWG up to 1,000 feet. The shield should be grounded at the evaporator unit.

238100 – UNITARY AIR CONDITIONERS
Window or wall mounted air conditioners are not acceptable. Where space cooling is needed and the building primary system cannot be sued, split DX cooling systems with a remote condenser shall be used.

End of Division 23
HEATING, VENTILATING AND AIR CONDITIONING